2019

The Role Of Mentalizing In Information Propagation

Elisa C. Baek
University of Pennsylvania, elisabaek@gmail.com

The Role Of Mentalizing In Information Propagation

Abstract

What are the psychological drivers that lead to successful information propagation between communicators and receivers of shared messages? What factors lead communicators to share information with others, and receivers to be successfully influenced by the information? The current dissertation focuses on the role of mentalizing, or considering other people's mental states, as one factor that leads to successful information propagation between communicators and receivers. Study 1 of this dissertation focused on the role of mentalizing in communicators of influence and provided behavioral evidence suggesting that mentalizing causally increases communicators' likelihood to share information. Specifically, instructing information sharers to consider how sharing would affect potential receivers' tendencies to feel positively, emotional, and focus inward led communicators to feel closer to potential receivers of their messages, leading to increased likelihood of sharing. Study 2 of this dissertation used neuroimaging to test the role of mentalizing in receivers of influence and showed that brain activity in the mentalizing regions of receivers is associated with increased likelihood of successful social influence in a paradigm that parallels the current online environment. Receivers were significantly more likely to change their own recommendations about mobile game apps when considering peer recommendations that elicited more mentalizing activity, and this effect was driven by negatively framed peer recommendations. Further, Study 2 provided novel evidence suggesting that in this context, the brain's mentalizing system may work independently from the value system in leading to successful social influence. Finally, Study 3 of this dissertation tested whether individual differences in communicators' tendencies to mentalize and consider social factors in decisions to share information are associated with higher rate of success in achieving social influence. Study 3 did not find support for this account, potentially due to the explicit social nature of the experimental paradigm that led to decreased variability in individual differences in mentalizing. Together, the current dissertation advances theories of information propagation and social influence by highlighting the role of mentalizing in both communicators and receivers of influence while also providing important insight on possible boundary conditions when individual differences in mentalizing may not be associated with more successful communication.

Degree Type
Dissertation

Degree Name
Doctor of Philosophy (PhD)

Graduate Group
Communication

First Advisor
Emily Falk

Keywords
mentalizing, social influence, social neuroscience

Subject Categories
Communication | Nanoscience and Nanotechnology | Psychology

THE ROLE OF MENTALIZING IN INFORMATION PROPAGATION

Elisa C. Baek

A DISSERTATION

in

Communication

Presented to the Faculties of the University of Pennsylvania

in

Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2019

Supervisor of Dissertation

____

Emily Falk, Associate Professor of Communication

Graduate Group Chairperson

____

Guobin Yang, Grace Lee Boggs Professor of Communication and Sociology

Dissertation Committee

Joseph N. Cappella, Gerald R. Miller Professor of Communication

Robert C. Hornik, Wilbur Schramm Professor of Communication

THE ROLE OF MENTALIZING IN INFORMATION PROPAGATION

ACKNOWLEDGMENTS

People often talk about how the dissertation process and graduate school can be a lonely process. I am so thankful that this process for me has been so very far from lonely, due to the incredible community that I've had the privilege of being part of within and outside the walls of Annenberg and Penn.

First and foremost, to my advisor Emily Falk, who has been pivotal in my development as a researcher and scholar in the past 5 years – thank you for not only providing critical feedback to my work, but also helping me to create and seek out opportunities. I have learned so much from you, not only about how to run and complete a neuroimaging study successfully but also in how to form connections with people from diverse disciplines. I am so lucky and proud to call myself one of your advisees and to join the wonderful group of people who call themselves an alum of the Communication Neuroscience Lab. To Drs. Robert Hornik and Joseph Cappella – thank you for challenging me to think beyond my comfort zone and in your insightful comments throughout the dissertation process.

I would also like to thank every single alum and member of the Communication Neuroscience Lab, which has served as my intellectual home throughout the last 5 years. I feel so lucky and privileged to have had the opportunity to work with people who are not only brilliant scientists and researchers but also so kind and supportive: Matthew Brook O'Donnell, Nicole Cooper, Christin Scholz, Chris Cascio, Ralf Schmaelzle, Jason Coronel, Yoona Kang, Bruce Doré, Steve Thompson, Nina Lauharatanahirun, Kristin Schumaker, Rui Pei, Prateekshit Pandey, Jacob Parelman, Mia Jovanova, Mary Andrews, Ally Paul, Melis Cakar, Lolo Lomax, and José Carreras-Tartak.

I would also like to thank the wonderful staff who have made Annenberg a community and a home, particularly the friendly faces of ASC 200 who made every coffee run or package pick up feel so warm. Thank you to Joanne whose hard work and cheerleading has helped countless Annenberg graduates to the finish line. I would also like to thank the IT staff, the finance office, the security team, and the building management team who help everything run so smoothly every day.

I'd like to also thank all of my friends at Annenberg, who have made the last 5 years so special and without whom I truly don't think I could have finished grad school (or at least finished grad school feeling happy). Thank you for being there through the million ups and downs that come with graduate school—for celebrating with me during the ups and for supporting me during the downs. Specifically, I would like to thank: Allie Volinsky, Betty Ferrari, Natalie Herbert, and Amber Hye-Yon Lee for being remarkable friends through it all.

I'd also like to thank my friends outside of Annenberg, particularly—Jennifer Liu (+ Liu family), Christian de Luna, David Bautista, Sam Ng—thank you for your relentless support and for reminding me that there is life outside of grad school.

This dissertation would not be possible had it not been for my family. Mom and Dad, I am so proud to be your daughter. Thank you for the innumerable sacrifices you made so that Clare and I could have better opportunities, and for instilling in us an excitement to pursue knowledge even in the midst of an incredibly challenging immigrant life. Thank you for loving me unconditionally and for believing in me – and all of your prayers that have lifted me up at my darkest moments. This Ph.D. is dedicated to you.

To my partner, Dan – we started our journey together the summer before we each started our roads to becoming doctors (although, of course, very different types of doctors). The last 5 years have been full of both challenges and joys as we went through many different growing pains, but I am so thankful that it was you who was beside me the whole time. Thank you for believing in me in so many moments when I did not believe in myself.

Finally – none of this would have been possible had it not been for my faith, my rock and my foundation. *Soli Deo Gloria*.

ABSTRACT

THE ROLE OF MENTALIZING IN INFORMATION PROPAGATION

Elisa C. Baek

Emily Falk

What are the psychological drivers that lead to successful information propagation between communicators and receivers of shared messages? What factors lead communicators to share information with others, and receivers to be successfully influenced by the information? The current dissertation focuses on the role of mentalizing, or considering other people's mental states, as one factor that leads to successful information propagation between communicators and receivers. Study 1 of this dissertation focused on the role of mentalizing in communicators of influence and provided behavioral evidence suggesting that mentalizing causally increases communicators' likelihood to share information. Specifically, instructing information sharers to consider how sharing would affect potential receivers' tendencies to feel positively, emotional, and focus inward led communicators to feel closer to potential receivers of their messages, leading to increased likelihood of sharing. Study 2 of this dissertation used neuroimaging to test the role of mentalizing in receivers of influence and showed that brain activity in the mentalizing regions of receivers is associated with increased likelihood of successful social influence in a paradigm that parallels the current online environment. Receivers were significantly more likely to change their own recommendations about mobile game apps when considering peer recommendations that elicited more mentalizing activity, and this effect was driven by negatively framed peer recommendations. Further, Study 2 provided novel evidence suggesting that in this context, the brain's mentalizing system may work independently from the value system in leading to successful social influence. Finally, Study 3 of this dissertation tested whether individual differences in communicators' tendencies to mentalize and consider social factors in decisions to share information are associated with higher rate of success in achieving social influence. Study 3 did not find support for this account, potentially due to the explicit social nature of the experimental paradigm that led to decreased variability in individual differences in mentalizing.

Together, the current dissertation advances theories of information propagation and social influence by highlighting the role of mentalizing in both communicators and receivers of influence while also providing important insight on possible boundary conditions when individual differences in mentalizing may not be associated with more successful communication.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER 1: INTRODUCTION

The Neuroscience of Influence and Message Virality: Key Role of Mentalizing

What are the psychological drivers that lead communicators to share information and successfully influence others? How do receivers process shared content that leads them to be influenced? This dissertation focuses on mentalizing (i.e., considering the mental states of other people) as one signal that contributes to social influence, including sharers' decisions to share information and receivers being influenced. Mentalizing is one key input to decision making in communicators and receivers of influence (Baek & Falk, 2018; Cascio, O'Donnell, Bayer, Tinney, & Falk, 2015; Scholz et al., 2017; Welborn et al., 2015), and it is theorized to play a central role in whether efforts to persuade and influence are successful (Baek & Falk, 2018; Cascio, O'Donnell, et al., 2015; Falk, Morelli, Welborn, Dambacher, & Lieberman, 2013; Falk & Scholz, 2018). Across various contexts and topics, higher levels of mentalizing in both communicators and receivers of shared messages distinguish whether such attempts will lead to information propagation (for reviews, see: Cascio, Scholz, & Falk, 2015; Cialdini & Goldstein, 2004; Falk & Scholz, 2018).

The current dissertation advances understanding of mentalizing's role in information propagation, through studies that observe both communicators and receivers of shared messages. Study 1 focuses on the role of mentalizing in communicators of messages, testing whether mentalizing causally increases the likelihood that communicators will share information, in the context of health-related news articles. Study 2 focuses on the role of mentalizing in receivers of shared messages, in the context of mobile game apps, testing whether increased mentalizing in receivers of social influence is associated with increased likelihood of successful social influence. Finally, Study 3 focuses on individual differences between people, testing whether individuals who show greater mentalizing activity on average when considering what to share are also more successful at achieving information propagation by persuading their receivers to share their opinions. See Figure 1 for an illustration of the schema and overview of the dissertation studies.

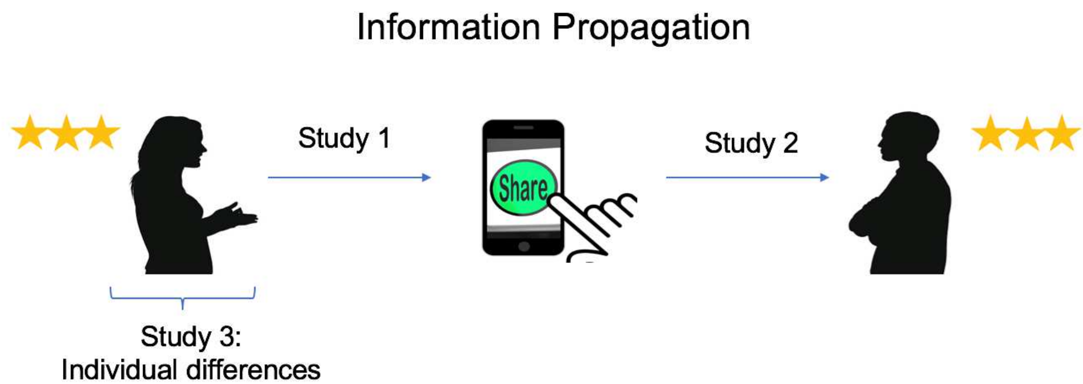


Figure 1. Schema of information propagation.

Information propagates from communicators to receivers. Study 1 of the current dissertation focuses on the role of mentalizing in communicators' decisions to share information with receivers. Study 2 tests the role of mentalizing in receivers who receive the shared information. Study 3 focuses on individual differences in communicators' tendencies to engage in mentalizing, and whether this feature distinguishes communicators who are more successful at influencing receivers.

What is Mentalizing?

Mentalizing, defined as considering the mental states of others, plays a critical role in human communication and social bonding (Adolphs, 2009; C. D. Frith & Frith, 2006; Luyten & Fonagy, 2015). Without the ability to interpret and understand the thoughts and feelings of others that precede their actions, people would be lost in navigating complex social interactions and relationships. The ability to mentalize is not only necessary to explicitly understand that others might hold different beliefs (e.g., "My brother never saw me eat the last ice cream cone, so he might look for it in the fridge"), but also to navigate complex social situations through implicit cues (e.g., "Susie feels embarrassed after her phone rang in the middle of the lecture, and she might feel better if I reassure her"). Indeed, deficits in the tendency or ability to mentalize characterize various psychosocial disorders including autism (Chung, Barch, & Strube, 2014), schizophrenia

(Chung et al., 2014), major depressive disorder (Bateman & Fonagy, 2012), and borderline personality disorder (Bateman & Fonagy, 2012).

A number of tasks are used to test and measure mentalizing abilities of individuals. In one such classic task, participants (often children) are tested in their ability to understand that others might hold an incorrect belief about the state of the world (Wimmer & Perner, 1983). In this false-belief task, participants read a narrative such as the following: *Mark puts his toy inside his drawer and leaves the room. Meanwhile, Katy comes into the room and moves the toy from the drawer to under the bed. Upon returning, where will Mark look for the toy?* In order to correctly identify that Mark will look for the toy in the drawer, participants must be able to understand that Mark holds a belief about the location of the toy that is both incorrect and different from their own. This simple false-belief task has primarily been utilized to test the development of mentalizing abilities in children, and more complex versions of the task have been adapted for adults that test the ability to understand advanced intentions (Happé, 1994; Z. Wang & Su, 2013). Findings from such tasks have advanced understanding of the development of mentalizing ability (U. Frith & Frith, 2003) and specific mentalizing deficits that characterize psychosocial disorders (Chung et al., 2014).

A large body of neuroscience evidence has also identified neural systems that support mentalizing. In particular, portions of the medial prefrontal cortex (MPFC), particularly subregions in the middle and dorsomedial prefrontal cortex (MMPFC, DMPFC), as well as bilateral temporoparietal junction (TPJ), precuneus (PC/PCC), superior temporal sulcus (STS), and temporal poles are robustly engaged when people are actively considering the mental state of others, as identified in a reverse-inference meta-analytical map retrieved from Neurosynth (See Figure 2; see also reviews by Amodio & Frith, 2006; Dufour et al., 2013; C. D. Frith & Frith, 2006). The incorporation of neuroscience tools in conjunction with behavioral measures affords opportunities to advance the study of mentalizing in various ways. For instance, neuroimaging tools allow for activity in the mentalizing system to be tracked in ‘real-time’ as individuals are actively processing stimuli, and thereby do not rely on individuals' ability to introspect on their internal thought processes. These advantages are particularly useful because mentalizing is often an implicit, instinctive process (U. Frith & Frith, 2003); in many social situations, people are able to understand others' perspectives without explicitly conscious or intentional effort. As such, the ability to infer a psychological state through measuring brain activity without the need for self-reports has advanced the study of mentalizing, by testing the role of mentalizing in non-verbal communication (for reviews, see: C. D. Frith & Frith, 2006; Kampe, Frith, & Frith, 2003), as well as the role of mentalizing in predicting behavioral outcomes ranging from susceptibility to peer influence (Cascio, O'Donnell, et al., 2015; Wasylyshyn et al., 2018; Welborn et al., 2015) to encoding of successful ideas (Falk et al., 2013; Falk, O'Donnell, & Lieberman, 2012).

Evidence reviewed thus far suggests that mentalizing is a critical ability for human social functioning, and that the human brain has evolved to support such abilities (Dunbar, 2008). Although the minds of other people are complex, people are generally good at understanding and reacting appropriately to different aspects of other people's mental states. For instance, people are not only able to distinguish when a colleague is feeling positively versus negatively, but also adept at identifying more complex mental states such as excitement versus jealousy. What mechanisms are in place to help organize and represent different aspects of other people's mindsets? A theoretical framework of mentalizing in the brain suggests that people represent other people's mental states along three primary dimensions: rationality/emotionality, socially-focused/individually focused, and positive/negative valence (Tamir, Thornton, Contreras, & Mitchell, 2016). This neuroscientifically grounded theory builds on and extends prior theories of social cognition have also suggested that mental states are represented among discrete dimensions (Fiske, Cuddy, & Glick, 2007; Gray, Gray, & Wegner, 2007; Russell, 1980). Additional work also suggests that the brain represents the mental states of others along identifiable dimensions that are then represented in identifiable sets of brain regions (Skerry & Saxe, 2015). Combined, this suggests that the human brain uses a representation system to efficiently organize others' mental states, allowing for the seamless inference of complex mental states. We leverage this neuroscientifically informed view of mentalizing to develop a manipulation of mentalizing in Chapter 2, and to test its influence on sharing decisions.

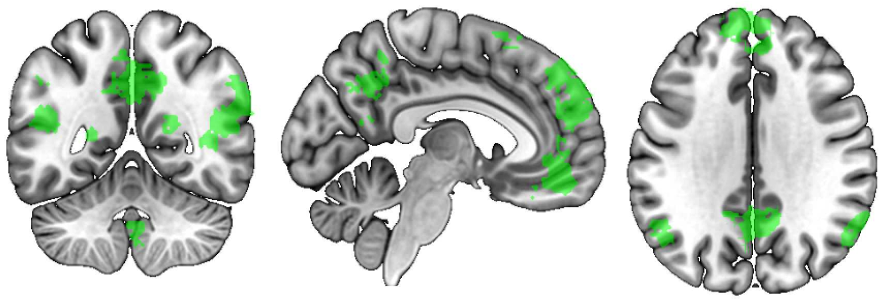


Figure 2. Brain regions associated with mentalizing.

A reverse inference meta-analytic map of the functional neuroimaging literature on "mentalizing" retrieved from Neurosynth shows that subregions in the middle and dorsal medial prefrontal cortex (MMPFC, DMPFC), bilateral temporoparietal junction (TPJ), precuneus (PC/PCC), superior temporal sulcus (STS), and temporal poles have been implicated in mentalizing.

Mentalizing in Communicators Increases Success of Social Influence

Mentalizing is associated with communicators' decisions to share information with others, as well as whether such shared information leads to success in persuading and influencing others (for reviews, see: Baek & Falk, 2018; Falk & Scholz, 2018). This may be in part because to effectively share information and influence others, communicators should consider the audience of their message, considering the receiver's attitude, knowledge, and preferences. Mentalizing allows a communicator to estimate how a message might be received by the receiver and, thus, what the probable social consequences of a given interaction will be (Berger, 2014). For instance, sharing information may lead to social rewards through opportunities to bond and obtain the approval of others, and information sharing serves to not only promote social relationships but also constructing shared understanding of reality in social networks (Baumeister, Maranges, &

Vohs, 2018). Indeed, one account suggests that communicators consider the characteristics of the receivers of their messages, adjusting their motivations, strategies, and approaches based on the characteristics of the receivers (Barasch & Berger, 2014; Scholz, Baek, O'Donnell, & Falk, 2019).

Further, communicators recruit the brain's mentalizing network when making decisions about sharing news articles with others compared to decisions to read the articles themselves or reflecting on the content of the articles (Baek, Scholz, O'Donnell, & Falk, 2017). Activity in mentalizing regions also positively scale with communicators' self-reported intentions to share the news articles, suggesting that the mentalizing system is recruited not only when communicators think about whether to share, but also that increased mentalizing is associated with increased sharing intention (Baek et al., 2017). This predictive power of activity in the mentalizing system goes beyond the individual study participants to population-level behavior; brain activity in a small number of participants as they considered news articles to share was associated with how often the article was actually shared in real life in larger groups of people (Scholz et al., 2017). Specifically, across two studies, brain activity within regions associated with mentalizing showed an indirect effect on population-level sharing of the articles that was mediated through neural value-related activity, suggesting that articles that encouraged mentalizing were perceived to be more valuable when communicators considered sharing content with others (Scholz et al., 2017). In this way, mentalizing activity is associated with increased likelihood that information is shared. Extending these results that implicate the mentalizing system in decisions to share information, Study 1 tested whether the observed association linking mentalizing activity with sharing intentions in communicators has a causal relationship, and what *types* of mentalizing leads to increased sharing. Further, Study 1 tested the idea that mentalizing leads to increased sharing by eliciting feelings of connectedness between communicators and receivers of shared information.

Mentalizing in Receivers Leads to Increased Likelihood of Social Influence

Evidence also suggests that receivers of social influence engage in mentalizing, and that consideration of others' attitudes, knowledge, and perspectives can increase a receiver's susceptibility to influence and persuasion. Social belonging and the maintenance of social relationships are fundamental human needs (Baumeister & Leary, 1995), and as such, receivers determine the value of complying to a message by evaluating potential social rewards of incorporating social norms (Cialdini & Goldstein, 2004). For instance, agreeing with a message shared by a friend or acting to appease a family member's request can lead to social bonding and positive relational outcomes, increasing the value of social compliance. In order for receivers to find conforming to social influence valuable, it is helpful to understand others' mindsets, perspectives, and values (for a review, see: Falk & Scholz, 2018). For instance, receivers may be more likely to find adapting an idea valuable if they are able to understand and relate to the perspectives and desires of the communicators, or if they believe the idea to be more socially salient (Cialdini et al., 2006; Cialdini & Goldstein, 2004). Mentalizing, therefore, is likely to be implicated in the processes that lead to social influence in receivers.

Indeed, receivers engage the mentalizing system when considering the opinions of others, and this activity is predictive of whether the message will lead to successful social influence (Cascio, O'Donnell, Bayer, Tinney, & Falk, 2015; Welborn et al., 2015). Mean neural activity in regions of the mentalizing system (DMPFC, rTPJ, left temporal pole) was associated with the likelihood that adolescent participants shifted their preferences for different works of art based on social feedback from both their peers and parents (Welborn et al., 2015). In novel contributions to the study of social influence, Study 2 extended these previous findings in several key ways. First, Study 2 tested how the valence of the social influence may interact with mentalizing to predict opinion change in response to social influence. Second, Study 2 used naturalistic text written by real people as stimuli, mimicking real world situations where participants encounter written recommendations by other people online. Third, Study 2 tested whether the brain’s mentalizing system works independently from or coordinates with the brain’s value system, which has been previously show to play a central role in social influence (Cascio, O’Donnell, et al., 2015; Klucharev, Hytönen, Rijpkema, Smidts, & Fernández, 2009; Klucharev, Smidts, & Fernandez, 2008; Nook & Zaki, 2015; Welborn et al., 2015).

Are Individual Differences in Mentalizing in Communicators Associated with Successful Influence?

Given that a communicator decides to share information, what sets apart successful communicators from their less successful counterparts? Some evidence suggests that communicators who show a heightened consideration of the thoughts of their receivers are more likely to be successful. Successful communicators are more likely to be socially flexible, with higher levels of self-monitoring in some contexts, or the tendency to adjust their behavior based on interpersonal cues (for a review, see: Baek & Falk, 2018; Snyder, 1974, though see Chapter 4). Further, successful communicators are characterized by environmental contexts that encourage greater ability to take the perspective of others, such as occupying social network positions that span many structural holes, meaning that more of their contacts rely on them to communicate with one another (Burt, 2004; O’Donnell, Bayer, Cascio, & Falk, 2017). Likewise, salespeople who are better at taking their customers’ perspectives are likely to have higher work performance (Limbu, Jayachandran, Babin, & Peterson, 2016). Combined, behavioral evidence suggests that the tendency to mentalize contributes to whether communicators will be successful in achieving social influence.

Although this account has not been widely tested using neuroimaging, a handful of studies suggest that the tendency to mentalize may distinguish successful communicators. Professional salespeople who self-reported higher levels of mentalizing also showed increased recruitment of brain regions associated with mentalizing, including the temporoparietal junction (TPJ) and medial prefrontal cortex (MPFC), and were more successful at adapting their strategies to meet their customers’ needs (Dietvorst et al., 2009). Further, these findings were mirrored in individuals who are not professional salespeople; participants who were more successful at convincing others to accept or reject TV show ideas based on their own preferences showed greater recruitment of the TPJ, a part of the brain's mentalizing system, during initial exposure to the ideas (Falk et al., 2013). Thus, the level of mentalizing in communicators may be one indication of the likelihood that information is shared in the first place, as well as whether the shared information leads to successful social influence. Study 3 sought to contribute to this literature by testing whether individual differences in mentalizing activity in communicators are also associated with their success in communicating the value of sharing certain types of news articles to their receivers.

Overview of Studies

Study 1 tested the causal role of mentalizing in leading to increased likelihood of sharing in communicators. In a series of pre-registered, iterative studies, Study 1 found robust evidence that mentalizing causally increases sharing. Using a framework derived from neural evidence that people represent other people's mental states along 3 different dimensions (Tamir et al., 2016), Study 1 also found that considering specific elements of potential receivers' mental states—considering how sharing might lead receivers to feel positively, emotional, and focus inward—led to higher likelihood of sharing. Further, this effect was mediated by feelings of closeness with potential receivers, suggesting that priming communicators to consider these aspects of potential receivers' mental states led to increased sharing through eliciting feelings of connectedness with potential receivers. Taken together, the results of Study 1 advance theories of information sharing and shed light on previously observed brain-behavior relationships.

Study 2 highlights the importance of mentalizing in receivers of one specific form of information propagation, the spread of online recommendations. We demonstrate that increased mentalizing activity in receivers of peer recommendations about mobile game apps was associated with recommendation rating change toward that of the peer. Further, this effect was driven by negatively framed peer recommendations, but not positively framed peer recommendations. Consistent with past research, increased mean activity in the brain's valuation system was associated more generally with recommendation rating change, regardless of the valence of the recommendation. Thus, in this context, the valuation signal may be tracking the value of the peer influence. Finally, in a novel contribution to the field, we show that decreased connectivity between the brain's mentalizing and value systems was associated with recommendation rating change. Findings suggest that the mentalizing and value systems may work relatively independently when people incorporate others' opinions to update their own recommendations, and work in a more coordinated manner to resist peer influence.

Finally, Study 3 sought to understand whether individual differences in tendencies to mentalize are associated with success of communication (i.e., whether communicators who are more successful at achieving behavioral correlation with receivers of their shared messages are distinguished by higher mean activity in the brain's mentalizing system). Study 3 observed brain activity while communicators considered content to share with potential receivers, and success was operationalized by the communicators' abilities to achieve correlation in preference ratings with receivers who saw their written messages to share the content. Study 3 did not find support for the account that communicators who are more successful at communicating the value of shared content with their receivers are distinguished by higher mentalizing activity, or other measures representing the communicators' tendencies to consider social factors (i.e., self-monitoring). Findings suggest that when participants are repeatedly and explicitly asked to actively reflect on whether and how they would share content, mentalizing may not distinguish successful communicators from their less successful counterparts. This may occur because the task reduces the effects of differences in natural tendency to consider receivers' perspectives.

CHAPTER 2: Study 1 – Considering Others' Mental States Causally Increases Information Sharing

Introduction

Information sharing is an integral part of human communication with important consequences at both the interpersonal and population levels. Information sharing can promote interpersonal connections through opportunities to bond and connect with others (Berger, 2014), and also affect the attitudes and behaviors of many when the information spreads across social networks (Cappella, Kim, & Albarracín, 2014; Rogers, 2003; Southwell & Yzer, 2007). What drives people to share information with others? One account suggests that social considerations, or thinking about other people's thoughts, desires, and perspectives ("mentalizing"), contribute to an overall computation of value that represents how rewarding sharing is expected to be (Baek et al., 2017; Falk & Scholz, 2018; Scholz et al., 2017; Scholz & Falk, 2017). In the current investigation, we tested whether mentalizing causally increases likelihood to share.

Mentalizing contributes to overall value of sharing. Neural and behavioral evidence suggests that mentalizing is associated with greater likelihood of sharing ideas with others (Baek et al., 2017; Falk & Scholz, 2018; Scholz et al., 2017), and that self-disclosure is inherently rewarding (Tamir & Mitchell, 2012). Anticipation of interacting and exchanging ideas with receivers is one motivation behind sharing (Berger, 2014; Lee, Ma, & Goh, 2011), and activity in the brain's mentalizing system scales with individual communicators' preferences to share information (Baek et al., 2017). Further, a theoretical framework of information virality, Value-Based Virality, posits that social and self-related considerations are key inputs to an overall domain-general value signal that determines the value of sharing a piece of information (Scholz et al., 2017). This domain-general value signal then predicts population-level virality, or how often an idea is shared in the real-world (Scholz et al., 2017). Thus, mentalizing has been linked to sharing behavior in individuals and content that evokes mentalizing activity in audience members is more likely to be shared widely at scale; however, extant findings have been all correlational, and it is therefore unclear whether this association between mentalizing and sharing is causal. The current investigation tested the hypothesis that mentalizing causally increases sharing. If mentalizing causally leads to increased sharing, then getting communicators to consider the mental states of potential information receivers should lead to higher likelihood that the communicator would share information.

Different types of mentalizing. Within the broad umbrella of mentalizing, it is also useful to consider whether specific types of thoughts about other people lead to increased sharing. Research reviewed thus far has investigated mentalizing generally and, as such, it remains unclear what *types* of thoughts about other people lead to the highest likelihood that an individual would share information with others. Information sharing in humans is theorized to play a critical role in constructing a socially shared understanding of reality (Baumeister et al., 2018), and therefore, considering specific elements of other people's cognitions, emotions, and experiences may lead to higher likelihood of information sharing through invoking thoughts about what may be socially valuable. In the current study, we explored whether considering certain specific mental states of potential receivers (i.e., dimensions of mentalizing), may most robustly promote the perceived value of sharing and sharing intent.

To identify relevant dimensions of mentalizing, we began with an empirically grounded theoretical framework of mentalizing in the brain (Tamir et al., 2016). This work suggests that people represent other people's mental states along three primary dimensions: rationality/emotionality, high social/individual focused, and positive/negative valence (Tamir et al., 2016). Although the minds of other people are complex, the ability to understand and respond appropriately to different mental states of other people is fundamental to promoting healthy social interaction; evidence from this body of work suggests that the brain organizes the diverse possibilities of mental states along these three primary dimensions, serving to efficiently support the ability to understand other people (Tamir et al., 2016). The first dimension (rationality/emotionality) captures the representation of others' mental states on a continuum from rational to emotional; on one end of this dimension are mental states such as "decision", "strategy", and "reason" whereas on the opposite end of this dimension are states such as "sadness", "ecstasy", and "emotion". The second dimension (high social/individual focused) captures the representation of others' mental states on a scale from highly social to focused on the individual, with one end of this dimension consisting of states in which the target is focused broadly on others such as "jealousy", "affection", and "playfulness" and the other consisting of states where the target is more narrowly and inwardly focused such as "calmness", "depression", and "tranquility". Finally, the third dimension (positive/negative valence) captures the representation of others' mental states on a scale from positive to negative valence, with one end of this dimension consisting of states such as "cheerfulness", "excitement", and "hope" while the other end consisting of states such as "horror", "fear", and "sadness". In the current investigation, we leveraged these theoretically derived dimensions to prime participants to consider different mental states of potential receivers of their shared information, and to examine whether considering some of these states might be more likely to increase sharing than others.

Mechanisms linking mentalizing and sharing. We then turn our attention to why mentalizing might increase sharing. Prior research suggests that people find inherent value in self-disclosure to others (Tamir & Mitchell, 2012). What is the source of this value? One possibility, following recent theorizing about mental state representation (Tamir et al., 2016), is that mentalizing might lead potential sharers to think in more fine grained ways about receivers' mental states. This more fine-grained representation of others' viewpoints might allow participants to anticipate more benefits to the receiver. Indeed, articles rated as more "useful" are shared more (Kim, 2015). In this case, mentalizing would be associated with increased distinction between the different mental states, and greater anticipated rewards to the receiver, which in turn could relate to increased desire to share. Another possibility is that mentalizing contributes to an overall value of sharing through eliciting thoughts in the sharer about the potential social benefits of sharing, such as opportunities to bond, connect, and feel close to potential receivers. Indeed, the need to socially belong and feel connected with others is a fundamental human need (Baumeister & Leary, 1995). Evolutionary theory suggests that the human biology evolved to value such interpersonal connections (Dunbar, 2008). Thus, this possibility suggests that priming thoughts about other people leads to increased likelihood of information sharing because it elicits thoughts about potential positive social consequences of such interactions. In the current study, we tested different theories of how mentalizing contributes to an overall value of sharing. We find evidence that mentalizing causes sharing by engendering feelings of closeness with potential receivers.

Current Study. We tested the notion that mentalizing causally increases sharing in 3 separate studies. Across all studies, participants were randomly assigned to first see instructions that prompted them to consider others' mental states in their sharing decisions, operationalized along a specific dimension of mentalizing, or a control condition in which they were simply asked to consider the content of the article while deciding to share information. Participants then read 5 headlines and abstracts of news articles and indicated their likelihood to share each article. In Study 1 (N = 400), we tested conditions that directly paralleled the dimensions identified by Tamir and colleagues (Tamir et al., 2016), resulting in 3 experimental conditions and 1 control condition. For instance, participants who were randomly assigned to the "rationality/emotionality mentalizing" condition were instructed to "*think about how sharing each article might affect potential receivers' tendencies to think rationally or feel emotional*," (i.e., asked to consider the mental state of potential receivers on the rationality/emotionality dimension as a whole). In Study 2 (N = 840), we tested each component (i.e., the "poles") of the 3 dimensions of mentalizing separately. This resulted in 6 experimental (2 per dimension of mentalizing) conditions and 1 control condition. For example, participants who were randomly assigned to the "rationality high" mentalizing condition were instructed to "*think about how sharing each article might affect potential receivers' tendencies to think rationally*," whereas participants who were assigned to the "emotionality high" mentalizing condition were instructed to "*think about how sharing each article might affect potential receivers' tendencies to feel emotional*." In Study 2, we also began to explore potential mechanisms linking mentalizing to sharing. Finally, in Study 3 (N=3500), we tested whether considering the mental states of potential receivers leads information sharers to share more information because it prompts sharers to think about potential social rewards of sharing, such as opportunities to feel close to potential receivers or reinforce bonds with close others. Study 3 had the same conditions and sharing decisions as Study 2. However, after reading the randomly assigned instructions, but prior to making sharing decisions, participants were asked to indicate how close they felt to potential receivers of the shared articles through a modified Inclusion of Other in Self task (Aron, Aron, & Smollan, 1992). The Inclusion of Other in Self is a graphical representation of overlapping circles that allows participants to express visually how much self-other overlap they perceived with potential receivers of the articles. This allowed us to test the theoretical mediation framework of mentalizing leading to feelings of closeness to potential receivers that then leads to increased likelihood of sharing. All studies were pre-registered prior to data collection (Study 1: https://osf.io/uevgb, Study 2: https://osf.io/mvyfk, Study 3: https://osf.io/8dz3x), and all instructions were pre-tested to ensure that they successfully manipulated the respective mentalizing dimension.

Materials and Methods

We conducted one pilot study and three iterative studies to test whether instructions to take the perspective of potential receivers lead to increased likelihood of information sharing, and why. In all iterations of the study, participants saw the headlines and abstracts of 5 articles from the health section of the *New York Times* and indicated their likelihood to share each article with others broadly on a 1-5 likert-like scale (*"How likely are you to share this article broadly (e.g., on your Facebook wall or Twitter)?" 1: very unlikely; 5: very likely*). These news articles were pre-tested to be neutral in their average likelihood of being shared (i.e., closest to 3) to avoid floor and ceiling effects, drawn from a sample of 96 news articles from the *New York Times* about healthy living and physical activity. Prior to making sharing decisions, participants were randomly assigned to one of the experimental conditions that instructed them to think about the mental states of potential receivers of their shared articles or a control condition. The mentalizing instructions primed participants to consider different aspects of the mental state of potential receivers.

Participants. Participants for the pilot study and 3 main studies were recruited on Amazon Mechanical Turk (MTurk). For the pilot study (N=144), studies 1 (N=400) and 2 (N=840), and a subset of study 3 (N=2026), participants were required to be in the United States and have completed a minimum of 500 "HITs", or assignments approved on the platform, with an approval rate of 98% and greater. Participants were prohibited from completing the survey more than once on the platform. Due to the need for a larger sample in study 3 (total N=3500), for the remaining 42% of the sample (N=1474), we recruited participants who were in the United States and had completed a minimum of 100 HITs approved with an approval rate of 96% and greater (i.e., we relaxed the inclusion criteria for worker status on MTurk to allow completion of the study). Participants in all studies were excluded if they wrote nonsensical or irrelevant text in the manipulation checks asking them to report how they completed the task, or if they failed an attention check (see Appendix A).

Dimensions of mentalizing. To manipulate mentalizing, we created instructions derived from a theoretical framework of mentalizing as identified in Tamir et al., (2016). Participants were instructed to consider the mental states of their receivers based on the 3 dimensions of mentalizing as a whole, as well as components (i.e., "poles") of each dimension of mentalizing. Specific details about this manipulation in each of the studies follow below.

Pilot study. We first recruited 144 participants (12 participants per condition) to pretest our instructions. Participants were randomly assigned to one of 9 mentalizing conditions or one of 3 control conditions. Three of the 9 mentalizing conditions focused on a dimension of mentalizing as a whole, while the remaining 6 tested each pole of each dimension separately (see Table 1).

Thus, we formulated three separate conditions for each dimension of mentalizing: one condition that instructed participants to consider the dimension as a whole, a second condition that tested one component of the dimension, and a third condition that tested the other component of the dimension. For example, for the valence dimension, participants could be assigned to consider the valence dimension of potential receivers as a whole (“valence_both”: how sharing information might make potential receivers feel positively or negatively), or the positive end of the valence dimension (“valence_positive”: how sharing information might make potential receivers feel positively), or the negative end of the valence dimension (“valence_negative”: how sharing information might make potential receivers feel negatively). See Table 1 for the instructions used for each condition. After reading the instruction, participants then saw the headlines and abstracts of 5 news articles and were asked to indicate their likelihood to share each article. After making the sharing decisions, all participants completed closed and open-ended manipulation checks that asked participants to describe the strategies they used in approaching the task, which allowed us to test whether the instructions were successful. Our results suggested that 1) participants understood the instructions as evidenced by their open-ended responses to how they approached the task, 2) participants successfully distinguished between the conditions, as evidenced by their responses to close-ended manipulation check questions, and 3) effects of the content and self control conditions were similar (effects of mentalizing compared to content control on sharing: $B = 0.660$, $t\ (130) = 2.208$, $p = 0.029$; effect of mentalizing compared to self control on sharing: $B = 0.677$, $t\ (130) = 2.280$, $p = 0.024$) and provided crude effect size estimates for mentalizing compared to control used to power studies 1 and 2, as detailed below (see Appendix A).

Table 1. Experimental Conditions

Condition	Descriptions of each condition and instructions (in italics)

Rationality High	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing each article might affect potential receivers' tendencies to **think rationally.**
Emotionality High	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing each article might affect potential receivers' tendencies to **feel emotional**.
Rationality Both	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing each article might affect potential receivers' tendencies to **think rationally or feel emotional.**
High Social	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing each article might make potential receivers **think about their social relationships.**
Individual Focused	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing each article might make potential receivers **focus inward.**
Social Impact Both	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing each article might make potential receivers **think about their social relationships or focus inward.**
Valence Positive	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing

	each article might make potential receivers **feel positively.**
Valence Negative	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing each article might make potential receivers **feel negatively.**
Valence Both	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. For this task, think about potential receivers of each article. Think about how sharing each article might make potential receivers **feel positively or negatively.**
Control Content	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. **For this task, think about the content of each article, and how likely you are to share the content.**
Control Self	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article. People share articles for various reasons. **For this task, think about your own opinions of each article. Think about how interesting each article is to you.**
Control None	You will read the headline and summary of 5 news articles. Consider how likely you would be to share each article.

Study 1. In Study 1, we tested whether mentalizing causally increases sharing using the instructions that considered each mentalizing dimension as a whole (i.e., rationality both, social impact both, and valence both conditions) compared to the control content condition (see Table 1 above). Pilot tests indicated participants in the mentalizing conditions were more likely to share information compared to both the control content and control self conditions (see Appendix A). The control content condition was used as the control condition for the all the studies that follow, which parallels a control condition used in a previous neuroimaging study on sharing (Baek et al., 2017). We recruited N=400 participants for this study, 100 per condition, determined through a

power analysis based on pilot data (providing 85% power to detect an effect size of 0.2, the estimated effect). Similar to the pilot study, participants were first randomly assigned to one the 3 experimental conditions designed to induce mentalizing (rationality both, social impact both, valence both) or the content control condition. Then, participants saw the headlines and abstracts of 5 news articles and indicated their likelihood to share each article. Afterwards, participants completed a questionnaire where they were asked to rate the perceived similarity between mental states as adapted from Thornton, Weaverdyck, & Tamir (2018), to allow us to explore this as one potential mechanism linking mentalizing and sharing (see Appendix A for results). All hypotheses were pre-registered prior to data collection (https://osf.io/uevgb).

Study 2. In Study 2, we tested whether mentalizing causally increases sharing using instructions that primed participants to consider each component of each dimension of mentalizing (i.e., emotionality, rationality, individual focused, high social, valence positive, valence negative) compared to the control content condition (see Table 1 for specific instructions). This resulted in 6 experimental conditions and 1 control condition. We recruited N=840 participants, 120 per condition, determined through a power analysis based on Study 1 (82% power to detect an effect size of 0.2). Similar to the other studies, participants were first randomly assigned to one of the 6 experimental conditions instructing them to consider a component of potential receivers' mental states or the control condition. Then, they indicated their likelihood to share the 5 news articles. Afterwards, participants completed two additional surveys that were designed to explore potential mechanisms that could link mentalizing to increased sharing. One measure tested the idea that prompting mentalizing may lead participants to think about the potential interpersonal benefits of sharing, such as opportunities to bond and feel closer with potential receivers of the message (i.e., social benefits for themselves and for the relationship). Thus, participants completed a modified version of the Inclusion of Other in Self Scale (Aron et al., 1992), where they indicated how close they felt with potential receivers of each shared article. A second measure tested the idea that mentalizing leads information sharers to think about how sharing may be beneficial for potential receivers of the article (i.e., purely other-focused benefit). Participants were thus asked to answer how beneficial they thought it would be for receivers of shared articles (*"How beneficial or harmful do you think sharing this article would be for potential receivers of the shared article?" 1 – Very Harmful; 5 – Very Beneficial*). Participants were randomly assigned to see either the Inclusion of Other in Self scale or the perceived benefits questions first. All hypotheses were pre-registered prior to data collection (https://osf.io/mvyfk).

Study 3. In Study 3, we built on results from study 2 to test whether instructions to consider the mental states of potential receivers led participants to feel closer to the potential receivers, which in turn led to increased likelihood to engage interpersonally through sharing information with them. In other words, we tested whether feelings of closeness to receivers, captured through the Inclusion of Other in Self scale, mediates the relationship between mentalizing and sharing. We recruited N=3500 participants, 500 per condition, determined through a power analysis based on study 2 data (91% power to detect effect of mediation, calculated based on marginal mediation effect linking mentalizing to sharing through inclusion of other in self we found in study 2). Study 3 was designed in a similar way to Study 2. Participants were randomly assigned to one of 7 mentalizing conditions (emotionality, rationality high, individual focused, high social, valence positive, valence negative) or the control condition. They first saw instructions as indicated in Table 1. Then, prior to making sharing decisions, participants answered the modified Inclusion of Other in Self scale where they indicated how close they felt to potential receivers of their shared article. Participants then indicated on a 1-5 scale their likelihood of sharing each article. This approach allowed us to test whether instructions to consider the mental state of potential receivers led participants to feel closer to potential receivers, which in turn is associated with increased likelihood of sharing. All hypotheses were pre-registered prior to data collection (https://osf.io/8dz3x).

Analyses. Across all studies, we first tested the idea that mentalizing causally increases sharing. To do so, we created a new binary indicator variable that combined all the experimental mentalizing conditions into a single “mentalizing” condition and all control participants to “control.” This allowed us to test whether mentalizing more generally (i.e., regardless of the specific form of mentalizing) causally leads to increased sharing. We ran multi-level models using *lmerTest* in R (Kuznetsova, Brockhoff, & Christensen, 2014) to predict sharing intentions from the binary condition variable with random intercepts to account for non-independence due to multiple observations per participant and article. The degrees of freedom for all multi-level models were approximated through the Welch-Satterthwaite equation, the default method used in *lmerTest*. We also calculated an aggregate mean effect size from our 3 studies by running a fixed effects model using the package *meta* in R (Schwarzer, 2019).

We also ran additional analyses in each study to compare each dimension of mentalizing to the control condition. To do so, we ran multi-level models to predict sharing intentions from the condition variable, with the reference factor level set to the control condition. For study 1, this allowed us to test the effects of priming the 3 mentalizing dimensions on sharing intentions compared to the control condition. For studies 2 and 3, this approach allowed us to test the effects of priming the poles of the 3 mentalizing dimensions on sharing intentions compared to the control condition. Next, we also calculated an aggregate effect size for each of the components of the 3 mentalizing dimensions on sharing intentions compared to the control condition using data from studies 2 and 3 by running a fixed effects model using the package *meta* in R (Schwarzer, 2019).

To test the mediation hypothesis in Study 3, we used brms in R (Bürkner, 2013) to fit Bayesian regression models to run a multi-level mediation model, accounting for non-independence due to multiple observations per participant and article.

Results

Mentalizing causally increases sharing. Across all 3 studies, we tested whether participants who were instructed to consider the mental states of their receivers, regardless of the specific type of mentalizing, indicated higher likelihood to share information with others compared to participants in the control condition who were instructed to consider the content of the articles. These analyses collapsed across the specific dimensions of mentalizing to consider whether mentalizing conditions, as a whole, increased participants' desire to share, relative to the control condition in which they were asked to consider the content of the article in their decisions to share information ("*Think about the content of each article, and how likely you are to share the content.")*. We found robust support for a causal relationship between mentalizing and sharing across all three studies: participants in the mentalizing conditions were significantly more likely to share information than participants in the control condition (see Table 2; see Appendix A for a table of means). We next calculated the mean aggregate effect size across all three studies using a meta-analytical approach. We found that the average effect of mentalizing on sharing was d = 0.105 [95% CI: 0.023 – 0.188], z = 2.51, p = 0.012.

Table 2. Mentalizing Causally Increases Sharing

Study	Variable	Estimate (SE)	t (df)	p
Study 1	Intercept	2.720 (0.198)	13.759 (7.15)	<.001
	Mentalizing	0.285 (0.118)	2.413 (398)	0.016
Study 2	Intercept	2.817 (0.183)	15.418 (6.730)	<.001
	Mentalizing	0.258 (0.091)	2.682 (837)	0.007
Study 3	Intercept	2.832 (0.199)	14.253 (4347)	<.001
	Mentalizing	0.092 (0.043)	2.076 (3250)	0.038
Aggregate Effect Size (Studies 1-3)		Cohen's *d*	*z*	*p*
	Mentalizing	0.105	2.51	0.012

ref level = control condition
Study 1: n obs = 2000, groups: n participants = 400, n articles = 5
Study 2: n obs = 4195, groups: n participants = 839, n articles = 5
Study 3: n obs = 16260, groups: n participants = 3252, n articles = 5

Dimensions of mentalizing driving effects on sharing. Next, we explored the effect of each dimension of mentalizing on sharing separately to examine whether some elements of mentalizing might be particularly driving sharing decisions. In study 1, we tested whether instructions to consider the 3 dimensions of mentalizing as a whole, compared to the control condition, led to increased sharing (i.e., rationality, social impact, and valence dimensions of mentalizing compared to the control condition). We found that all 3 dimensions of mentalizing led to directionally greater likelihood to share compared to the control condition, although the effects of the rationality and valence conditions were marginally significant (see Table 3). Further, the confidence intervals of the three conditions overlap, suggesting that although each of the dimensions of mentalizing led to greater likelihood of sharing compared to the control condition, the effects did not differ between the mentalizing conditions.

Next, in studies 2 and 3, we tested the effects of promoting the poles of each dimension of mentalizing on sharing, compared to the control condition (i.e., rationality high, emotionality high (rationality low), social impact high, introspection high (social impact low), valence positive, and valence negative instructions compared to the control condition). In study 2, we found that when participants were prompted to consider how sharing would affect potential receivers' tendencies to feel emotional (i.e., emotionality high/rationality low), focus inward (i.e., introspection high/social impact low), and feel positive (i.e., valence positive), they were significantly more likely to share information with others compared to the control condition (see Table 4). In study 2, prompting participants to consider how sharing would affect potential receivers' tendencies to think rationally (i.e., rationality high), think about their social relationships (i.e., social impact high), and feel negative (i.e., valence negative) did not lead to increased sharing compared to the control condition (see Table 4). Although we found evidence that some sub-dimensions showed significant effects compared to the control condition, and others didn't, we do not find strong evidence for differentiation across the sub-dimensions (i.e., the confidence intervals largely overlap), and post-hoc Tukey tests indicated that distinctions between the sub-dimensions do not survive multiple comparison correction (see Appendix A for a complete table of contrasts).

In study 3, we also found that prompting participants to consider how sharing would lead potential receivers to feel positively (i.e., valence positive) led to increased sharing compared to the control condition, and the effects of prompting participants to consider how sharing would affect potential receivers' tendencies to feel emotional (i.e., emotionality high/rationality low) were marginally significant (see Table 5). Prompting participants to consider the other 4 components of mentalizing (i.e., rationality high, introspection high/social impact low, social impact high, and valence negative) did not lead to increased sharing compared to the control condition. As above, although we found evidence that some sub-dimensions showed non-zero effects and others didn't, we do not find strong evidence for differentiation across the sub-dimensions (i.e., the confidence intervals largely overlap), though post-hoc Tukey tests indicated that positive valence led to significantly increased likelihood of sharing compared to the social impact high, introspection high/social impact low, and valence negative conditions (see Appendix A).

We next calculated aggregate effect sizes of each dimension of mentalizing on sharing compared to the control condition using data from studies 2 and 3. We found that the aggregate effect of prompting participants to consider how sharing may lead receivers to feel positively on sharing compared to the control condition was robust with a Cohen's d = 0.192, whereas the aggregate effect of prompting participants to consider how sharing may affect receivers' tendencies to feel emotional was marginally significant with a Cohen's d = 0.112 (see Table 6). Aggregate effect sizes for the other 4 components of mentalizing were not significant (i.e., statistically not different from control).

Causal effect of mentalizing on sharing is mediated by inclusion of other in self. In studies 1 and 2, we began to explore possible mechanisms through which mentalizing might increase sharing. In study 1, we tested the possibility that mentalizing leads to increased sharing by leading participants to distinguish between the mental states of their receivers with higher granularity, but we did not find support for this theory (see Appendix A for more information). In study 2, we tested two additional potential mechanisms through which mentalizing increases sharing: 1) perceived benefit of sharing the article content for potential receivers and 2) increased feelings of closeness to potential receivers. In study 2, we found no link between mentalizing and perceived benefits of the content to receivers (B = 0.020, t (834) = 0.380, p = 0.704). We did find, however, that mentalizing marginally increased feelings of closeness to potential receivers share, operationalized by a modified version of inclusion of Other in Self scale (B = 0.200, t (837) = 1.721, p = 0.086), and that higher perceived inclusion of other in self was significantly related to participants' desires to share (B = 0.336, t (4161) = 32.19, p <.001). Given this suggestive evidence, in study 3, we powered the study to test for evidence for the theory that mentalizing leads to increased sharing because it prompts sharers to think about the potential positive social consequences of sharing, such as fostering bonding and feelings of closeness with potential receivers of the shared information (operationalized as inclusion of other in self scale with potential receivers and self). We found support for this mediation hypothesis in study 3. We estimated the mediation model (a path: mentalizing → inclusion of other in self (Mean posterior distribution = 0.072, 95% credibility interval = [0.011 – 0.129]); b path: inclusion of other in self → sharing (Mean posterior distribution = 0.470, 95% credibility interval = [0.457 – 0.483]) and found that participants were significantly more likely to share information when they reporting feeling a greater overlap of themselves and potential receivers of the articles (see Figure 3). Further, the effects of mentalizing on sharing were significantly mediated by inclusion of other in self such that the indirect effect of mentalizing on sharing through inclusion of other in self was significant (see Figure 3).

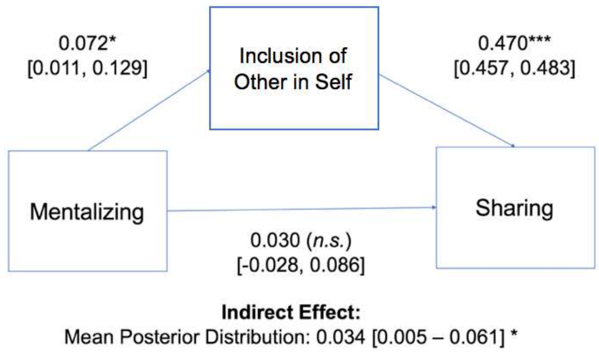


Figure 3. Mentalizing Leads to Sharing Through Inclusion of Other in Self.

Dimensions of mentalizing driving effects on sharing through inclusion of other in self. We next tested whether the mediation effect we found (mentalizing → inclusion of other in self → sharing) was driven by specific dimensions of mentalizing. We tested this possibility using study 3 data. We found that the significant mediation was driven by the positive valence and high emotionality (i.e., low rationality) conditions, which most robustly led to increased sharing in study 3, as well as the high introspection (i.e., low social impact) condition, which was significantly associated with increased sharing in study 2 (see Figure 4). In other words, we found that the indirect effects of prompting participants to consider how sharing would lead receivers to feel positively, affect receivers' tendencies to feel emotional, and lead receivers to focus inward on sharing through inclusion of other in self were significant compared to the control condition (see Figure 4), though the confidence intervals for the causal effects of the different sub-dimensions on inclusion of other in self were overlapping, and thus we do not make strong claims about differences between the sub-dimensions in this context.

Table 3. Study 1: Dimensions of Mentalizing on Sharing

Study	Variable	Estimate (SE)	t (df)	p
Study 1	Intercept	2.724 (0.198)	13.751 (7.165)	<.001

	Rationality (both)	0.278 (0.145)	1.920 (396)	0.056
	Social Impact (both)	0.332 (0.145)	2.294 (396)	0.022
	Valence (both)	0.244 (0.145)	1.686 (396)	0.093

ref level = control condition, n obs = 2000, groups: n participants = 400, n articles = 5

Table 4. Study 2: Components of Dimensions of Mentalizing on Sharing

Study	Variable	Estimate (SE)	t (df)	p
Study 2	Intercept	2.817 (0.183)	15.432 (6.705)	<.001
	Rationality High	0.142 (0.125)	1.131 (832)	0.259
	Emotionality High (Rationality Low)	0.385 (0.125)	3.073 (832)	0.002
	Social Impact High	0.187 (0.125)	1.490 (832)	0.137
	Introspection High (Social Impact Low)	0.322 (0.125)	2.571 (832)	0.010
	Valence Positive	0.413 (0.125)	3.299 (832)	0.001
	Valence Negative	0.097 (0.125)	0.772 (832)	0.441

ref level = control condition; n obs = 4195, groups: n participants = 839, n articles = 5

Table 5. Study 3: Components of Dimensions of Mentalizing on Sharing

Study	Variable	Estimate (SE)	t (df)	p
Study 3	Intercept	2.832 (0.199)	14.254 (4.346)	<.001
	Rationality High	0.089 (0.058)	1.532 (3245)	0.126
	Emotionality High (Rationality Low)	0.100 (0.058)	1.692 (3245)	0.091
	Social Impact High	0.030 (0.058)	0.513 (3245)	0.608
	Introspection High (Social Impact Low)	0.043 (0.058)	0.745 (3245)	0.457
	Valence Positive	0.231 (0.057)	4.027 (3245)	<.001
	Valence Negative	0.059 (0.058)	1.014 (3245)	0.311

ref level = control condition; n obs = 16260, groups: n participants = 3252, n articles = 5

Table 6. Aggregate Mean Effect Size (Study 2 and Study 3)

Study	Variable	Cohen's *d* [95% CI]	*z*	p
Study 2 and Study 3	Rationality High	0.071 [-0.044 -0.187]	1.21	0.226
	Emotionality High (Rationality Low)	0.112 [-0.003 – 0.227]	1.91	0.057
	Social Impact High	0.044 [-0.071 – 0.159]	0.75	0.455
	Introspection High (Social Impact Low)	0.072 [-0.043 – 0.188]	1.23	0.218
	Valence Positive	0.192 [0.078 – 0.307]	3.28	0.001
	Valence Negative	0.048 [-0.067 – 0.163]	0.82	0.414

ref level = control condition
Study 2: n obs = 4195, groups: n participants = 839, n articles = 5
Study 3: n obs = 16260, groups: n participants = 3252, n articles = 5

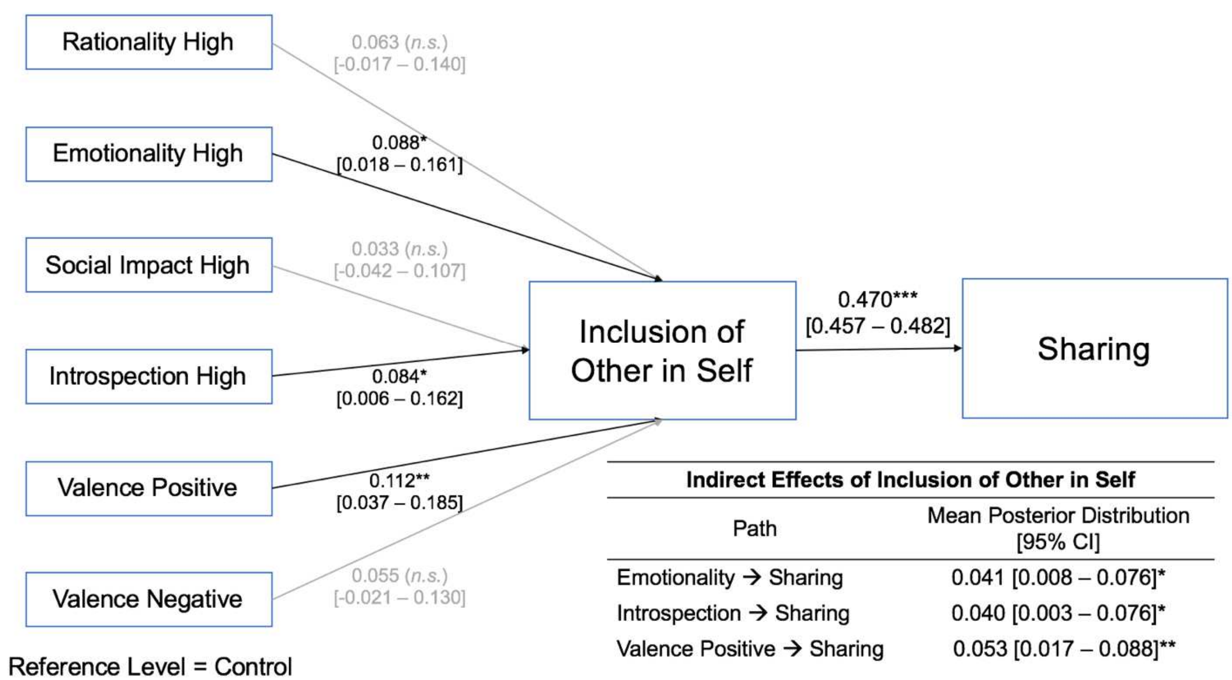


Figure 4. Mediation effect of inclusion of other in self is driven by emotionality high, introspection high, and valence positive conditions. **p* <.05, ***p* <.01

Discussion

In three pre-registered studies, the current investigation tested whether mentalizing causally leads to increased likelihood of information sharing, which dimensions drive this effect, as well as potential mechanisms that elucidate how mentalizing contributes to the value of sharing information. We found robust evidence that mentalizing causally increases sharing: instructing participants to consider the mental states of potential receivers generally led to increased likelihood of sharing. Our findings provide novel causal evidence extending previous findings showing that activity in the brain's mentalizing system is associated with sharing (Baek et al., 2017). Priming people to think about the minds of other people leads to a higher probability of interpersonal sharing. Our data shed light on the psychological processes that drive interpersonal sharing, one ubiquitous human behavior that serves to promote healthy social interactions (Baumeister et al., 2018; Berger, 2014) and is critical to the spread of ideas and behavior in society (Rogers, 2003).

Our findings also support an account of information sharing where mentalizing contributes to an overall value signal of information sharing by eliciting feelings of interpersonal closeness and bonding or by calling to mind close others with whom one could share. The link between mentalizing and sharing was significantly mediated by feelings of connectedness with potential receivers. This suggests that thinking about potential receivers' mental states might increase sharing by priming communicators to feel closer to potential receivers of their shared information, potentially by bringing to mind specific close others that they might share with, or opportunities to bond with receivers. Further, these effects were particularly strong when considering certain aspects of potential receivers' mental states: when participants considered how sharing information may lead receivers to feel positively, emotional, and focus inward, participants reported feeling closer to potential receivers, which in turn was associated with increased likelihood of information sharing. On the other hand, considering how sharing information may lead receivers to feel negatively, affect receivers' tendencies to think rationally, and make receivers think about their social relationships was not associated with feelings of closeness with receivers compared to the control condition, and did not lead to increased information sharing. Although we show a statistically significant indirect effect of mentalizing on sharing through feelings of closeness with receivers, it is also possible that mentalizing's effect on desire to share could have also made people feel closer to potential receivers. In other words, given that the relationship between inclusion of other in self and sharing is correlational, future studies that test the causal direction between feelings of closeness and sharing behavior can clarify the direction of this effect and contribute to broader theories on sharing behavior.

Findings are consistent with a value-based account of information sharing (Falk & Scholz, 2018; Scholz et al., 2017; Scholz & Falk, 2017; Tamir & Mitchell, 2012), suggesting that considerations of how sharing information may make receivers of shared information feel positively leads sharers to report feeling closer to potential receivers, which in turn is associated with increased likelihood of sharing. Specifically, thinking about how sharing information would lead receivers to feel positively may cause increased feelings of closeness because sharing information that leads to positive consequences for the receivers may also result in positive consequences for the sharer's relationships with the receivers. For instance, sharing information that will lead receivers to feel happy will likely lead them to look fondly upon the information sharer, leading to positive social consequences for the relationship between them (Berger, 2014). In turn, this suggests that information sharers may seek to share content that will cause receivers to feel positively because it can lead to positive social benefits for themselves and the relationship.

Further, considering how sharing may affect receivers' tendencies to feel emotional also led sharers to feel more connected with potential receivers, and indirectly led to increased sharing. These findings are consistent with the idea that social expression of emotions (i.e., expressing emotions and feelings with social ties) promotes feelings of connectedness and bonding that leads to social and individual well-being (Williams, Morelli, & Zaki, 2018). Thus, thinking about how sharing may lead receivers to feel emotional may lead sharers to anticipate potential opportunities to bond and feel closer, thereby increasing the social value of sharing, whereas thinking about how sharing may affect receivers' tendencies to make rational decisions may not lead to increased feelings of bonding compared to reflecting about the content of the article. Another possibility is that when sharers think about how sharing might lead receivers to feel emotional, they might default to thinking about positive (versus negative) emotional states of receivers, given the tendency for humans to overestimate the possibility of positive events in the future (i.e., optimism bias) (Sharot, 2011).

Findings suggest that considering how sharing would lead potential receivers to think introspectively, focus inward, and reflect internally also may invoke feelings of connectedness in information sharers, which in turn may lead to increased sharing. One possibility is that focusing on the individual mind of receivers leads sharers to individuate the mass audience of potential receivers, hence leading to increased likelihood of sharing, whereas focusing on receivers' social relationships leads to a deindividuation of potential receivers. Indeed, people are more other-focused when they consider sharing content with one other person (i.e., 'narrowcasting') compared to larger groups of people (i.e., 'broadcasting') (Barasch & Berger, 2014), and show greater engagement of the brain's mentalizing system during narrowcasting decisions compared to broadcasting decisions (Scholz et al., 2019). Thus, instructions to consider the individual-focused mindset of potential receivers may have led participants to consider specific potential receivers with whom they may be close to (i.e., stimulating the processes involved in narrowcasting), leading to increased sharing. We interpret these findings with some caution because although we found a direct effect of considering the introspective mental states of potential receivers on sharing in study 2, we found that only the indirect effect through feelings of connection with receivers in study 3, and the confidence intervals for these effects overlap. Future studies that investigate the nuances of considering different mental states of potential receivers and its relationship to sharing in other contexts may further elucidate the mechanisms involved.

Further of note, the effect size of mentalizing on sharing was smaller in study 3 compared to studies 1 and 2, potentially due to participants doing the Inclusion of Other in Self Task prior to making sharing decisions, which may have reduced the effects of the mentalizing manipulations (versus when participants were primed with specific mentalizing or control instructions and made sharing decisions immediately after). Although a comparison of the mean sharing intentions in control and mentalizing conditions across the 3 studies do not show large differences, in study 3, participants in the control condition were slightly more likely to share and participants in the mentalizing conditions were slightly less likely to share compared to participants in Studies 1 and 2 (see Appendix A). One possibility is that doing the Inclusion of Other in Self Task in between the mentalizing (or control) instructions and sharing decisions may have dampened the effects of the instruction for participants in the mentalizing conditions, while priming social thoughts in control participants. Additional follow-up may help clarify these possibilities.

Although we found that priming certain dimensions of mentalizing (i.e., positive valence, high emotionality, and individual focused) led to increased sharing compared to the control whereas other dimensions (i.e., negative valence, high rationality, and high social impact) did not, our data do not show fine-grained, sharp distinctions *between* the dimensions on sharing behavior. For instance, the confidence intervals of estimates for the effects of priming each dimension of mentalizing on sharing behavior largely overlap with one another. Thus, although some dimensions significantly lead to increased sharing compared to the control condition whereas others do not, the distinctions between the dimensions remain less clear, and instead we focus our conclusions primarily on the overall effect of mentalizing on sharing decisions. Future studies that test the distinctions between the dimensions may further precisely uncover the role of mentalizing in sharing.

Despite several strengths of our design for establishing causal effects of mentalizing on sharing, we also interpret the findings in light of limitations inherent in our design. First, explicit instructions to mentalize may have led to experimental demand, such that participants assigned to the mentalizing conditions inferred the purpose of the experiment and rated their sharing intentions accordingly. If this were the case, however, then we might have also expected that participants would share less when primed with thoughts about how sharing would lead potential receivers to feel negatively (compared to the control condition). However, across two studies, we did not see significant differences in participants' sharing intentions between the negative valence mentalizing and the control conditions, and although not statistically significant, the estimates for the negative valence mentalizing condition were directionally positive. Further, we observed some distinctions in the dimensions of mentalizing, with some dimensions leading to increased sharing compared to the control while others did not, suggesting that participants in the experimental conditions were likely not responding exclusively according to perceived demand. Future studies that manipulate mentalizing in more subtle ways, and specifically using manipulations that do not employ explicit instructions, would further strengthen our claims. Second, our data show that mentalizing causally increases sharing in the context of health news articles. It is unclear, however, whether these results would generalize in other contexts. For instance, it is possible that increased mentalizing while considering different types of information (e.g., highly controversial or negative information or information likely to evoke strong reactions) may not lead to increased sharing. Future studies that explore potential boundary conditions of our findings would provide additional nuance to the role of mentalizing in sharing behavior.

In conclusion, findings suggest that mentalizing causally increases the value of sharing through eliciting feelings of connectedness between the communicator and potential receivers of shared content. Specifically, considering how sharing may maximize the social value to the communicator leads to increased sharing, suggesting that sharing supports an inherent human motivation to pursue meaningful social connections (Baumeister & Leary, 1995; Baumeister et al., 2018). Findings advance theoretical understand of the mechanisms involved in decisions to share information, a ubiquitous human behavior. Findings further suggest that one potential intervention to increase interpersonal interactions may be as simple as getting people to think about other people's minds.

CHAPTER 3: STUDY 2 –THE INVOLVEMENT OF MENTALIZING AND VALUATION BRAIN NETWORKS IN SOCIAL INFLUENCE ON MESSAGE RECEIVERS

Introduction

Word of mouth recommendations are a powerful form of communication (Berger, 2014), influencing consumer decisions (Chevalier & Mayzlin, 2006), political mobilization (Bond et al., 2012), and the subjective value of objects and ideas in a wide range of contexts (Klucharev et al., 2009; Nook & Zaki, 2015; Zaki, Schirmer, & Mitchell, 2011). What takes place in the mind of receivers exposed to recommendations from peers, experts, and even strangers that determines whether the communicator's opinion spreads further? In the current study, we studied recommendations from peers as one source of social influence on behavior (Senecal & Nantel, 2004). Past research has suggested that assessing the value of different stimuli (i.e., subjective valuation) (Campbell-Meiklejohn, Bach, Roepstorff, Dolan, & Frith, 2010; Cascio, O'Donnell, et al., 2015; Klucharev et al., 2008; Nook & Zaki, 2015; Zaki et al., 2011) and understanding others' mental states (i.e., mentalizing) (Campbell-Meiklejohn et al., 2010; Cascio, O'Donnell, et al., 2015; Welborn et al., 2015) are key processes in adopting and propagating recommendations. These processes are associated with specific networks in the brain; the valuation system includes ventromedial prefrontal cortex (VMPFC) and ventral striatum (VS) (Bartra, McGuire, & Kable, 2013) and the mentalizing system includes portions of the medial prefrontal cortex (MPFC), particularly subregions in the middle and dorsomedial prefrontal cortex (MMPFC, DMPFC), as well as bilateral temporoparietal junction (TPJ), precuneus (PC/PCC), superior temporal sulcus (STS), and temporal poles (Dufour et al., 2013; C. D. Frith & Frith, 2006). We used neuroimaging and natural language classifiers: 1) to test the role of these neural systems in updating opinion in response to positive and negative recommendations, 2) to extend past results to a more naturalistic context (i.e., responding to real written recommendations with natural language text), and 3) to examine a new question about the extent to which these neural systems work together or independently to produce recommendation rating change in response to naturalistic recommendations.

Brain activity in the valuation system predicts successful social influence. Prior neuroimaging research has highlighted the involvement of the brain's valuation system in successful social influence, supporting the propagation of ideas between a communicator and a receiver (for reviews, see: Cascio, Scholz, & Falk, 2015; Falk & Scholz, 2018). Generally, the brain's valuation system, including the ventral striatum (VS) and the ventromedial prefrontal cortex (VMPFC), computes the subjective value of different types of stimuli, including primary (e.g., food) and secondary (e.g., social) rewards (Bartra et al., 2013). In the context of social influence on recommendations, the value system is implicated in tracking the value of different decision-relevant information over time, including the social rewards of being in alignment with a group (Campbell-Meiklejohn et al., 2010; Klucharev et al., 2008), positive valuation of the social recommendation and anticipated rewards of conforming (Campbell-Meiklejohn et al., 2010; Cascio, O'Donnell, et al., 2015; Welborn et al., 2015), and one's internal value of the stimuli (Klucharev et al., 2008; Nook & Zaki, 2015; Zaki et al., 2011).

In the context of online media platforms, people often encounter recommendations that are different from their own opinions and immediately update and share their own recommendations. In situations paralleling this online social context, the valuation signal in the brain tracks the value of peer recommendations, where greater activity in the valuation system is associated with receivers of influence conforming to peer recommendations, versus resisting peer influence (Cascio, O'Donnell, et al., 2015; Welborn et al., 2015). Extant neuroimaging studies whose timing most closely mirrors online recommendation contexts (in presenting recommendations and then recording participants' updated opinions immediately), however, have focused on adolescents (Cascio, O'Donnell, et al., 2015; Welborn et al., 2015). This makes it unclear whether these findings are specific to adolescents or more generally true of the process of incorporating peer feedback on recommendations in real time. In the current neuroimaging study, we tested this paradigm in a young adult sample. If the neural signal in the valuation system tracks the value of social recommendations and anticipated rewards of conforming, we hypothesized that increased activation in response to either positive or negative recommendations should track with the participant subsequently updating their opinion in line with peer recommendations.

Brain activity in the mentalizing system predicts successful information propagation. Prior studies of individual differences in recommenders also offer preliminary evidence suggesting the importance of the brain's mentalizing system for the successful propagation of ideas (for a reeview, see: Baek & Falk, 2018). Successful recommenders often show greater neural activity in the mentalizing system compared to less influential recommenders (Dietvorst et al., 2009; Falk, Morelli, Welborn, Dambacher, & Lieberman, 2013; Falk, O'Donnell, & Lieberman, 2012; c.f., chapter 4 of this dissertation). Furthermore, ideas that people want to share elicit greater activity in the mentalizing system (Baek, Scholz, O'Donnell, & Falk, 2017; Scholz et al., 2017; Falk et al., 2013). In parallel, receivers who are more persuadable to update their own recommendations also show greater mentalizing activity (Cascio, O'Donnell, et al., 2015), and increased brain activity in mentalizing regions during social feedback is associated with greater likelihood of conforming to peer opinions (Welborn et al., 2015). Greater activity in mentalizing regions is also observed in the processing of divergent peer influence, including when a receiver of social influence finds out that he or she is not in alignment with peer opinions (Campbell-Meiklejohn et al., 2010; Cascio, O'Donnell, et al., 2015). This finding suggests that the mentalizing system may enable the receiver to understand the recommender's intentions or point of view (Campbell-Meiklejohn et al., 2010; Cascio, O'Donnell, et al., 2015). Thus, the tendency to consider other people's mental states may be an important element in updating one's own initial opinion, and we expect that neural activity in the mentalizing system will track the successful spread of recommendations.

Our research also examines an open question in the literature about whether brain activity tracking social influence is sensitive to the valence of recommendations. Mentalizing may broadly aid in understanding others' viewpoints, tracking with opinion change in response to both positive and negative recommendations; alternatively, the mentalizing system may respond more strongly in situations where people are most likely to assess social consequences of their actions, such as in response to negative social evaluation (Bebbington, MacLeod, Ellison, & Fay, 2017; Falk et al., 2014; Vaish, Grossmann, & Woodward, 2013; Yoo, 2009). Behavioral evidence suggests that negative (versus positive) peer recommendations may lead to greater conformity (Cascio, O'Donnell, et al., 2015; Chevalier & Mayzlin, 2006). This 'negativity bias', or the idea that people exhibit greater sensitivity to negative information than positive information of equal objective polarity, has been observed across diverse fields (Rozin & Royzman, 2001). To this end, we tested whether the valence of peer recommendations influences the engagement of the valuation and mentalizing systems during recommendation propagation.

Does brain connectivity between valuation and mentalizing systems predict conformity or resistance to peer influence on recommendations? Although prior studies of recommendation behavior have focused on average neural activation within specific, separate brain regions (e.g., regions within the valuation and mentalizing systems), this does not provide insight about how different brain systems might coordinate to facilitate or suppress receptivity to persuasive influence. Therefore, we extend prior work by also examining the interplay between regions of the brain's valuation and mentalizing systems in recommendation propagation. We tested two competing hypotheses. One possibility is that increased coordination between activity between the brain's valuation and mentalizing systems in response to peer recommendations might be associated with greater recommendation rating change. If increased value placed on the peers' opinion leads to greater mentalizing, we anticipate greater connectivity between these systems leading to **more** recommendation-congruent opinion change. An alternative hypothesis is that increased coordination in activity between the brain's valuation and mentalizing systems in response to peer recommendations might be associated with *less* recommendation-congruent opinion change. If decreased value placed on the peers' opinion leads to suppression of mentalizing, we would also anticipate that greater connectivity between these systems would be associated with **less** recommendation-congruent opinion change. This would be consistent with past research on motivated reasoning (Kunda, 1990). Accordingly, recommendation rating change may be supported by decreased functional connectivity between the brain's valuation and mentalizing regions. To test these competing hypotheses, we used psychophysiological interaction (PPI) analysis (O'Reilly, Woolrich, Behrens, Smith, & Johansen-Berg, 2012) to compare functional connectivity between the brain's valuation and mentalizing regions when participants changed (vs. didn't change) their recommendations in response to peer recommendations.

The current study. Participants performed a modified version of the App Recommendation Task (Cascio et al., 2015; Figure 5) in which they learned about mobile game apps and then read real text of peer recommendations related to the apps while their brain activity was measured using neuroimaging (functional MRI, or fMRI). The task simulated real-life situations when people consider others' recommendations during decisions to consume and recommend a product to other people. Before the fMRI scan, participants rated their likelihood to recommend 80 mobile game applications based only on the information from the app developers, and then during the scan, approximately an hour later, participants read peer recommendations written by other users and could update their recommendation rating. The valence of the recommendations shown to participants was scored using a sentiment analysis tool (http://text-processing.com/api/sentiment/), where high scores indicated positivity and low scores indicated negativity. We calculated 'recommendation rating change' as being positive if participants changed their own recommendation ratings in the direction of the peer recommendations (i.e., became more positive in response to positive reviews or more negative in response to negative reviews).

Unlike other studies of processes involved in the integration of social influence at a time point after the influence has taken hold (Klucharev et al., 2009, 2008; Nook & Zaki, 2015), our paradigm also allowed us to test the neural and psychological processes that are implicated in the current online recommendation context, where people are exposed to peer opinions and then update their own recommendations in real-time. Further, we used written recommendations from a separate group of participants, which more closely reflects real-life social influence contexts and a richer, naturalistic measure of social influence. Collectively, our approach allowed us to test the role of the valuation and mentalizing systems in recommendation propagation, and how the valence of peer endorsements may modulate such effects. In a novel contribution to the field of neuroscience of communication and social influence, we also tested whether functional connectivity between the valuation and mentalizing systems is associated with recommendation propagation.

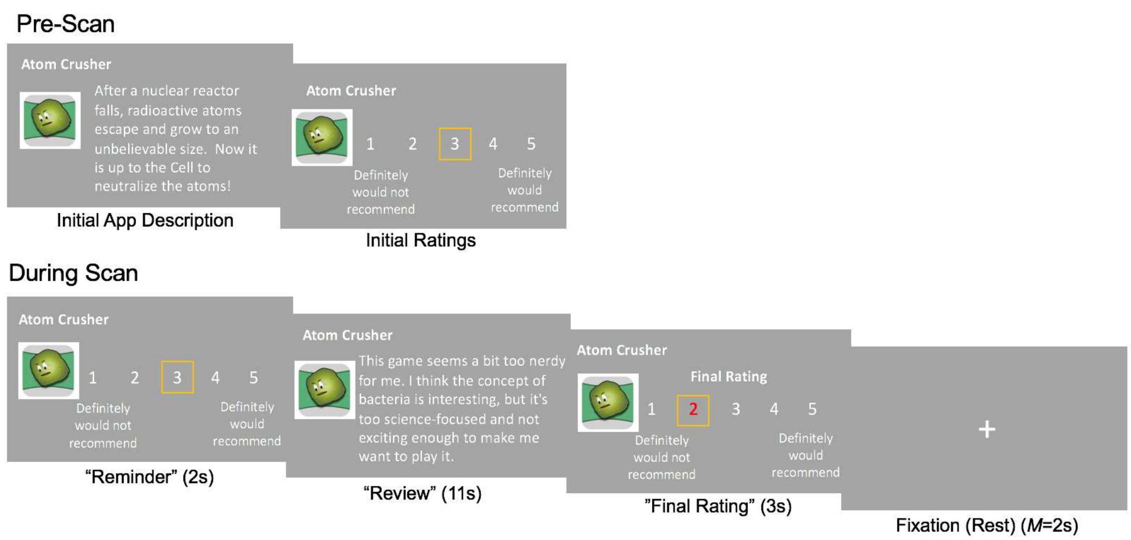


Figure 5. Task Schema

Before the scan, participants saw descriptions of 80 mobile game apps and provided initial ratings of their likelihood to recommend each app to others. In the scanner, participants were first reminded of their initial recommendation ratings. Then, they read peer recommendations about each of the 80 mobile game apps. Recommendations ranged in valence, with some being positive and others negative. During the final rating period of the scan, participants had the opportunity to update their recommendation ratings based on the peer feedback.

Materials & Methods

Participants. Forty participants (28 females) between the ages of 18 and 24 (M = 20.9, SD = 2.1) were recruited for a single three-hour study appointment, incorporating a one-hour fMRI scan. The fMRI scan was obtained as part of a larger study that included another task. In the current paper, we focus on a single task (the App Rating Task) that spanned 3 runs. All participants gave informed consent in accordance with the procedures of the Institutional Review Board of the University of Pennsylvania. Participants met standard fMRI eligibility criteria, including being right-handed, not currently taking any psychoactive medications, no history of psychiatric or neurological disorders, not currently pregnant, no metal in their body contraindicated for MRI, and not suffering from claustrophobia. All runs from one participant and run 3 from three participants were excluded due to data corruption. Further, all runs from one participant and one run from one participant were excluded due to excessive movement. This resulted in thirty-eight participants included for analysis, with partial data from four participants.

Procedure. Participants completed the first part of a modified version of the App Recommendation Task (Cascio, O'Donnell, et al., 2015) outside of the scanner, before the fMRI scan. They read the title, logo, and brief description of 80 mobile game applications taken from the iTunes App Store and indicated their initial likelihood of recommending ('initial recommendations') each game app. In the second part of the task, which took place inside the MRI scanner, participants reviewed the same 80 mobile game apps. For each mobile game app, participants were first shown the title and logo of each game and reminded of their initial recommendation rating for 2 seconds ('reminder period'). Then, the participants read a short recommendation of the game app that they were (truthfully) told was written by their peers (M = 32.4 words, SD = 7.2 words) for 11 seconds ('review period'). The peer recommendations were written by a separate group of participants that were similar in demographics to the current study (N = 43, age M = 22.1) as part of an earlier study. We used text written by a separate group of participants to maximize external validity of the recommendations, reflecting real-life situations that young adults are likely to experience as they contemplate online peer recommendations. Each participant read peer recommendations for 80 mobile game apps, each from one of two randomly assigned peer reviewers (one recommendation per app; 40 total recommendations per recommender). After reading each peer recommendation, participants had 3 seconds to provide a final rating of their own likelihood to recommend the game app ('final rating period'). See Figure 5 for an illustration of the task design.

fMRI Image Acquisition. Neuroimaging data were acquired using 3 Tesla Siemens scanners[1]. Three functional runs were acquired for each participant (500 volumes per run). Functional images were recorded using a T2*-weighted reverse spiral sequence (TR = 1500 ms, TE = 25ms, flip angle = 70°, -30° tilt relative to AC-PC line, 54 axial slices, FOV = 200 mm, slice thickness = 3mm; voxel size = 3.0 x 3.0 x 3.0 mm, order of slice acquisition: interleaved) and high-resolution T1-weighted images (MPRAGE; TI = 1110 ms, 160 slices, FOV = 240 mm, slice thickness = 1 mm, voxel size = 0.9 x 0.9 x 1 mm) and in-plane, structural, T2-weighted images (slice thickness = 1 mm, 176 sagittal slices, voxel size = 1 mm x 1 mm x 1 mm) in-place with the BOLD images for use in coregistration and normalization.

Sentiment Analysis. Each peer recommendation that participants read was scored using a sentiment analysis API (http://text-processing.com/api/sentiment/) on a continuous measure of positive to negative sentiment, with the highest score indicating the highest amount of positivity (sentiment=1.0) and the lowest score indicating the highest amount of negativity (sentiment =0.0). For example, the recommendation "This game sounds awesome" receives a positive probability score of 0.7, whereas the recommendation "This game sounds terrible" receives a positive probability score of 0.2 (see Table 7 for additional examples). These probability scores from the machine learning classifier represent the conditional probability of the recommendation being positive based on the features occurring in the text.

---

[1]Due to scheduling issues at our scanner center, 33 participants were scanned on a TIM Trio scanner, and the remaining 7 on a Prisma scanner. Models controlling for scanner type showed no significant or meaningful differences from those reported.

Table 7. Example of peer recommendations and their sentiment scores

Peer Recommendation	Sentiment Score
This game was one of the most boring games I have ever played. The idea is not original and the graphics are not what they could be at all. I would save your time.	0.10
This bear can only move while touching blocks; so be sure to get rid of all the circles and triangles so she can freely move along to the next level!	0.50
In this game you are on a fantastical journey to release a dragon from a book. It is a unique premise and is definitely entertaining. Original and fun.	0.82

Human Coding. To validate the sentiment scores from the machine learning classifier, each peer recommendation was also scored by human coders recruited on Amazon's Mechanical Turk. Each recommendation was rated by 3 human coders on a 0-100 scale (0=most negative; 100=most positive) with high interrater reliability (Krippendorff's alpha = 0.738).

Behavioral Data Analysis. To investigate whether peer recommendations influenced participants to change from their initial recommendation rating, we ran a multi-level linear model in R (R Core Team, 2014) using the *lme4* (Bates, Maechler, Bolker, & Walker, 2014) and *lmerTest* (Kuznetsova et al., 2014) packages. We defined recommendation rating change as being positive (+1) if the participant changed their initial ratings in the direction of the sentiment of the peer recommendation, negative (-1) if the participant changed their initial ratings away from the sentiment of the peer recommendation, and zero (0) if participants did not change their ratings. For this purpose, peer recommendations were classified into binary categories as either "positive" or "negative" by using the probability scores produced by the sentiment analysis; if the classifier indicated that the recommendation was more likely to be positive than negative, then it was categorized as positive (and vice versa). Thus, if participants changed their initial recommendation of a "5" to a final recommendation rating of a "3" after reading a peer recommendation that was classified as "negative", then the recommendation rating change was calculated as "1". To determine the relationship between peer recommendation sentiment scores and participants' recommendation rating change, we ran a multi-level linear regression predicting the participants' recommendation rating change from the sentiment scores of the peer recommendations. Participants were treated as random effects with intercepts allowed to vary randomly, accounting for non-independence in the data due to repeated measures from each participant.

Imaging Data Analysis. Functional data were pre-processed and analyzed using Statistical Parametric Mapping (SPM8, Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK). To allow for stabilization of the BOLD (blood oxygen level dependent signal), the first five volumes (7.5s) of each run were not collected. Functional images were despiked using the 3dDespike program as implemented in the AFNI toolbox (Cox, 1996). Next, data were corrected for differences in the time of slice acquisition using sinc interpolation, with the first slice serving as the reference slice (using FSL Slicetimer; Sladky et al., 2011). Data were then spatially realigned to the first functional image. Next, in-plane T2-weighted images were registered to the mean functional image. Next, high-resolution T1 images were registered to the in-plane image (12 parameter affine). After coregistration, high-resolution structural images were segmented into gray matter, white matter, and cerebral spinal fluid (CSF) to create a whole brain mask for use in modeling. Masked structural images were normalized to the skull-stripped MNI template provided by FSL ("MNI152_T1_1mm_brain.nii"). Finally, functional images were smoothed using a Gaussian kernel (8mm FWHM).

Regions of Interest Analysis. To investigate the relationship between neural activity as participants read peer recommendations and made decisions to update their own recommendations, we conducted a series of analyses using neural activity extracted from *a priori* regions-of-interest (ROI). To understand the relationship between participants' recommendation rating change and brain regions implicated in valuation and mentalizing, we used Neurosynth

(Yarkoni et al., 2011) to retrieve “association test” meta-analytic maps of the functional neuroimaging literature on “value”, which consisted of subregions in the striatum and ventral medial prefrontal cortex (VMPFC) (see Figure 6), and “mentalizing”, which consisted of subregions in the middle and dorsal medial prefrontal cortex (MMPFC, DMPFC), bilateral temporoparietal junction (TPJ), precuneus (PC/PCC), middle temporal gyrus (MTG) (see Figure 7).

Figure 6. Brain regions associated with “value”, as identified through Neurosynth.

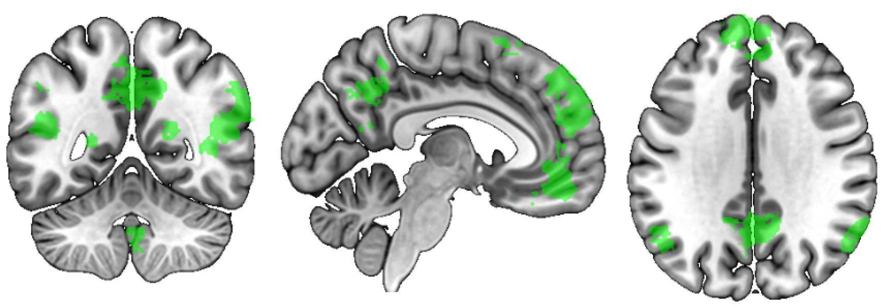


Figure 7. Brain regions associated with “mentalizing”, as identified through Neurosynth.

Task and Item-Based Analyses. Data were modeled using the general linear model as implemented in SPM8. For each trial, the review (11 s) and final rating (3 s) periods were modeled together, since participants were incorporating peer recommendations to inform their final recommendation ratings during both periods. All models included six rigid-body translation and rotation parameters derived from spatial realignment as nuisance regressors. Low-frequency noise was removed using a high-pass filter (128 s). We constructed individual models for each subject in which the review and final rating periods for each mobile game app were treated as separate regressors in the design matrix (i.e., an item-based model) using SPM8. Reminder periods across trials were modeled using one regressor of no interest. Fixation periods (i.e., rest periods) served as an implicit baseline. Neural activity in our mentalizing and valuation ROIs was extracted for each mobile game app at the individual level, and percent signal change was calculated by dividing mean task activity by the baseline/rest period. For each participant, the extracted percent signal change was mean centered across the mobile game apps.

Combining Mean Brain Activity and Behavior Data. In order to understand the relationship between brain activity and sentiment of peer recommendations, and participants' recommendation rating change, we ran linear mixed effects models in R (R Core Team, 2014) using the *lme4* (Bates et al., 2014) and *lmerTest* (Kuznetsova et al., 2014) packages. Participants and mobile game app were treated as random effects with intercepts allowed to vary randomly, accounting for non-independence in the data due to repeated measures from each participant and mobile game app.

First, to examine whether neural activity was influenced by the sentiment of peer recommendations participants received in the scanner, we ran multi-level linear regression models predicting participants' percent signal change in each of our ROIs from the sentiment scores, including random intercepts for participant and app (mean brain activity = b_0 + $b_1$sentiment + (1|participant_ID) + (1|app_number) + ϵ_i).

Next, to determine the relationship between brain activity and participants' recommendation rating change, we ran additional multi-level linear regressions predicting participants' recommendation rating change from neural activity extracted as percent signal change from each of our ROIs per mobile game app, including random intercepts for participant and app (recommendation rating change = b_0 + $b_1$brain activity + (1|participant_ID) +

(1|app_number) + $\epsilon_{i,}$ where "brain activity" represents activity in the target regions of interest, with separate models run for mentalizing and valuation systems).

Finally, to determine whether the effects of brain activity on recommendation rating change were particularly driven by positive or negative recommendations, we tested the interaction between brain activity and sentiment to predict recommendation rating change, including random intercepts for participant and app (recommendation rating change = b_0 + $b_1$brain activity + $b_2$sentiment + $b_3$brain activity*sentiment + (1|participant_ID) + (1|app_number) + ϵ_i, where "brain activity" represents activity in the target regions of interest, with separate models run for mentalizing and valuation systems). For these analyses, we mean centered the sentiment variable (i.e., so that 0 = neutral sentiment). As previously noted, the brain activity variables were mean centered within each participant for all analyses.

Whole Brain Analysis. We also conducted exploratory whole brain analyses to examine whether additional regions were associated with recommendation rating change. We constructed models for each individual participant examining brain activity during the review and final rating screens for the main contrast of interest, when participants changed their recommendation ratings to be congruent with peer recommendations (ratingCHANGE) versus when participants did not change their recommendation ratings (NOratingCHANGE). We then averaged across these individual level maps in a random effects analysis at the group level. Images were thresholded at $p < .05$, corrected for false discovery rate using the nilearn and nistats packages in Python 2.7 (Abraham et al., 2014). All coordinates are reported in MNI space.

Psychophysiological Interaction (PPI) Analysis. We next tested the relationship between functional connectivity between neural activity in the brain's valuation and mentalizing systems and recommendation rating change. We used psychophysiological interaction (PPI) analysis (O'Reilly et al., 2012). PPI tests the hypothesis that brain activity in one region (e.g., mentalizing system) can be explained by the interaction between brain activity in another region (e.g., valuation system) and a cognitive process (e.g., accepting vs. resisting peer influence).

Accordingly, we used PPI to compare the strength of functional connectivity between the brain's mentalizing and valuation systems when participants changed their recommendation ratings to be congruent with peer recommendations (ratingCHANGE) versus when participants did not change their recommendation ratings (NOratingCHANGE). We used the same valuation region of interest as defined above for the mean activation analyses as the seed region. Using the SPM generalized PPI toolbox (McLaren, Ries, Xu, & Johnson, 2012), time courses in the seed region were extracted, averaged, and deconvolved with the canonical HRF using the deconvolution algorithm in SPM8 for each participant. Then, the time course in the seed region was multiplied by the behavior variable of interest (ratingCHANGE vs NOratingCHANGE), and this resulting time course was re-convolved with the canonical HRF. The PPI model also included 6 motion parameters as nuisance regressors of no interest. The group-level model was then created by combining first-level contrast images using a random effects model. Finally, average parameter estimates of functional connectivity between the seed (i.e., valuation) region and target mentalizing region of interest were extracted at the group level.

Results

Our analysis examined whether the brain's mentalizing and valuation systems could account for variability in changing participants' own recommendations in response to peer recommendations. We related mean brain activity in the valuation and mentalizing systems to a) the sentiment of the peer recommendations, b) whether participants changed their original recommendations after reading peer recommendations (i.e., recommendation rating change), and c) the interaction of the mean brain activity in the valuation and mentalizing systems with the sentiment of the peer recommendations to predict recommendation rating change. We then also tested whether functional connectivity between the valuation and mentalizing systems is associated with increased or decreased likelihood of recommendation rating change.

Sentiment Classifier and Human Coding. We first compared our machine learning classifier sentiment scores with the human coded sentiment scores to validate our measure. The two measures were significantly correlated (r = 0.611, t (2930) = 41.802, p <.001), suggesting that our use of the machine learning classifier is reasonable. We focus on results using the machine learning classifier measure of sentiment because this measure is scalable in the online environment and reproducible, but analogous analyses using the human coded measures of sentiment produce similar results (see Appendix B), thereby increasing our confidence in the machine classifier and validating our approach.

Recommendation Rating Change and Sentiment. We then checked whether the sentiment of the peer recommendations influenced whether participants changed their own initial recommendations. Participants changed their initial recommendations 43.12% of the time, primarily in alignment with the sentiment of the peer recommendations; that is, participants changed their initial recommendations to be more positive when they read peer recommendations higher in positivity and vice versa (effect of positivity vs. negativity on the direction of opinion change in a multilevel model accounting for non-independence due to repeated observations from participants and mobile game app: B = 1.064, t (2784) = 12.493, p <.001). In addition, such effects were greater for peer recommendations higher in negativity than positivity, with participants more likely to change their initial recommendation toward that of their peers after reading recommendations higher in negativity (effective of positivity vs. negativity on likelihood to change opinion in a multilevel model accounting for non-independence due to repeated observations from participants and mobile game app: B = -0.450, t (2160) = -6.928, p < 0.001). Thus, both positive and negative peer recommendations significantly and robustly affected participants' final ratings; further, recommendations that were more negatively framed had the greatest influence in changing the initial recommendation of participants, suggesting that negativity may propagate more strongly than positivity in this context.

Mean Brain Activity and Sentiment of Recommendation. We next examined whether neural activity in the valuation and mentalizing systems was correlated with the sentiment of the peer recommendations. Results indicated that mean activity in the mentalizing regions, but not valuation regions, was increased when participants were considering peer recommendations that were higher in negativity (mentalizing: B = -0.063, *t* (2234) = -2.121, *p* = 0.034; valuation: B = 0.016, *t* (2930) = 0.598; *p* = 0.550). Thus, the more that a peer recommendation conveyed negative sentiment about the mobile game app, the greater the engagement of the mentalizing system. By contrast, positive and negative reviews were equally likely to change activity in the valuation system.

Mean Brain Activity and Recommendation Rating Change. We next examined whether neural activity in the valuation and mentalizing systems changed during trials where participants updated their initial recommendation ratings to align with their peers. Increased mean activity in the valuation and mentalizing regions was associated with a significantly higher likelihood that participants changed their ratings to align with the peer recommendation (valuation: B = 0.115, *t* (2769) = 2.696; *p* = 0.007; mentalizing: B = 0.083, *t* (2770) = 2.096, *p* = 0.036). Thus, the more a written peer recommendation engaged activity in the valuation and mentalizing regions of the brain, the more likely participants were to update their initial recommendations about the mobile game app to align with that recommendation. We did not observe any interaction between the sentiment of the review and neural activity in the valuation system in predicting recommendation rating change (see Table 8), suggesting that the value signal was equally indicative of whether a participant would change their initial recommendation to be consistent with the peer recommendation for both positive and negative reviews. In the mentalizing system, however, we observed a marginally significant interaction between the sentiment of the review and brain activity (see Table 9), such that increased response in mentalizing regions to negative recommendations resulted in greater opinion change (simple effect of mentalizing on recommendation rating change for negative peer recommendations: *B* = 0.129; *t* (1659) = 2.763; *p* = 0.006), but not in response to positive peer recommendations (simple effect of mentalizing on recommendation rating change for positive peer recommendations: *B* = -0.008; *t* (1075) = -0.119; *p* = 0.905).

Table 8. Predicting participants' congruent recommendation rating change from mean activity in valuation regions, sentiment of peer recommendations and their interaction (positive coefficients indicate greater change in the direction of the recommendation).

Predictor	*B*	*t*	*df*	*p*
Intercept	0.145	7.088	41.01	<.001***
Valuation	0.123	2.897	2764	0.004**
Sentiment	-0.087	-7.008	2163	<.001***
Valuation*Sentiment	0.027	0.634	2780	0.526

**p* <.05, ***p* <.01, ****p* <.001

Table 9. Predicting participants' congruent recommendation rating change from mean activity in mentalizing regions, sentiment of peer recommendations and their interaction (positive coefficients indicate greater change in the direction of the recommendation).

Predictor	*B*	*t*	*df*	*p*
Intercept	0.144	7.120	40.644	<.001***
Mentalizing	0.076	1.865	2766	0.062†
Sentiment	-0.085	-6.845	2158	<.001***
Mentalizing*Sentiment	-0.065	-1.669	2785	0.095†

†p <.10, *p <.05, **p <.01, ***p <.001

Whole Brain Analysis. Next, we performed a whole brain analysis to explore whether regions outside of the valuation and mentalizing ROIs were associated with recommendation rating change. Our whole brain analysis showed that brain regions that overlap with our main mentalizing and value ROIs were associated with congruent recommendation rating change, in addition to regions outside of these focal ROIs, noted in Table 10 and Figure 8.

Table 10. Whole brain associations of neural activity associated with congruent recommendation rating change, thresholded at p<.05, FDR corrected.

Region	MNI coordinates				
	x	*y*	*z*	Number of voxels (*k*)	*t* (37)
Inferior Parietal Lobule (Bilateral)	42	-42	49	5558	7.688
Precuneus/Posterior Cingulate Cortex (Right)	-30	-58	55	--	7.585
Precuneus/Posterior Cingulate Cortex (Left)	30	-70	58	--	7.060
Dorsomedial PFC (Bilateral)	12	29	58	1005	5.709
Orbitofrontal/ventromedial PFC	12	62	-23	39	4.354
Caudate (Bilateral)	-12	2	16	433	6.100
Dorsolateral PFC (Right)	51	47	-5	135	4.911
Dorsolateral PFC (Left)	-54	44	-5	64	4.275
Cerebellum (Bilateral)	-39	-58	-44	300	3.864

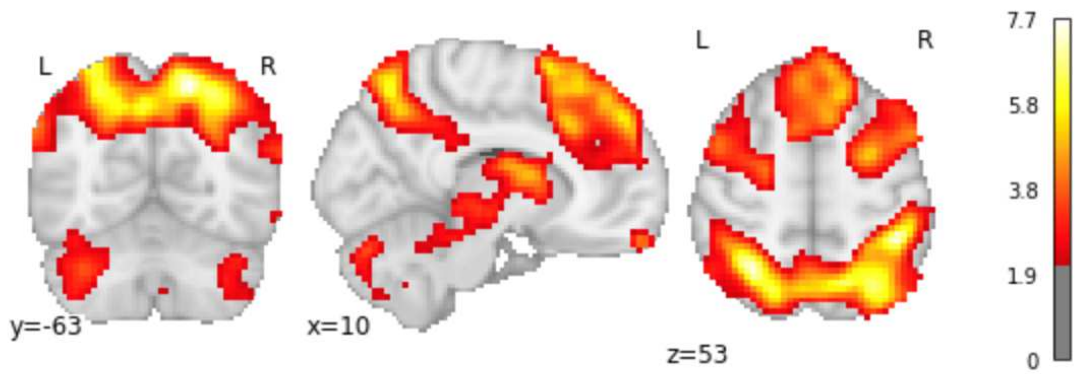


Figure 8. Whole brain map of regions associated with congruent recommendation rating change

Functional Connectivity and Recommendation Rating Change. We next examined whether functional connectivity between regions of the brain's valuation and mentalizing systems was associated with increased or decreased likelihood of recommendation rating change to align with peers. Results using PPI with our valuation regions of interest as a seed indicated that greater connectivity between the brain's valuation and mentalizing systems was associated with decreased likelihood of recommendation rating change to align with peers (t (32) = -2.111, p = 0.043). In other words, recommendation rating change was associated with less correlation in activity between the brain's valuation and mentalizing systems.

Discussion

Results of the current study highlight the robust involvement of the brain's valuation system in tracking and incorporating social influence on recommendations, in situations analogous to online recommendations made in the current media environment. Increased brain activity in hypothesized valuation regions as participants read naturalistic peer recommendations was associated with recommendation rating change to conform with peer opinions. This did not differ by the sentiment of the social influence. Thus, in this context, the brain's valuation system tracked the value of the peer recommendation, such that increased valuation activity was associated with greater likelihood of recommendation congruent change. Further, findings suggest that brain systems that support considering others' mental states are important in incorporating peer recommendations to inform one's own recommendations, and that this effect is particularly driven by negatively framed peer recommendations. We also show novel evidence that suggests that decreased connectivity between valuation and mentalizing is associated with recommendation rating change (i.e., increased connectivity between valuation and mentalizing is associated with resistance to peer influence). One possibility is that a devaluation of the peer recommendation might lead to a suppression of the mentalizing system, which in turn leads to less recommendation-congruent change. In other words, the brain's value and mentalizing regions may operate relatively independently when people incorporate others' opinions to update their own recommendations, and work in a more coordinated manner to resist peer influence.

The Role of Valuation in Social Influence. Using an externally valid paradigm of peer influence on recommendations in the online media context (Cascio, O'Donnell, et al., 2015), we found that increased mean activity within the brain's valuation regions as participants incorporated peer recommendations in real-time is associated with greater recommendation rating change to conform with peer recommendations. This aligns with prior research on peer recommendations in adolescents showing that mean activity in regions of the brain's valuation system during peer feedback is associated with likelihood to conform to peer influence (Cascio, O'Donnell, et al., 2015; Welborn et al., 2015). We extend these findings to suggest that these effects are not specific to adolescents, but general to a young adult sample, and to a context with more complex, natural language recommendations (rather than sparser information about peer opinions).

We did not observe a significant interaction between the sentiment of the recommendation and activity in the brain's valuation system to predict recommendation rating change. This finding suggests that, in this recommendation paradigm, the value signal tracked the value of the peer recommendation when receivers of influence were first exposed to peer opinions and actively made decisions to update their own opinions. In contrast to studies showing that the value signal tracks whether a receiver's initial opinion is in line with the peer influence, such that greater activity is associated with already agreeing with peers (Klucharev et al., 2009, 2008; Nook & Zaki, 2015), we find that greater activity in the value system seems to track likelihood to change opinions to come into alignment with peers. This difference may arise from the timing of the feedback. The studies where the valuation system tracks the congruence in opinion (Klucharev et al., 2009, 2008; Nook & Zaki, 2015) have collected receivers' initial opinions and provided peer feedback directly following, but then collected final ratings in a later session (e.g., one hour later); in contrast, studies consistent with our finding that valuation activity positively tracks whether participants choose to conform to peer influence (Cascio, O'Donnell, et al., 2015; Welborn et al., 2015), the initial product ratings have been collected before the fMRI scan, and then approximately an hour later the peer influence takes place and final ratings are made directly after learning the peer opinion. Taken together, these data suggest that the valuation system may serve a different role depending on the relative timing of peer influence and the receiver's own ratings. This is relevant to the current online social environment where receivers read reviews and immediately post their own recommendations, which is similar to the current paradigm. Our result augments a growing body of literature that examine social influence in contexts that more closely resemble online recommendation platforms (e.g., Yelp, Amazon), suggesting the valuation signal tracks the value of the peer recommendation in this context (Cascio, O'Donnell, et al., 2015; Welborn et al., 2015).

The Role of Mentalizing in Social Influence. We found that the mean activity in the brain's mentalizing regions while participants considered and incorporated peer recommendations was associated with recommendation rating change. These findings corroborate previous research showing that mean activity in regions of the brain's mentalizing system is implicated in processing of divergent social feedback (Cascio, O'Donnell, et al., 2015; Welborn et al., 2015), and showing that receivers of influence who display greater mean mentalizing activity are also more likely to change their opinion toward that of peer influence (Cascio, O'Donnell, et al., 2015).

We observed a marginally significant interaction between the sentiment of the recommendation and activity in the brain's mentalizing system to predict recommendation rating change, suggesting that the brain's mentalizing system may be recruited more strongly in situations where social consequences are the most salient, such as those that may signal negativity. Our data are consistent with research on negativity bias which suggests that across diverse domains, people are more sensitive to negative than positive information (Rozin & Royzman, 2001); for instance, negative recommendations have greater impact on consumer behavior than positive recommendations (Chevalier & Mayzlin, 2006), and negative information more robustly affects formations of social impressions (Klein, 1991; Shaw & Steers, 2000). Our data extend these findings to suggest that people show increased neurocognitive and behavioral sensitivity to recommendations that express negativity about an entity, with negative recommendations invoking more thoughts about the social implications of one's own opinion. Given the importance of social coordination in humans (Baumeister & Leary, 1995; Baumeister et al., 2018), the increased mentalizing response is consistent with the idea that people may find negative recommendations as more socially important or relevant. Indeed, activity in the brain's social pain and mentalizing regions during social exclusion is associated with greater vulnerability to social influence (Falk et al., 2014), and negative information is preferentially propagated over positive information in social contexts (Bebbington et al., 2017). These findings are interpreted with caution given that the interaction effect was marginal, but together our findings corroborate an account of social influence where negatively framed information may be thought to be more socially salient and lead to greater conformity to social influence.

Additional regions involved in social influence. Although our primary analyses focused on a priori defined regions of interest in the value and mentalizing systems, we also conducted a whole-brain exploratory analysis to identify whether regions outside of the value and mentalizing regions might track opinion change as well. In this analysis, in addition to observing robust activations in parts of the value and mentalizing systems, we also observed activation in the inferior parietal lobule, lateral prefrontal cortex, and the cerebellum. These regions may be worth future investigation given their association with recommendation rating change.

Greater connectivity between value and mentalizing regions is associated with less opinion change. In a novel contribution, we also examined whether and how valuation and mentalizing regions in the brain might coordinate to respond to peer recommendations. Our data are consistent with the idea that decreased valuation of the peer recommendation in situations where participants ultimately did not change their recommendations are associated with decreased mentalizing activity. One possibility is that the negative valuation of peer recommendations leads to motivated suppression of the mentalizing system (i.e., resistance to peer influence may involve motivated attention away from the recommender's views). By contrast, when receivers of influence **do** update their own recommendations in response to peer influence, the valuation and mentalizing signals operate relatively independently. This is consistent with past research showing that the flexibility of VMPFC, a sub-region of the brains' valuation system. (i.e., the degree to which VMPFC coordinates with different brain networks) is associated with greater message-congruent behavior change (Cooper et al., 2018). Taken together, it is possible that a dynamic VMPFC signal may support the mechanisms necessary to flexibly incorporate the value of new information and in decisions to whether update one's own opinion or behavior. Our results build on and extend these findings to suggest that VMPFC and the value response being more consistently connected to mentalizing activity is associated with less behavior change. Additional work that further examines brain network connections will help paint a more complete picture of the neural mechanisms that support social influence.

In conclusion, our data suggest that brain systems that support processing the value of different entities and understanding others' mental states are important in leading to recommendation rating change as a result of social influence in a context that mirrors the new media environment. We used real text-based recommendations and tracked how participants' brains responded to peer feedback in real time to update their immediate recommendations. Further, we examined whether and how the sentiment of the recommendations interacted with key brain processes to influence recommendation change. We found that the relationship between mentalizing and recommendation rating change was marginally stronger for recommendations that are negative than positive, suggesting that valence may be an important factor to consider in future studies of social influence. We further highlight the value of investigating the functional connectivity between these regions in the brain. Our data support an account of social influence that suggest that devaluation of the peer recommendation leads to suppression of the mentalizing system, leading to less likelihood of recommendation rating change. These results inform how recommendations propagate and the neurocognitive dynamics and features of recommendations that are important to this process.

CHAPTER 4: STUDY 3 – INDIVIDUAL DIFFERENCES IN MENTALIZING AND SUCCESSFUL PERSUASION

Introduction

What makes certain people better at influencing others and more likely to be aligned with their receivers' preferences, leading these individuals to be successful in propagating their ideas? The current study seeks to understand neural variables that lead people to be successful communicators. Although extant studies have suggested that social considerations may distinguish successful persuaders from their less successful counterparts (for a review, see: Baek & Falk, 2018), only a small body of literature has used neuroimaging to uncover the neural and psychological processes that distinguish successful persuaders (Dietvorst et al., 2009; Falk et al., 2013). The current study tests a neural account of individual differences in tendencies to consider other people's mental thoughts, or mentalizing, as one potential variable that results in greater synchrony of preferences between communicators and their receivers. However, in this chapter, we do not find support for this hypothesized relationship.

Behavioral evidence from psychology, marketing, and network sciences suggests that successful communicators are distinguished by a greater focus on social factors. For instance, effective salespeople have greater levels of empathy and emotional intelligence, with an ability to better tailor their sales pitches to individual customers' needs (Franke & Park, 2006; Limbu et al., 2016). Further, individuals who are more successful at communicating their ideas also tend to occupy social network positions that promote opportunities to take the perspective of others, for example by connecting to others who don't know one another and might have differing perspectives (Bolander, Satornino, Hughes, & Ferris, 2015; Burt, 2004). Findings from the small body of research that have linked individual differences in neural activity in persuaders to communication success suggest that people who are better at getting others to adapt their ideas to conform to the communicator's preferences are distinguished by higher activity in one region of the mentalizing system (rTPJ) when first considering the ideas (Falk et al., 2013). Likewise, professional salespeople with higher work performance also show greater engagement of parts of the brain's mentalizing system, including MPFC and TPJ (Dietvorst et al., 2009). Further, non-human primates have brain systems that specialize in social processing (Sliwa & Freiwald, 2017; Tremblay, Sharika, & Platt, 2017), and the structure and function of these structures are associated with the social status of individual primates (Noonan et al., 2014; Tremblay et al., 2017).

The current study tests this account of mentalizing as one possible neural mechanism that may distinguish communicators who achieve greater synchrony with their receivers. Specifically, the current study tests whether people who are better at getting others to see the value of re-sharing information (i.e., sharing preference synchrony) also show greater engagement of brain activity within the mentalizing system when considering whether to share content. Brain activity was observed as participants ("communicators") actively considered and thought about the message they would generate to share news articles with other study participants ("receivers"). Subsequently, these messages were seen by other participants ("receivers").

In the current study, we focused on each communicators' ability to achieve preference coupling in information sharing with their receivers; that is, the ability to get others to value sharing the same information. Preference coupling was operationalized in two different ways: correlations between communicators and receivers in perceived benefits of sharing and correlations in intentions to share. For one, people share information with others because they believe it will lead to valuable outcomes, such as opportunities to socially bond and connect with others (Berger, 2014; Study 1 of this dissertation). A communicator's ability to effectively convince a receiver of the potential benefits of sharing the same information with another receiver is one form of influence that can impact the spread of information down the communication chain (e.g., getting the receiver to see the value of sharing a piece of information can lead to actual sharing behavior, which in turns results in successful information propagation). Further, greater similarity in perceived benefits of sharing between communicators and receivers has been associated with greater similarity in neural activity, suggesting that achieving this correlation is one element underpinning successful communication (Scholz, Dore, Baek, O'Donnell & Falk, in prep). The current study focused on these types of synchrony – correlations between communicators and receivers in perceived benefits of sharing news articles – as one indicator of communicator success. In addition, correlations in intentions to share information were used as another indicator of communicator success. Whereas *perceived benefit of sharing* measures a psychological motivation or belief in the value of sharing information (Berger, 2014), *sharing intention* serves as an antecedent to actual sharing behavior. Thereby, these two measures were used as dependent variables to hypothesize:

> **H1a.** Communicators who achieve higher correlations with their receivers in reported perceived benefits of sharing and sharing intentions with their receivers will show higher mean region of interest (ROI) activation in brain regions previously associated with mentalizing while reading and considering whether to share articles.

Further, the current study also investigated the relationship between individual differences in achieving preference correlations with receivers and individual differences in the personality trait of self-monitoring. Self-monitoring captures the sensitivity of an individual to adapt his or her behavior based on interpersonal cues; for instance, high self-monitors are marked by a high level of social awareness and change their behavior based on their social environment, whereas low self-monitors are more strongly guided by their internal cues (Snyder, 1974). High self-monitors are also more likely to be seen as leaders (Panagopoulos & Ogilvie, 2015; Zaccaro, Foti, & Kenny, 1991), achieve higher work performance (Kilduff & Day, 1994; Panagopoulos & Ogilvie, 2015; Spiro & Weitz, 1990), and hold influential positions in their social networks (Oh & Kilduff, 2008; S. Wang, Hu, & Dong, 2015). Thus, we hypothesized that people who are high in self-monitoring will also be more likely to achieve preference coupling with their receivers, as their tendencies to be socially flexible may lead them to be better at tailoring their messages to be potential receivers of the messages, making the value of the message more salient to potential receivers. Given that self-relevance is one factor relevant to successful social influence in receivers of influence (Falk & Scholz, 2018), and that receivers of influence are more persuaded by content that is tailored to them (Chua et al., 2011; Rimer & Kreuter, 2006), a communicator's ability to frame shared messages to make value to the receiver more salient may be one key factor in whether receivers value sharing the same information as communicators. As such, the current study tested whether high self-monitors are also more likely to be successful at conveying the value of sharing information:

H1b: Communicators who achieve higher correlations of perceived benefits of sharing and sharing intentions with their receivers will self-report higher levels of self-monitoring.

Successful communicators are often distinguished by a greater focus on social factors, and are more socially flexible, able to adapt their strategies and messages based on the social context (Baek & Falk, 2018). In other words, successful communicators tailor their messages to the receivers' needs and wants, thereby making the value of the messages more salient to the receivers. Given that people feel closer to people who have similar preferences to them (McPherson, Smith-Lovin, & Cook, 2002), and that people are more likely to adapt behaviors if they are in a network with people who are similar to them (Centola, 2011), the current study hypothesized that communicators who have greater preference coupling with receivers will also lead their receivers to feel more connected with them:

H1c: Communicators who achieve higher correlations of perceived benefits of sharing and sharing intentions with their receivers will achieve higher average levels of connection with their receivers (as self-reported by the receivers).

Finally, Study 3 also asked whether communicators who achieve higher self-reported preference correlations with receivers also achieve greater mean neural coupling with receivers who read their shared messages than communicators who are less successful in reproducing their own preferences in receivers. Although neural coupling has been linked with behavioral coupling at the message level (i.e., a message that generates greater neural coupling in the communicator and receiver is also likely to generate greater behavioral coupling (Scholz, Dore, Baek, O'Donnell, & Falk, in prep), it is currently unknown whether individual differences in achieving neural coupling can help explain what distinguishes communicators who achieve higher preference correlation with receivers. It might be expected that communicators who are better at achieving preference coupling with their receivers would also be better on average at inducing neural coupling with their receivers. The current study focused specifically on three key brain systems—brain regions involved in self-related processing, mentalizing, and subjective valuation— that have been previously associated with behavioral coupling on the perceived benefits of sharing information (Scholz, et al., 2017b).

Therefore, the current study hypothesized the following:

> **H1d:** Communicators who achieve higher correlations of perceived benefits of sharing and sharing intentions with their receivers show higher mean coupling with their specific receivers in brain regions previously associated with mentalizing, reward, and self-related processing with their receivers.

Materials & Methods

Procedure. Participants attended a single neuroimaging appointment where they completed self-report surveys, including the self-monitoring scale, and had their brain activity measured through blood-oxygen-level-dependent (BOLD) fMRI while they completed two tasks – the communicator task and the receiver task. After the fMRI scan, participants completed two additional tasks: the post-scan communicator task and the post-scan receiver task. In the post-scan communicator task, participants once again were asked to consider the 48 news articles that they saw in the scanner. Details about each of the tasks follow.

Communicator Task. For each trial in the communicator task in the fMRI scanner, participants first saw an instruction screen that prompted them of the motivation they should be considering in sharing the news article. Then, participants read the headline and abstract of a news article. After this screen, participants were prompted to think about the message they would write on social media to share the article with other study participants. Participants then indicated their likelihood of actually sharing the article in real life on a Likert scale from 1 (*very unlikely*) to 5 (*very likely*). See Figure 9 for an illustration of the task.

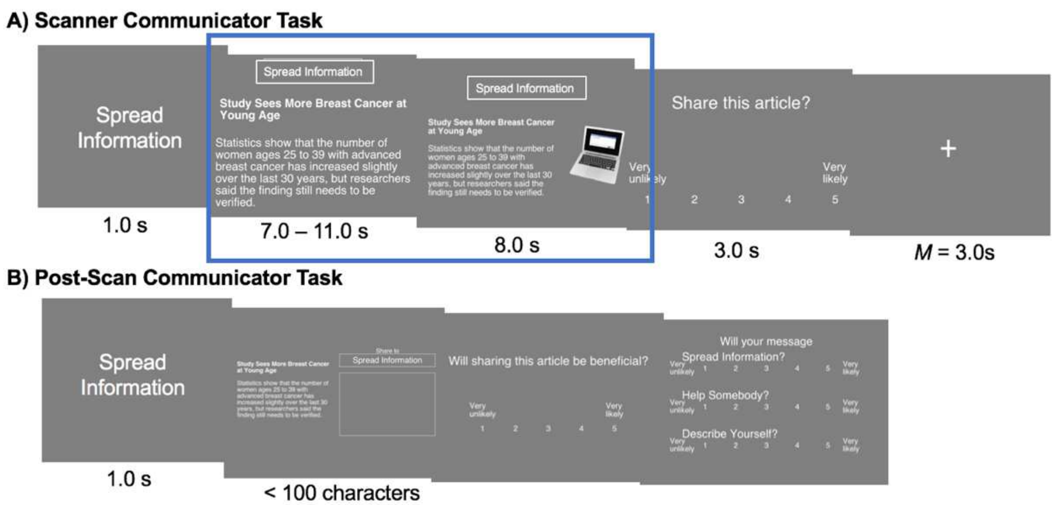


Figure 9. Illustration of the scanner and post-scan communicator tasks.

A) Illustration of an example trial sequence in the in-scanner communicator task. Participants first saw an instruction screen with directions about how to think about sharing the subsequent article. They then saw a headline and teaser for the article and were prompted to think about what they would write if they were to share the article on social media. They then rated their likelihood to share the article. Trials were separated by a fixation rest period. Blue boxes indicate the screens that will be modeled in the main analyses. There were 48 total trials in this task (i.e., participants considered sharing 48 different news articles). B) Illustration of an example trial sequence in the post-scan communicator task. Participants saw the same 48 articles again. For each article, participants were instructed to actually write messages to share the article with the prompted goal in mind. Then, they indicated how beneficial they thought it would be to share the article in real life. They also rated how confident they felt that their messages achieved each of the sharing motivations.

Post-Scan Communicator Task. After the scan, in the post-scan communicator task, participants once again considered the same 48 news articles that they saw in the in-scanner communicator task. For each trial, participants first saw an instruction screen for 1.0 s that reminded them of the motivation they should be considering in sharing the news article, which matched the instruction given in the scanner. Then, participants read (for the second time) the headline and abstract of a news article for 7.0-11.0 s, which was predetermined based on the length of the article. After this screen, participants were asked to actually write a message to share the article with other study participants with no time constraints. Participants had to write a minimum of 100 characters to proceed. Then, participants were asked to rate whether they thought sharing the news article would be beneficial to them (*will sharing this article be beneficial?)* on a Likert-scale from 1 (*very unlikely*) to 5 (*very likely)*. Participants then answered a series of questions about how confident they were that their message achieved the sharing motivation (not of interest in the current investigation; see Appendix C for more information). See Figure 8 for an illustration of the task.

Receiver Task. In the receiver task, participants read 48 messages written by other study participants who wrote these messages to share specific news articles when they were in the communicator role (see *post-scan communicator Task*). Participants saw written messages from two other study participants, resulting in each receiver seeing 24 messages from each communicator (see Figure 10). These messages were written about 48 news articles that did not overlap with the articles seen in the communicator task for each individual. For each trial, participants first saw the headline of the original news article and a message written by the communicator about sharing the news article. Then, they were prompted to think about the message they would write to respond to the message. After this screen, participants indicated how connected they felt to the participant who shared the message with them on a Likert scale from 1 (*not at all*) to 5 (*very much*). Then, they indicated their likelihood of actually sharing the news article (not the message written by the communicator, but the news article the communicator was writing about) in real life on a Likert scale from 1 (*very unlikely*) to 5 (*very likely*). See Figure 11 for an illustration of the task.

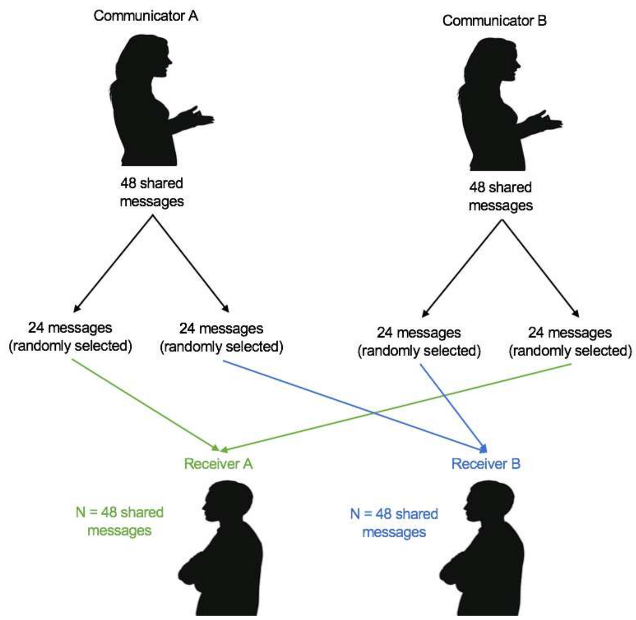


Figure 10. Illustration of the task schema.

In the Post-Scan Communicator Task, each communicator wrote a total of 48 messages to share with receivers. Half (N=24) of these messages were seen by one receiver, and the remaining half (N=24) were seen by a second receiver. In turn, in the Receiver Task, each receiver saw a total of 48 shared messages, 24 messages from each communicator.

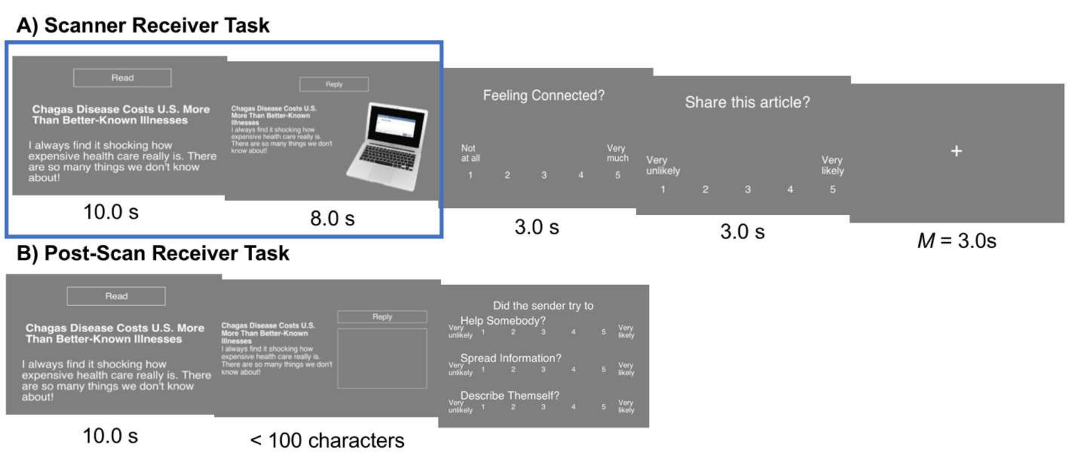


Figure 11. Illustration of the scanner and post-scanner receiver tasks.

A) Illustration of an example trial in the receiver task. Participants first saw the headline of a news article and a message written by a communicator. Then, they were prompted to think about what they would write if they had received this shared message on social media. They then rated how connected they felt to the communicator, as well as their likelihood to share the article in real life. Trials were separated by a fixation rest period. There were 48 total trials in this task (i.e., participants saw 48 messages written by communicators about 48 different articles). Blue boxes indicate the screens that were modeled in the main analyses. B) Illustration of an example trial sequence in the post-scan receiver task. Participants saw 18 of the 48 messages they saw in the scanner. For each message, participants were instructed to actually write messages to respond to the communicator who shared the article with them, and then indicate how beneficial they thought it would be to share the original article. They also were asked to guess the sharing motivation of the communicator.

Post-Scan Receiver Task. After the scan, in the post-scan receiver task, participants saw 18 of the 48 messages that they saw in the in-scanner communicator task. For each trial, participants read (for the second time) the headline of a news article and a message written by another study participant to share the news article for 10.0 s. After this screen, participants were asked to actually write a message to respond to the participant who shared the news article. Participants had to write a minimum of 100 characters to proceed and were not given any time constraints. Then, participants were asked to rate whether they thought sharing the original news article (*not* the message written by the communicator) would be beneficial to them (*will sharing this article be beneficial?)* on a Likert-scale from 1 (*very unlikely*) to 5 (*very likely)*. Participants then answered a series of questions to guess the sharing motivation of the communicator (not of interest in the current investigation; see Appendix C for more information).

Stimuli. Across both tasks, participants considered content relevant to 96 news articles about healthy living and physical activity that were published on the health section of the New York Times website between July 2012 and February 2013. These stimuli were assigned to each task using a randomization scheme that treated article length as a blocking factor (i.e., to balance the length of articles across tasks), resulting in 48 news articles being assigned to each task. For each task, the stimuli were further divided into two runs, resulting in 24 news articles per run, per task. The 48 articles in the communicator task were further assigned into 3 experimental conditions designed to manipulate communicator motivations in sharing the news articles, but this experimental manipulation is not the focus of Study 3 (see Appendix C for more information). All analyses in the current study collapse across these experimental conditions, and instead focus on individual differences in tendency to mentalize across conditions. All participants except the first and last four participants completed both the communicator task and the receiver task. The first four participants only completed the communicator task (to generate initial stimuli subsequent participants could receive), and the last four participants only completed the receiver task (since we didn't plan to collect further data so no one would be able to receive their shared messages had they done the communicator task).

In the post-scan receiver task, participants were asked to consider messages about 18 of the articles that they had previously seen in the scanner, 9 from each of two communicators assigned to them. The 9 articles from each communicator were pseudo-randomly selected (see Appendix C for more information). We used a counterbalanced design to control for any order effects across the two scanner tasks (i.e., participants were randomly assigned to do the communicator or receiver task first) and the two post-scan tasks (i.e., participants were randomly assigned to do the post-scan communicator or post-scan receiver task first). Paralleling data collection in the fMRI scanner, the first four participants only did the post-scan communicator task, and the last four participants only did the post-scan receiver task.

Participants. We planned to collect data for 40 participants who fulfilled the roles of communicators and receivers in separate tasks. A total of 54 participants completed the full protocol. The first 14 participants who took part in the study were affected by an error in the task coding which led to a mismatch between experimental conditions in the communicator scanner and post-scan tasks. This error was discovered in the middle of data collection and because it impacts our ability to test the main hypotheses for the present analyses, we elected to add additional participants prior to examination of any data or results to achieve our planned sample size. Thus, only data from 40 participants not affected by the coding error were eligible to be included for analysis. From the 40 eligible participants, for the Communicator Task, all data from one participant and partial data from four participants were excluded due to excessive head movement (a total displacement of >10mm or more than 10% of the frames showed a framewise displacement of greater than 0.5mm) and corrupted data. Further, one participant's data from the Post-Scan Communicator Task were excluded due to data corruption, and the last 4 participants only completed the Receiver Task. This resulted in 35 participants included in data analysis for the Communicator Task, with partial data from 4 participants, and 34 participants included in data analysis for the Post-Scan Communicator Task. For the Receiver Task, all data from three participants and partial data from three participants were excluded due to excessive head movement using the same criteria as above. Further, the first 4 participants only completed the Communicator Task. This resulted in 33 participants included in data analysis with partial data from 3 participants for the Receiver Task. Participants were required to be between the ages of 18 and 34 and meet standard fMRI exclusion criteria, including no metal in body, not currently taking any psychiatric medications, no history of psychiatric or neurological disorders, not currently pregnant, and not claustrophobic. Participants were also required to be right-handed. All participants gave informed consent in accordance with the procedures of the institutional review board of the University of Pennsylvania.

fMRI image acquisition. Neuroimaging data were acquired using a 3-T Siemens Magnetom Prisma scanner. Four functional runs were acquired for each participant (500 volumes per run). Functional images were recorded using a reverse spiral sequence (repetition time = 1,000 ms, echo time = 27 ms, flip angle = 60°, −30° tilt relative to the anterior commissure–posterior commissure line, 56 axial slices, field of view = 200 mm, slice thickness = 2.5 mm; voxel size = 2.5 × 2.5 × 2.5 mm). High-resolution T1-weighted images (magnetization-prepared rapid-acquisition gradient echo, 160 slices, slice thickness = 0.9 × 0.9 × 1 mm) and T2-weighted images were used in place with the BOLD images for coregistration and normalization.

Neuroimaging Data Analysis. Data underwent fMRI pre-processing following the fmriprep protocol with freesurfer reconstruction option to prepare the imaging data for analysis (Esteban et al., 2018). First, anatomical T1 and T2 weighted images were normalized to the skull stripped

MNI template provided by FSL ("MNI52_T1_1mm_brain.nii"). Next, normalized structural images were segmented to determine gray matter, white matter, and cerebrospinal fluid (CSF). Then, surfaces of the cortical sheet were reconstructed from the T1 and T2 weighted images. Functional images from the BOLD runs were then spatially realigned and co-registered to the structural images. The functional images were then smoothed with a 6mm Gaussian kernel. Nine confound signals that are outputs of fmriprep were included as nuisance regressors in our models: three FSL-DVARS signals ('stdDVARS', 'non-stdDVARS', 'vx-wisestdDVARS') and six motion parameters ('X', 'Y', 'Z', 'RotX', 'RotY', 'RotZ').

To test neural hypotheses, we used regions of interest masks of voxels in which activity is meta-analytically associated with self-related, mentalizing, and value-related processing. The mentalizing mask was obtained using the Neurosynth reverse inference masks (FDR, $p < .01$) for the term 'mentalizing' (Yarkoni et al., 2011). For value-related processing, we used a meta-analytically defined mask of subjective valuation consisting of VS and VMPFC as identified in Bartra et al. (2013). For self-related processing, we used a meta-analytically defined mask of self-related processing consisting of MPFC and PCC as identified in Murray et al. (2012) as well as the 'self-referential' mask obtained from www.neurosynth.org (thresholded at FDR, $p < .01$).

Behavioral Data Analysis. The two primary dependent variables were correlations of perceived "benefit of sharing" ratings and "sharing intention" ratings. For each paired communicator and receiver, we calculated the correlation of perceived benefit ratings as well as sharing intention ratings.

Primary Hypotheses Tests. Trial-wise, percent signal change in neural activity during the combined read (i.e., when participants actively read the news article) and sharing screens (i.e., when participants were instructed to think about how they would share the article with others) within each region of interest, representing neural activity evoked by each trial compared to baseline rest, was extracted from a first-level model of the communicator neuroimaging data using SPM12 (Wellcome Department of Cognitive Neurology, Institute of Neurology, the

University of London). We then calculated the mean level of neural activity within each region of interest at the participant level to create a measure of individual differences in tendency to engage the brain's mentalizing system across trials.

H1a: Communicator Success and Mean Mentalizing Activity. To determine the link between communicator success in achieving preference coupling and mean neural activity, we ran linear regressions to determine the relationship between communicators' mean neural activity in the mentalizing ROI (IV) and perceived benefit correlation with receivers and intention rating correlation (DVs) and as specified above. Thus, we ran the following linear regressions:

$$\text{Perceived Benefit Cor} = b_0 + b_1\text{*Communicator's Mean Mentalizing Activity} + \varepsilon_i$$

$$\text{Sharing Intention Cor} = b_0 + b_1\text{*Communicator's Mean Mentalizing Activity} + \varepsilon_i$$

H1b: Communicator Success and Self-Monitoring. Self-monitoring was calculated from the self-report surveys following standard methods that included summing the 25 items on the scale (Cronbach's $\alpha = 0.791$) (Snyder, 1974). To determine the link between communicator success in achieving preference coupling and self-monitoring, we then ran linear regressions to determine the relationship between communicators' self-reported self-monitoring (IV) and perceived benefit correlation with receivers and intention rating correlation (DVs).

$$\text{Perceived Benefit Cor} = b_0 + b_1\text{*Communicator Self-Monitoring} + \varepsilon_i$$

$$\text{Sharing Intention Cor} = b_0 + b_1\text{*Communicator Self-Monitoring} + \varepsilon_i$$

H1c: Communicator Success and Receivers' Connection Ratings. Using the connection ratings made by receivers in the scanner, we averaged the connection ratings across all the trials for each communicator-receiver pair. This allowed us to determine, on average, how connected each receiver felt to each communicator. We used this mean connection rating as an individual difference measure for the communicators. To determine the link between communicator success in achieving preference coupling and receivers' self-reported connection ratings with the communicator, we then ran linear regressions to determine the relationship between receivers' mean connection ratings for the communicator (IV) and perceived benefit correlation with receivers and intention rating correlation (DVs).

Perceived Benefit Cor = $b_0 + b_1$*Communicator Mean Connection Rating with Receiver + ε_i

Sharing Intention Cor = $b_0 + b_1$*Communicator Mean Connection Rating with Receiver + ε_i

H1d: Communicator Success and Neural Coupling in Key Regions-of-Interest. Mean neural coupling was assessed through calculating correlations between percent signal change in communicator neural activity within each ROI for each article and the brain activity during the corresponding article obtained in the paired receivers. To determine the link between communicator success in achieving preference coupling and mean neural coupling, we ran linear regressions to determine the relationship between mean neural coupling between the communicator and the paired receivers in each of the three ROIs (IVs) as specified above and perceived benefit correlation with receivers and intention rating correlation (DVs).

Perceived Benefit Cor = $b_0 + b_1$*Mean Neural Coupling in Mentalizing + ε_i

Sharing Intention Cor = $b_0 + b_1$*Mean Neural Coupling in Mentalizing + ε_i

Perceived Benefit Cor = $b_0 + b_1$*Mean Neural Coupling in Self-Related Processing + ε_i

Sharing Intention Cor = $b_0 + b_1$*Mean Neural Coupling in Self-Related Processing + ε_i

Perceived Benefit Cor = $b_0 + b_1$*Mean Neural Coupling in Subjective Valuation + ε_i

Sharing Intention Cor = $b_0 + b_1$*Mean Neural Coupling in Subjective Valuation + ε_i

Results

The current study investigated the relationships between communicator success, as operationalized by correlations with receivers in perceived benefit of sharing and intentions to share, and 1) communicator mean mentalizing activity, 2) communicator self-monitoring scores, 3) receiver connection ratings, and 4) communicator-receiver neural coupling in key regions-of-interest. Findings do not provide support for any of the hypothesized relationships. Descriptive histograms and plots for each of the tested relationships can be found in Appendix C.

Dependent Variables. We operationalized communicator success in two ways: 1) correlation between communicator and receiver ratings in perceived benefits of sharing the articles, and 2) correlation between communicator and receiver ratings in sharing intentions. Communicators ranged in their ability to achieve correlations with receivers in the perceived benefit (M = 0.108, SD = 0.169, range = -0.352 – 0.532) and sharing intention ratings (M = 0.045, SD = 0.146, range = -0.275 – 0.396), suggesting that some communicators were more successful than others in communicating the value of sharing the same information as them. Further, the two dependent variables were uncorrelated (r = -0.034, t (32) = -0.192, p = 0.849), indicating that communicators who achieved high correlation with their receivers in perceived benefit of sharing the article did not necessarily achieve high correlation in sharing intentions (see Appendix C).

H1a: Communicator Success and Mean Mentalizing Activity. We first tested the relationship between mean mentalizing activity and communicator success. Mean mentalizing activity was not associated with correlation in perceived benefits (B = -0.050; t (33) = -0.051; p = 0.959) nor correlation in sharing intentions (B = -0.569; t (33) = -1.036; p = 0.309).[2]

H1b: Communicator Success and Self-Monitoring. We next tested the relationship between self-monitoring and communicator success. There was no relationship between self-

---

[2]For exploratory purposes, we also conducted analyses looking at mean activity in the reading and sharing screens separately. The results remained non-significant.

monitoring and correlation in perceived benefits (*B* = -0.007; *t* (33) = -0.825; *p* = 0.416) nor correlation in sharing intentions (*B* = 0.001; *t* (33) = 0.243; *p* = 0.809).

H1c: Communicator Success and Receivers' Connection Ratings. We next tested whether communicators who were more successful at relaying the value of sharing articles with their receivers were also more likely to elicit feelings of connectedness from their receivers. We did not find a support for a relationship between receivers' feelings of connectedness and correlation of perceived benefit ratings (*B* = 0.089; *t* (33) = 1.075; *p* = 0.290) nor correlation of sharing intentions (*B* = 0.025; *t* (33) = 0.508; *p* = 0.615).

H1d: Communicator Success and Neural Coupling in Key Regions-of-Interest. Lastly, we tested whether communicators who were more successful at achieving preference coupling with their receivers were also more likely to show higher mean coupling in brain regions associated with self-related processing, mentalizing, and reward. We did not find relationships between coupling in brain regions associated with self-related processing (*B* = -0.208; *t* (31) = -0.208; *p* = 0.479), mentalizing (*B* = -0.179; *t* (31) = -0.613; *p* = 0.545), or valuation (*B* = -0.260; *t* (31) = -0.893; *p* = 0.380) and correlation of perceived benefit ratings. Similarly, we also did not find relationships between coupling in brain regions associated with self-related processing (*B* = 0.260; *t* (31) = 1.380; *p* = 0.179), mentalizing (*B* = 0.216; *t* (31) = 0.166; *p* = 0.205), or valuation (*B* = 0.158; *t* (31) = 0.932; *p* = 0.360) and correlation of sharing intentions.

Discussion

The current study aimed to understand neural and psychological variables that may distinguish communicators who are more successful at communicating the value of sharing information with their receivers. Specifically, the current study tested the relationships between two measures of successful communication; one, the ability of the communicators to achieve preference coupling in perceived benefit of sharing information with their receivers (i.e., successfully communicating the potential value of sharing certain types of information) and two, the ability of the communicators to achieve intention coupling in intentions to share information with their receivers (i.e., successfully communicating their actual intention to share). Based on prior literature, four different types of potential variables were identified to explain individual differences that distinguish successful communicators: one, the tendencies of the communicators to consider other people's mental states, as measured by brain activity in the mentalizing regions-of-interest; two, communicators' self-monitoring scores, which captures the sensitivity of an individual to change his or her behavior based on social cues; three, receivers' feelings of connection with communicators, which may serve as a proxy for the ability of the communicator to tailor the content to potential receivers; and four, individual differences in ability to achieve neural coupling in key brain regions that have previously been associated with sharing behavior. Study 3 did not find significant associations from any of these four variables and individual differences in communicator success in achieving preference coupling with receivers.

Although prior studies have found that greater consideration of others' mental states and social factors more generally characterize communicators who are more successful at persuading and influencing receivers of their influence (for a review, see: Baek & Falk, 2018), the current study did not find support for this account in the brains of communicators sharing health news articles. One possibility is that instructing participants to consider sharing information with others led to high levels of mentalizing across all participants, leading to a smaller range than might be expected if they were given another task (such as deciding whether to read the articles themselves). Further, we had a second task in the study (i.e., Receiver Task), where participants read shared messages from others that may have encouraged heightened levels of mentalizing, which is in line with the finding that people are more effective writers after giving feedback to others, because it encourages perspective taking (Traxler & Gernsbacher, 1992). Indeed, when people are making decisions to share information with others, they show greater recruitment of the brain's mentalizing system compared to when they are making decisions about the content of the information, or when they are making decisions about personal consumption (Baek et al., 2017). Further, brain activity during decisions to consume information oneself predicts sharing at the population-level, while brain activity during decisions to share does not (Scholz et al., 2017). Indeed, post-hoc exploratory analyses showed that individual differences in tendencies to mentalize in the current study participants, who were explicitly instructed to share, was higher on average compared to individual differences in mentalizing in another group of participants who considered information to read themselves (Baek et al., 2017, see Appendix C). Further, the variance in Study 3 participants' mean mentalizing activity was much smaller than in the comparison sample, suggesting that our task instructions may have led to both heightened mentalizing activity during sharing decisions and a reduced range in individual differences of mean mentalizing (see Appendix C).

Likewise, individual differences in self-reported trait empathy have been previously associated with increased recruitment of the brain's mentalizing systems during *spontaneous* processing of natural social compared to non-social items (i.e., when participants were not instructed to engage in explicitly social decisions) (Wagner, Kelley, & Heatherton, 2011). It is possible that globally elevated recruitment of the brain's mentalizing system during sharing decisions in this task may not have allowed us to capture variance across individuals' tendencies to mentalize that is relevant to their success as communicators. In other words, it is possible that successful communicators are differentiated in that they are better at taking social considerations into account in situations across contexts that are not obviously social (i.e., even when not explicitly instructed to consider how and why to share with others), and that this difference may be supported in brain structure that supports these tendencies (Banissy, Kanai, Walsh, & Rees, 2012); by contrast, such differences may not be present when all participants are instructed to consider what others are likely to think and to frame information to share with them, and also to be presented with the opportunity to serve as a receiver in the same study (thus encouraging the ability to take the receiver's perspective).

Next, although prior studies have found a link between self-monitoring and successful communication (for a review, see: Baek & Falk, 2018), our data did not find support for this relationship in the way we defined "successful communication" (i.e., preference synchrony). Prior studies that have found a link between self-monitoring and successful communication have largely defined successful communication in real-life contexts, often in a work environment. For instance, individual differences in self-monitoring have been linked to various real-life work performance metrics, such as increased promotions (Kilduff & Day, 1994), greater sales performance (Panagopoulos & Ogilvie, 2015), and influence in social networks (S. Wang et al., 2015), thereby in situations where communicators know their audience fairly well. Paralleling our argument above, it is therefore possible that high self-monitorers are most likely to be differentiated in contexts where they are not actively instructed to take others' perspectives, but rather where they might spontaneously do so more, and do so in contexts where it is most beneficial. In other words, our laboratory task may have diminished effects of self-monitoring by prompting high and low self-monitorers alike to actively consider how and why to share information with others. Further, the communicators and receivers did not know any information about one another, other than that they were other participants in the study. The trait of self-monitoring reflects the tendencies to flexibly adapt and adjust to different social situations (Snyder, 1974), and one possibility is that in order to exercise this ability to be socially flexible, communicators need more information about their receivers. Future studies that provide additional opportunities for communicators to engage with receivers may provide a richer opportunity to test this theory.

Further, the current study's operationalization of successful communication may have been susceptible to idiosyncratic features of the receivers of the study. Each communicator's messages were only seen by two receivers, and one receiver's ratings have a large influence on a communicator's ability to achieve preference coupling. A potentially more robust measure of individual differences in successful communication might be to expose each communicator's messages to a large number of receivers and calculate the communicator's ability to achieve preference coupling with them (e.g., Schmälzle, Häcker, Honey, & Hasson, 2014). Supporting this view, the only previous study that have used a similar paradigm that found individual differences in mentalizing activity to be associated with successful communication had four receivers rate messages from each communicator, double the amount of receivers the current study used (Falk et al., 2013). As such, this approach of using multiple receivers may be less susceptible to the idiosyncratic preferences of one or two receivers and allow for a measure of successful influence across a larger group of people.

Additionally, our main dependent variables focused on communicators' levels of preference coupling with their receivers in the value of sharing information (i.e., getting receivers to prefer to share the same information). This approach differs from traditional studies of persuasion which typically test the effects of persuasive messaging strategies on an explicitly targeted behavior or attitude (for a review, see O'Keefe, 2017). An approach more parallel to the extant persuasion literature would be to measure a communicator's ability to convince receivers to read the shared content, or change their opinions or behaviors according to the information. In addition, our participants were not explicitly instructed to try to persuade, so their motivations to do so may have varied. As such, one possibility is that our dependent variables of interest did not directly capture communicators' ability to explicitly and more directly influence receivers' attitudes and behaviors.

In addition, the current study investigated individual differences in tendencies to mentalize generally, and as such, did not distinguish the different types of mentalizing that people may have been engaging in during decisions to share information. Given the evidence that some dimensions of mentalizing more strongly cause sharing (Study 1 of this dissertation), a more nuanced approach that takes individual differences in tendencies to engage in different dimensions of mentalizing may further elucidate the relationship between mentalizing and communicators' ability to achieve successful communication. Although not the focal point of the current investigation, participants were also assigned to consider specific motivations in sharing information (see Appendix C). These instructions may have primed participants to engage in specific types of mentalizing, potentially creating additional noise for the current investigation, and further exacerbating the issue of providing strategies for people to use in considering others' mental states.

One potential concern is that that the current study was not adequately powered to detect individual differences in successful communication (i.e., we had 35 usable participants, thus limiting the degrees of freedom for our main analyses). Previous neuroimaging studies that found associations between individual difference characteristics and neural activity have used similar or smaller sample size of communicators (*N* = 20 used by Dietvorst et al., 2009; *N* = 20 used by Falk et al., 2013; *N* = 48 used by Wagner et al., 2011), and the study whose design is closest to the present study paradigm also used communicators' ability to achieve preference correlations with receivers (Falk et al., 2013), suggesting that under some circumstances, effects may be large enough to detect even in samples half the size of the current study. More importantly, however, several of the hypothesized effects showed negative correlations where positive correlations were predicted, and most effect sizes appeared close to zero, with the exception of effects of neural coupling in self and value regions on preference coupling; given that these results are the only ones that are plausibly in the hypothesized direction out of many tests, these effects would need to be investigated in larger, independent samples to draw any conclusions. Combined, this suggests that lack of statistical power was not likely the reason for the lack of support found of the proposed hypotheses, but rather a real lack of effect, and that other reasons as proposed above may be more plausible explanations for the null results. That said, as noted above, the small sample size does increase problems with potential confounds related to who was assigned as receivers for each communicator, increasing vulnerability to confounds with communicators' and receivers' idiosyncratic preferences. In addition, some of the independent variables (e.g., self-monitoring, coupling in self-related processing regions) did not follow a normal distribution (see Appendix C). We conducted additional analyses with log-transformed data, but all results remained null. Future studies with more normally distributed data may be less prone to potential confounds.

In conclusion, the current study investigated the relationships between communicator success, as operationalized by correlations with receivers in perceived benefit of sharing and intentions to share, and 1) communicator mean mentalizing activity, 2) communicator self-monitoring scores, 3) receiver connection ratings, and 4) communicator-receiver neural coupling in key regions-of-interest. Findings do not provide support for any of the hypothesized relationships. Future studies that investigate these relationships in a more naturalistic context and without instructions that may lead all participants to mentalize might be fruitful to test whether the null results represent a true lack of relationship between individual differences in tendencies to mentalize and successful communication.

CHAPTER 5: CONCLUSIONS

Using behavioral experiments and neuroimaging, the current dissertation highlights the role of mentalizing in supporting information propagation between communicators and receivers of influence while also elucidating some nuances to this account. The current dissertation examined the role of mentalizing in information propagation in three ways: one, the role of mentalizing in the first chain of information propagation, communicators' decisions to share information with others (Study 1); two, the role of mentalizing in receivers of shared information who process and incorporate this social feedback (Study 2); and three, the role of mentalizing in individual differences in communicators' tendency to successfully propagate information to receivers (Study 3).

Focusing on the first part of the information propagation chain, communicators' decisions to share information with others, Study 1 advances theories of information sharing in several key ways. First, across three pre-registered studies, we provide robust evidence for the causal role of mentalizing in information sharing, showing that instructing people to think about other people's thoughts, minds, and experiences leads to higher likelihood that a communicator will share information. Two, we show that this relationship may not be driven by all types of mentalizing equally, and that particularly strong relationships exist for thinking about how sharing the information would affect potential receivers to feel positively, emotional, and focus inward (though we did not observe strong evidence for differences among sub-dimensions). Three, we show that mentalizing causally increases sharing potentially because it leads information sharers to feel closer to potential receivers of shared information, potentially through eliciting thoughts about how sharing would lead to opportunities to bond with potential receivers (thereby leading to positive social consequences for the sharers), or by leading sharers to think about potential receivers with whom they have close relationships with. Study 1 extends previous findings that have shown correlational evidence linking brain activity in the mentalizing system and sharing at the individual and population levels (Baek et al., 2017; Scholz et al., 2017), and suggest that information sharing in sharers is driven by fundamental human motivations to maintain social relationships (Baumeister & Leary, 1995). Overall, Study 1 advances theories of information sharing by showing evidence for a causal relationship between mentalizing and information sharing and providing insight about the mechanism linking mentalizing and sharing.

Focusing next on receivers of shared information, Study 2 extends and advances understanding of the effects of social influence on recommendation propagation. First, Study 2 shows that mean activity in the brain's mentalizing and value systems while receivers considered and incorporated peer recommendations about mobile game apps is associated with increased likelihood that receivers will change their own recommendations toward that of their peers. These findings corroborate previous findings that highlight the role of the mentalizing system in social influence in the current online media environment, where people are exposed to peer recommendations and immediately update their own recommendations in response (Cascio, O'Donnell, et al., 2015; Welborn et al., 2015). Second, Study 2 extends these previous findings by showing that the relationship mentalizing and recommendation rating change in receivers is driven by negatively framed peer recommendations, suggesting that valence is an important component to consider in studying social influence. Third, in a novel contribution to the field, Study 2 investigates functional connectivity between the brain's mentalizing systems and value systems in associations with recommendation rating change. Results show decreased functional connectivity between the brain's mentalizing and value systems is associated with recommendation rating change, supporting an account of social influence that suggest that devaluation of the peer recommendation leads to suppression of the mentalizing system, leading to less likelihood of recommendation rating change. Overall, results from Study 2 inform how recommendations propagate and the neurocognitive dynamics and features of recommendations that are important to this process in receivers of influence.

Finally, Study 3 focuses on individual differences in communicators, and does not find support for the hypothesis that higher mean mentalizing characterizes communicators who show greater preference coupling with receivers of their shared messages. Previous studies have found that successful communicators are distinguished in their considerations of social factors (for a review, see: Baek & Falk, 2018); results from Study 3 provide important insight on potential boundary conditions of this relationship. One possibility is that successful communicators are distinguished in their ability and tendency to recruit the brain's mentalizing system in non-explicit social contexts (i.e., in situations where some people might process information socially, whereas others do not) (Wagner et al., 2011), whereas the instructed and explicit social nature of the Study 3 paradigm led to high levels of mentalizing across all participants (i.e., thereby invoking a situation where all people are explicitly processing information socially), resulting in smaller variability compared to other studies that have tested this account in less explicitly social contexts. Further, while previous studies have shown associations between communicators' tendencies to be socially flexible (i.e., self-monitoring) and characteristics of successful communicators (e.g., work performance, leadership metrics, and influential positions in social networks) (Kilduff & Day, 1994; Kilduff, Mehra, Gioia, & Borgatti, 2017; Zaccaro et al., 1991), Study 3 did not find this effect. One potential explanation is that in order to demonstrate their ability to be socially flexible, communicators need to know information about potential audience and receivers of their messages, which they were not afforded in the asynchronous communication environment of Study 3. Further, in Study 3, communicator success was operationalized by communicators' abilities to achieve preference coupling with receivers in valuing sharing the same piece of information, which was a less explicit form of influence. One possibility is that mentalizing may matter the most in situations of direct persuasion and influence. Although Study 3 did not find support for hypothesized relationships, results provide important insights into the potential boundary conditions in the relationship between individual differences in mentalizing and successful communication. Future studies that explicitly test these theories would be potentially fruitful in uncovering the nuanced relationship between mentalizing and individual differences in successful communication.

In conclusion, the current dissertation advances theory in the role of mentalizing in information propagation, in both communicators and receivers of influence, in different contexts that are ubiquitous in the current online media environment (i.e., sharing health news, recommending mobile game apps). Future studies that continue to explore the nuances of this relationship, through incorporating contextual information such as features of messages or the nature of the communication environment, will serve to further illuminate the role of mentalizing in information propagation.

APPENDIX A: SUPPLEMENTARY MATERIALS FOR STUDY 1

Number of participants excluded in each study (due to failed attention checks or non-sensical text):

Study 1 (target *N* = 400)

- Participants were required to be in the United States and have completed a minimum number of 500 HITs approved on MTurk, with an approval rate of 98% or greater.
- 30 participants (7.5%) were excluded. As planned, we recruited additional 30 participants who met the qualification criteria to fill our target sample size of 400.

Study 2 (target *N* = 840)

- Participants were required to be in the United States and have completed a minimum number of 500 HITs approved on MTurk, with an approval rate of 98% or greater.
- 118 participants (14%) were excluded. As planned, we recruited additional participants until we met 118 eligible participants to fill our target sample size of 840.

Study 3 (target *N* = 3500)

- The first 2026 participants were required to be in the United States and have completed a minimum number of 500 HITs approved on MTurk, with an approval rate of 98% or greater.
- Of these, 174 participants (8.6%) were excluded.
- Due to the need for a larger sample in study 3, the remaining 1474 participants were required to be in the United States and have completed a minimum number of 100 HITs approved on MTurk, with an approval rate of 96% or greater.
- Further, due to the less stringent MTurk criteria used in Study 3, we also added an additional manipulation check to ensure that participants understood English and could

follow basic directions. This 10-second attention check excluded participants before they did any study-related tasks.

- 586 participants were excluded due to this initial failure in attention check.
- Of the second group in study 3 (with less stringent recruitment criteria), 74 (5.5%) participants were excluded due to writing nonsensical or irrelevant text while doing study-relevant tasks.

Pilot data results:

Effects of mentalizing conditions compared to each control condition:

Control condition = Content Control

Study	Variable	Estimate (SE)	t (df)	p
Pilot	Intercept	2.250 (0.321)	7.003 (42.580)	<.001
	Rationality Both	1.167 (0.393)	2.967 (110)	0.004
	Rationality High	0.583 (0.393)	1.484 (110)	0.141
	Emotionality High (Rationality Low)	0.733 (0.393)	1.865 (110)	0.065
	Social Impact Both	0.433 (0.393)	1.102 (110)	0.273
	Social Impact High	0.717 (0.393)	1.823 (110)	0.071
	Introspection High (Social Impact Low)	0.833 (0.393)	2.119 (110)	0.036
	Valence Both	0.783 (0.393)	1.992 (110)	0.049
	Valence Positive	1.200 (0.393)	3.052 (110)	0.003
	Valence Negative	-0.050 (0.393)	-0.127 (110)	0.899

Control condition = Self Control

Study	Variable	Estimate (SE)	t (df)	p

Pilot	Intercept	2.233 (0.314)	7.105 (46.73)	<.001
	Rationality Both	1.183 (0.390)	3.036 (110)	0.003
	Rationality High	0.600 (0.390)	1.539 (110)	0.127
	Emotionality High (Rationality Low)	0.750 (0.390)	1.924 (110)	0.057
	Social Impact Both	0.450 (0.390)	1.155 (110)	0.251
	Social Impact High	0.733 (0.390)	1.881 (110)	0.063
	Introspection High (Social Impact Low)	0.850 (0.390)	2.181 (110)	0.031
	Valence Both	0.800 (0.390)	2.053 (110)	0.042
	Valence Positive	1.217 (0.390)	3.122 (110)	0.002
	Valence Negative	-0.033 (0.390)	-0.086 (110)	0.932

Control condition = Control None

Study	Variable	Estimate (SE)	t (df)	p
Pilot	Intercept	2.633 (0.325)	8.109 (36.21)	<.001
	Rationality Both	0.783 (0.389)	2.014 (110)	0.047
	Rationality High	0.200 (0.389)	0.514 (110)	0.608
	Emotionality High (Rationality Low)	0.350 (0.389)	0.900 (110)	0.370
	Social Impact Both	0.050 (0.389)	0.129 (110)	0.898
	Social Impact High	0.333 (0.389)	0.857 (110)	0.393
	Introspection High (Social Impact Low)	0.450 (0.389)	1.157 (110)	0.250
	Valence Both	0.400 (0.390)	1.028 (110)	0.306
	Valence Positive	0.817 (0.390)	2.099 (110)	0.038
	Valence Negative	-0.433 (0.390)	-1.114 (110)	0.268

Table of Mean Sharing Ratings by Condition

Study	Condition	Mean (SD)
Study 1	Control	2.724 (1.380)
	Mentalizing	3.009 (1.432)
Study 2	Control	2.817 (1.388)
	Mentalizing	3.074 (1.383)
Study 3	Control	2.832 (1.414)
	Mentalizing	2.924 (1.386)

Study 2: Comparison of each dimension of mentalizing to every other dimension

(Tukey's post-hoc tests, corrected for multiple-comparisons using family-wise error)

Study	Variable	Estimate (SE)	z	P
Study 2	Valence Positive > Rationality High	0.272 (0.125)	2.177	0.384
	Valence Positive > Emotionality High (Rationality Low)	0.028 (0.125)	0.227	1.000
	Valence Positive > Social Impact High	0.227 (0.125)	1.816	0.763
	Valence Positive > Introspection High (Social Impact Low)	0.091 (0.125)	0.724	1.000
	Valence Positive > Valence Negative	0.317 (0.125)	2.537	0.168
	Emotionality High (Rationality Low) > Rationality High	0.243 (0.125)	1.950	0.615
	Emotionality High (Rationality Low) > Social Impact High	0.198 (0.125)	1.589	1.000
	Emotionality High	0.062 (0.125)	0.497	1.000

	(Rationality Low) > Introspection High (Social Impact Low)			
	Emotionality High (Rationality Low) > Valence Negative	0.288 (0.125)	2.310	0.292
	Introspection High (Social Impact Low) > Rationality High	0.181 (0.125)	1.448	1.000
	Introspection High (Social Impact Low) > Social Impact High	0.136 (0.125)	1.089	1.000
	Introspection High (Social Impact Low) > Valence Negative	0.226 (0.125)	1.808	0.763
	Social Impact High > Valence Negative	0.090 (0.125)	0.721	1.000

Study 3: Comparison of each dimension of mentalizing to every other dimension using Tukey's post-hoc tests, corrected for multiple-comparisons using family-wise error (bolded indicate comparisons that survive $p < .05$, corrected for multiple comparisons)

Study	Variable	Estimate (SE)	z	P
Study 3	Valence Positive > Rationality High	0.142 (0.057)	2.493	0.152
	Valence Positive > Emotionality High (Rationality Low)	0.134 (0.057)	2.351	0.206
	Valence Positive > Social Impact High	**0.202 (0.057)**	**3.547**	**0.006**
	Valence Positive > Introspection High (Social Impact Low)	**0.188 (0.057)**	**3.303**	**0.013**
	Valence Positive > Valence Negative	**0.172 (0.057)**	**3.022**	**0.033**
	Emotionality High (Rationality Low) >	0.009 (0.057)	0.153	1.000

Rationality High			
Emotionality High (Rationality Low) > Social Impact High	0.059 (0.057)	1.032	1.000
Emotionality High (Rationality Low) > Introspection High (Social Impact Low)	0.054 (0.057)	0.953	1.000
Emotionality High (Rationality Low) > Valence Negative	0.039 (0.057)	0.678	1.000
Introspection High (Social Impact Low) > Rationality High	0.046 (0.057)	0.795	1.000
Introspection High (Social Impact Low) > Social Impact High	0.013 (0.057)	0.235	1.000
Introspection High (Social Impact Low) > Valence Negative	-0.016 (0.057)	0.273	1.000
Social Impact High > Valence Negative	-0.029 (0.057)	-0.509	1.000

Study 1: State Similarity Results

To explore one potential mechanism linking mentalizing and sharing, we tested whether participants assigned to one of the mentalizing conditions perceived different mental states with greater granularity compared to participants assigned to the control condition. We did not find support for this account.

To test this account, we first correlated participant ratings of distance between states and the normative ratings of distance between states (obtained from Tamir, Thornton, Contreras, & Mitchell, 2016) on each of the three dimensions of mentalizing, and then z-scored the correlations, which allowed us to determine the granularity to which participants saw the different mental states on each of the three dimensions of mentalizing. Then, we predicted this measure of distance between mental states from the condition that participants were assigned to (binary variable: ment = any of the mentalizing conditions; control = control condition). Results follow for each of the dimension of mentalizing, respectively:

Predicting distance between states on the **rationality** dimension:

Study	Variable	Estimate (SE)	t	p
Study 1	Intercept	-0.016 (0.011)	-1.505	0.133
	Mentalizing	-0.015 (0.012)	-1.215	0.225

Ref level = control condition

Predicting distance between states on the **social impact** dimension:

Study	Variable	Estimate (SE)	t	p
Study 1	Intercept	0.172 (0.013)	12.90	<.001
	Mentalizing	0.025 (0.015)	1.62	0.106

Ref level = control condition

Predicting distance between states on the **valence** dimension:

Study	Variable	Estimate (SE)	t	p
Study 1	Intercept	0.246 (0.017)	14.246	<.001
	Mentalizing	0.003 (0.020)	0.147	0.883

Ref level = control condition

APPENDIX B: SUPPLEMENTARY MATERIALS FOR STUDY 2

Main results using human-coded sentiment scores

To validate our machine-learning sentiment classifier, we ran additional models that parallel the main analyses using the human-coded sentiment scores. We found that our results that use human-coded sentiment scores largely support the findings using the machine-learning sentiment classifier that we report in the main manuscript.

Behavioral data analysis

We defined recommendation rating change in an analogous manner to how we defined it in the main manuscript. Accordingly, we defined recommendation rating change as being positive (+1) if the participant changed their initial ratings in the direction of the sentiment of the peer recommendation, negative (-1) if the participant changed their initial ratings away from the sentiment of the peer recommendation, and zero (0) if participants did not change their ratings. For this purpose, peer recommendations were classified into binary categories as either “positive” or “negative” by using the sentiment scores produced by the human coders, which ranged from 0-100 (0 being the most negative and 100 being the most positive). Thus, if the human-coded sentiment scores indicated that the recommendation was more likely to be positive than negative (>50), then it was categorized as positive (and vice versa). Thus, if participants changed their initial recommendation of a “5” to a final recommendation rating of a “3” after reading a peer recommendation that was classified as “positive”, then the recommendation rating change was calculated as “+1”. Paralleling the method that we used in the main manuscript, to determine the relationship between peer recommendation sentiment scores and participants’ recommendation rating change, we ran a multi-level linear regression predicting the participants’ recommendation rating change from the sentiment scores of the peer recommendations. Participants were treated as random effects with intercepts allowed to vary randomly, accounting for non-independence in the data due to repeated measures from each participant.

Recommendation rating change and sentiment (Human-Coded)

Paralleling the main results, participants changed their ratings in alignment with the human-coded sentiment of the peer recommendations (B = 0.012, t (2240) = 18.51; p <.001), and the effects were greater for peer recommendations higher in negativity than positivity (B = -0.003, t (1972) = -7.018, p <.001).

Brain activity and sentiment

We ran analyses examining whether the neural activity in the mentalizing and value also correlated with human coded sentiment scores. Paralleling results in the main manuscript, we found that the relationship between mean activity in the mentalizing regions and human coded sentiment scores was marginally significant (B = 0.003, t (1903) = -1.666, p = 0.096), and that the relationship between mean activity in the valuation regions and human coded sentiment scores was not significant (B = 0.002, t (1882) = 0.834, p = 0.404).

Brain activity and recommendation rating change

We next ran analyses examining whether neural activity in the mentalizing and reward systems correlated with trials where participants changed their initial ratings toward that of the peers, using the recommendation rating change variable calculated from human coded sentiment scores. We found that mean activity in the mentalizing and reward regions was associated with recommendation rating change, though the relationship with mentalizing was marginal (mentalizing: B = 0.075, t (2765) = 1.948, p = 0.052; value: B = 0.102, t (2762) = 2.454, p = 0.014).

We next ran analyses predicting recommendation rating change from the interaction of the human coded sentiment scores and mean brain activity. We found a directional trend of an interaction between the sentiment of the review and neural activity in the mentalizing system in predicting recommendation rating change (see Table B1 below), but not an interaction between the sentiment of the review and neural activity in the valuation system in predicting recommendation rating change (see Table B2 below).

Table B1. Predicting participants' congruent recommendation rating change from mean activity in mentalizing regions, human-coded sentiment of peer recommendations and their interaction (positive coefficients indicate greater change in the direction of the recommendation).

Predictor	*B*	*t*	*df*	*p*
Intercept	0.199	8.513	39.22	<.001***
Mentalizing	0.067	1.744	2763	0.081
Sentiment	-0.084	-6.917	1982	<.001***
Mentalizing*Sentiment	-0.061	-1.504	2782	0.133

Table B2. Predicting participants' congruent recommendation rating change from mean activity in valuation regions, human-coded sentiment of peer recommendations and their interaction (positive coefficients indicate greater change in the direction of the recommendation).

Predictor	*B*	*t*	*df*	*p*
Intercept	0.199	8.465	39.45	<.001***
Valuation	0.108	2.616	2762	0.009**
Sentiment	-0.086	-7.092	1988	<.001***
Valuation*Sentiment	0.033	0.769	2773	0.442

APPENDIX C: SUPPLEMENTARY MATERIALS FOR STUDY 3

As part of a larger study from which Study 1 draws data, articles for the communicator task were assigned into 3 experimental conditions using a randomization scheme that used article length as a blocking factor. For each article, participants were asked to consider one of three motivations in thinking about sharing the article with others: 1) describe yourself, 2) help somebody, or 3) spread information. Each article was assigned to one of these conditions, and participants saw each article only once in the scanner. See below for detailed instructions on how each condition was explained to the participants.

Communicator Task Instructions:

“While browsing the internet, we often come across content we want to share with others for various reasons. Sometimes we want to help somebody solve a problem. At other times we want to tell others something about ourselves, for instance, how excited we are about an event, sport, or recipe.

You are asked to think about sharing New York Times articles about healthy living and physical activity with another study participants through a Facebook message. To give you an idea of who these people are. All participants are recruited on campus and many are Penn students or employees or live close to the community.

For each article, we would like you to follow a specific goal while sharing it. There are three different goals:

1. Describe yourself: When your goal is to describe yourself, use the article to tell another study participant something about yourself. For instance, you could describe how your interests, experiences, or personality traits relate to the article or tell a story about something you have done or are planning to do in relation to the article topic. You may also express that the article does not relate to you and why.
2. Help Somebody: When your goal is to help somebody, use the article to help another study participant. For instance, you could describe how the information in the article could

help another study participant solve a problem or why it might be interesting. You may also give somebody the tip to avoid something mentioned in the article and why.

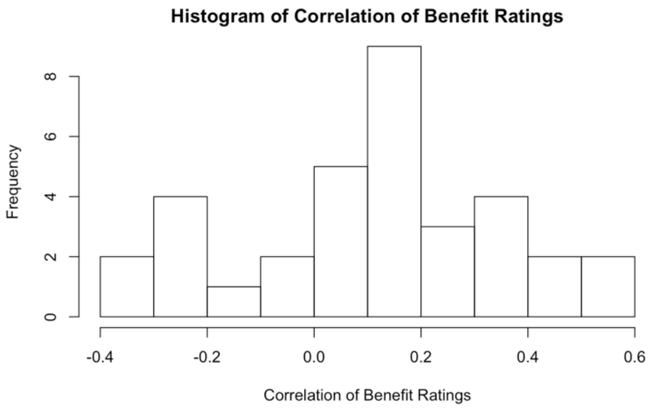
3. Spread Information: When your goal is to spread information, relay information provided in the article to another study participant in your own words without evaluating or changing it. For instance, tell another study participant what the main topic of the article is and what is said about the topic."

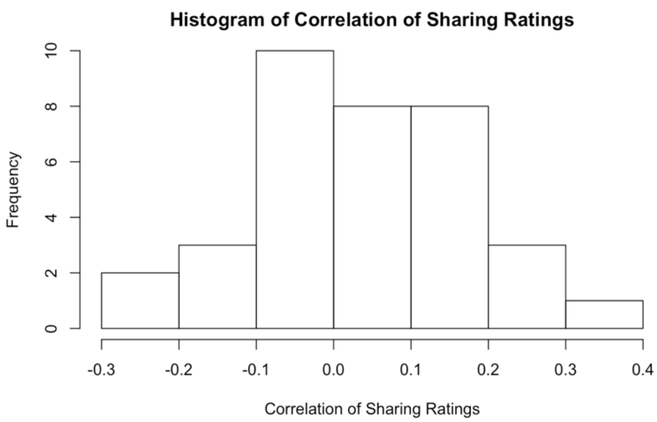
During the in-scanner receiver task, participants saw 24 written messages from each communicator. Messages from each communicator were selected with a randomization scheme that used communicator motivation as a blocking factor (i.e., to ensure that messages for each communicator motivation were equally seen by each receiver). Likewise, in the post-scanner receiver task, participants saw 9 written messages from each communicator that were selected with a randomization scheme that used communicator motivation as a blocking factor.

During the post-scanner communicator task, participants were also asked to indicate their confidence that their message achieved the sharing motivation. They answered 3 questions: "*Will your message spread information?" "Will your message describe yourself?" "Will your message help somebody?"* on a 1-5 Likert scale from 1 (very unlikely) to 5 (very likely).

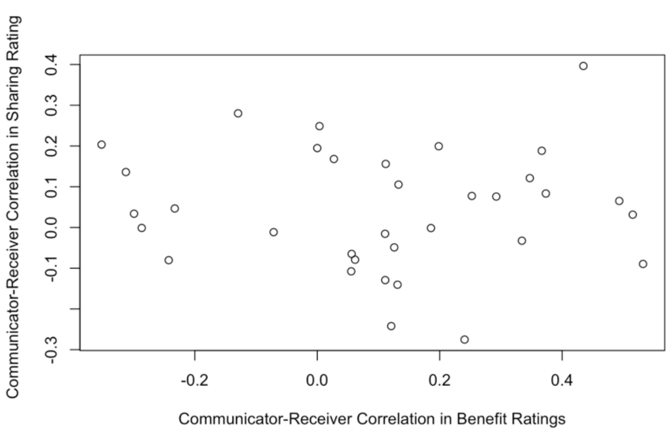
During the post-scanner receiver task, participants were also asked to guess the sharing motivations of the communicator who shared the news article with them. They answered 3 questions: "*Did the sender try to spread information?" "Did the sender try to describe themselves?" "Did the sender try to help somebody?"* on a 1-5 Likert scale from 1 (very unlikely) to 5 (very likely).

Descriptive Histograms for the Dependent Variables



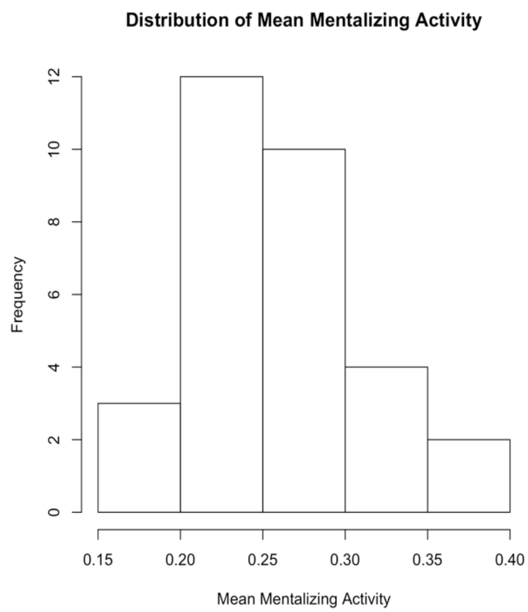


Plot: Correlation of the Two Dependent Variables

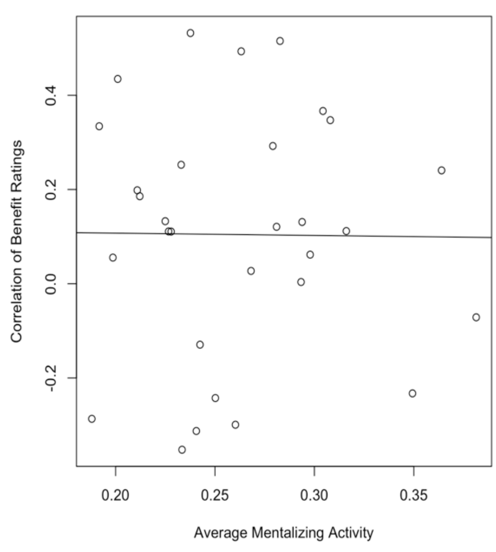


H1a: Communicator Success and Mean Mentalizing Activity.

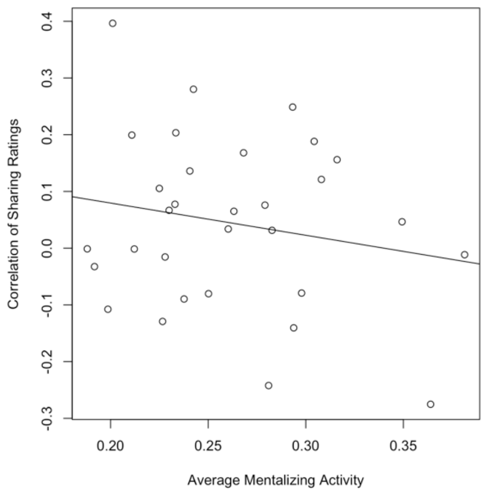
Descriptive Histogram of Mean Mentalizing Activity Across Communicators



Plot: Mean Mentalizing Activity Predicting Correlation of Benefit Ratings



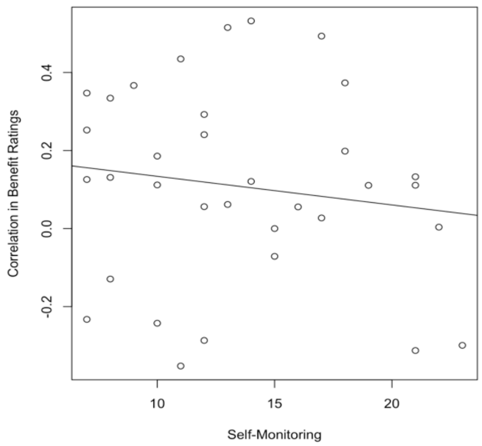
Plot: Mean Mentalizing Activity Predicting Correlation of Sharing Ratings



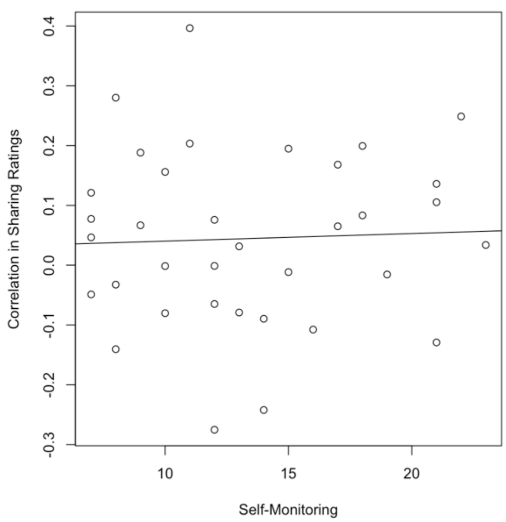
H1b: Communicator Success and Self-Monitoring

Descriptive Histogram of Self-Monitoring

Plot: Self-Monitoring Predicting Correlation of Benefit Ratings

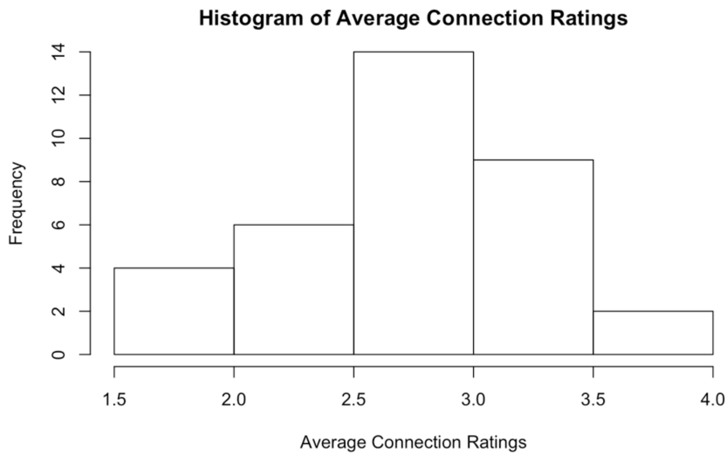


Plot: Self-Monitoring Predicting Correlation of Sharing Ratings

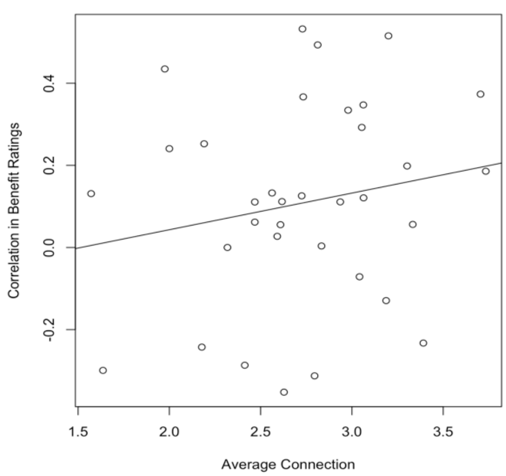


H1c: Communicator Success and Receivers' Connection Ratings

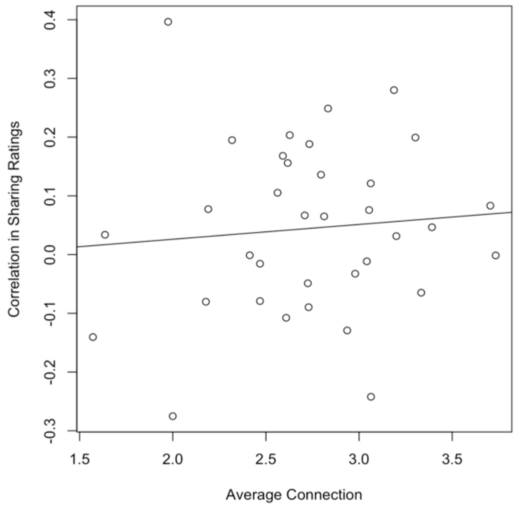
Descriptive Histogram of Receivers' Connection Ratings



Plot: Average Connection Ratings (reported by receivers) Predicting Correlation of Benefit Ratings

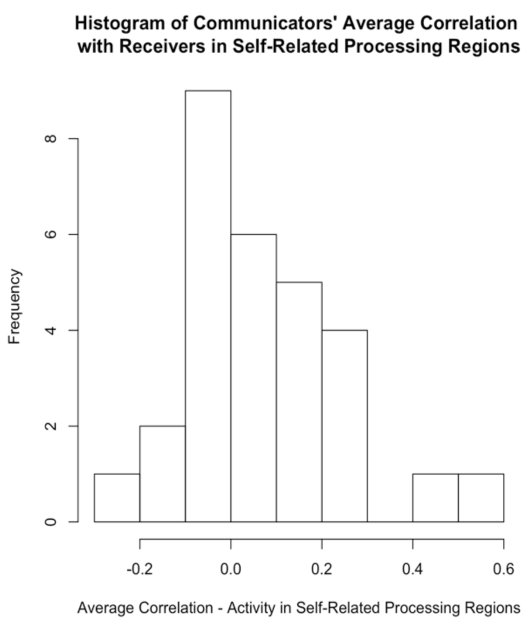


Plot: Average Connection Ratings (reported by receivers) Predicting Correlation of Sharing Ratings

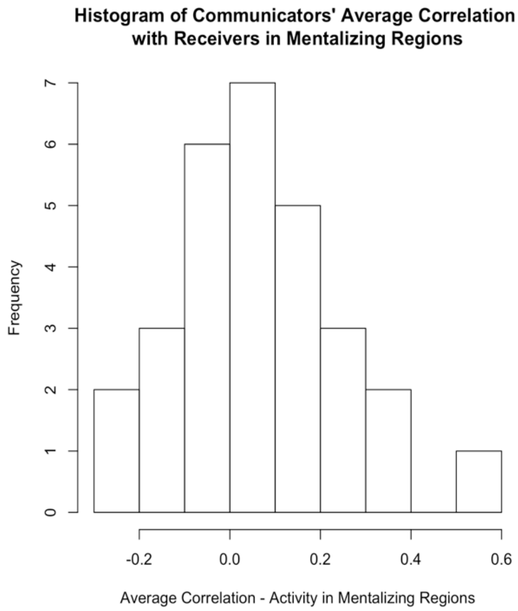


H1d: Communicator Success and Coupling in Key Brain Regions

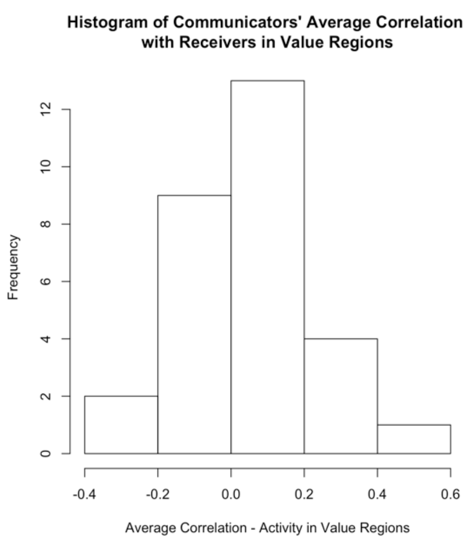
Descriptive Histogram of Coupling in Self-Related Processing Regions



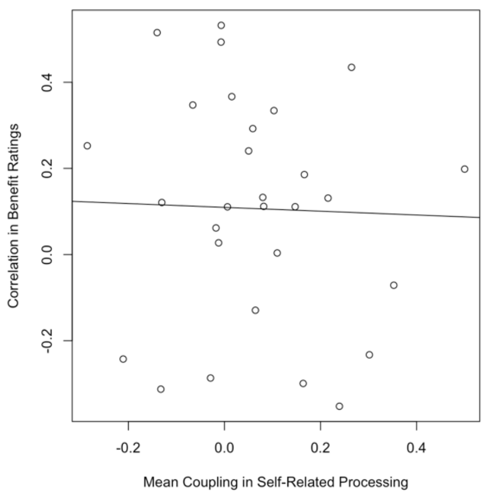
Descriptive Histogram of Coupling in Mentalizing Regions



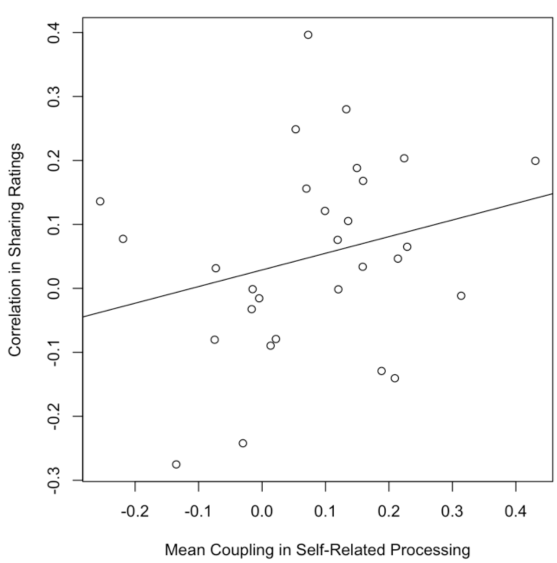
Descriptive Histogram of Coupling in Value Regions



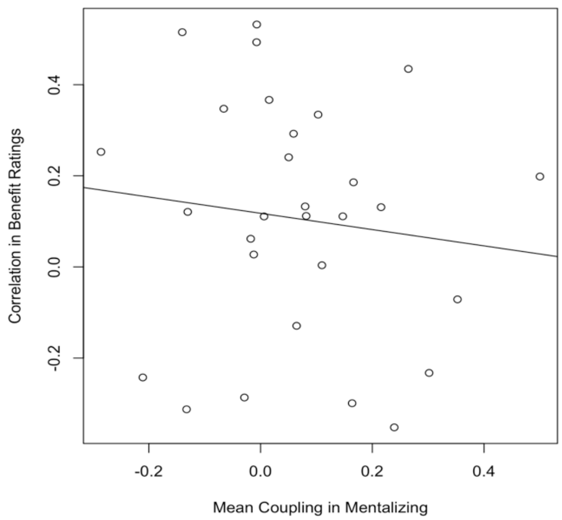
Plot: Communicators' Mean Correlation in Self-Processing Regions with Receivers Predicting Correlation of Benefit Ratings



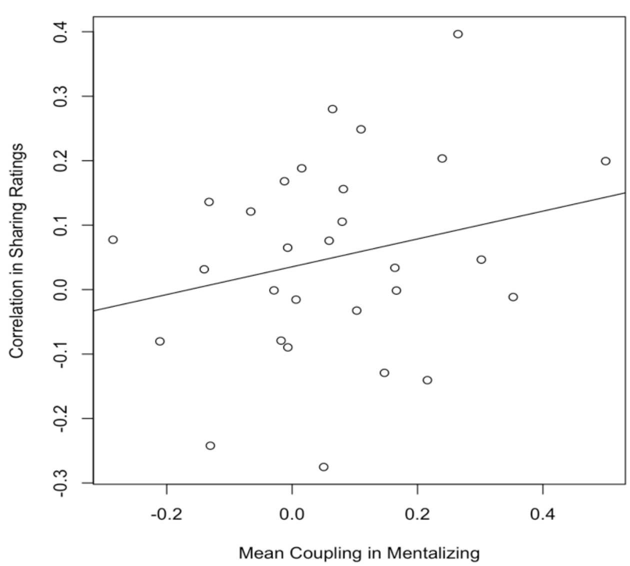
Plot: Communicators' Mean Correlation in Self-Processing Regions with Receivers Predicting Correlation of Sharing Ratings



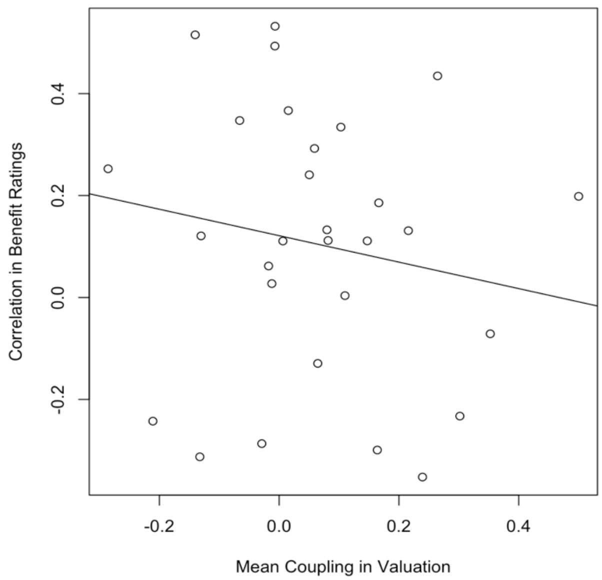
Plot: Communicators' Mean Correlation in Mentalizing Regions with Receivers Predicting Correlation of Benefit Ratings



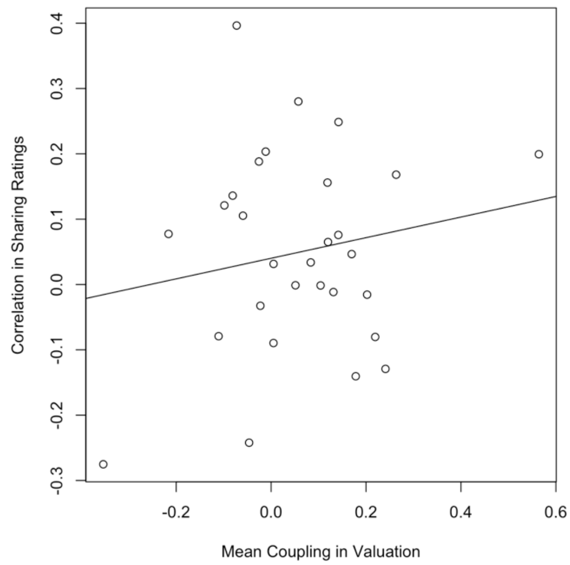
Plot: Communicators' Mean Correlation in Mentalizing Regions with Receivers Predicting Correlation of Sharing Ratings



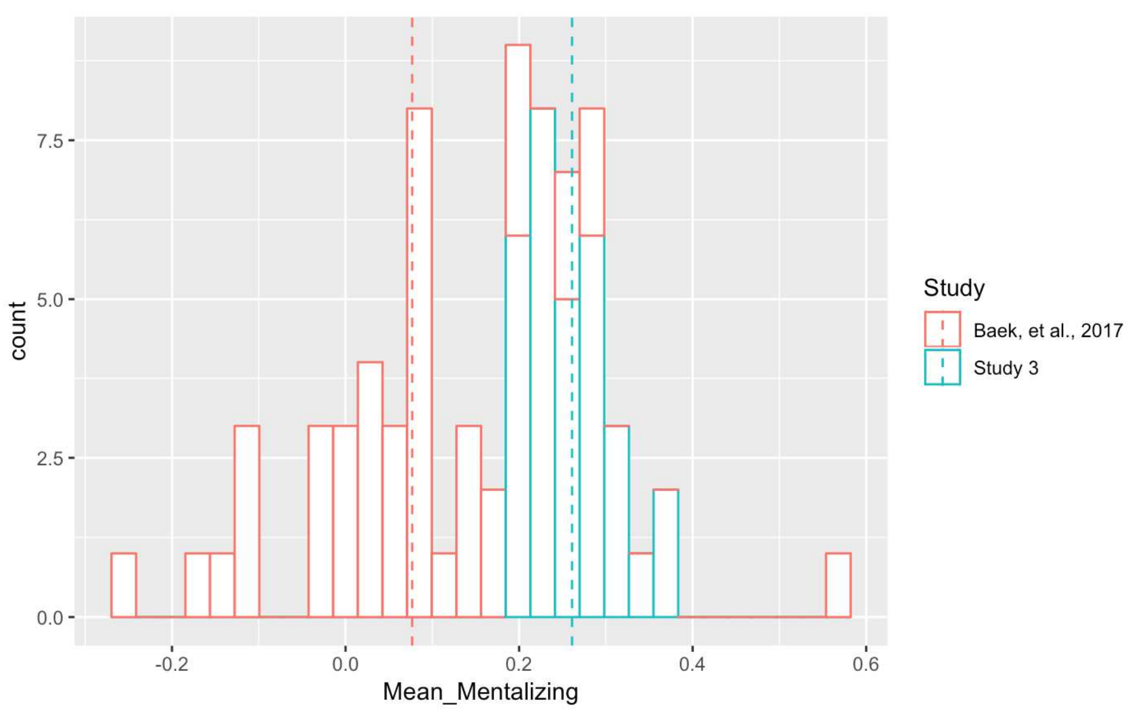
Plot: Communicators' Mean Correlation in Valuation Regions with Receivers Predicting Correlation of Benefit Ratings



Plot: Communicators' Mean Correlation in Valuation Regions with Receivers Predicting Correlation of Sharing Ratings



Histogram: Post-Hoc Comparison of Individual Differences in Mean Mentalizing Distribution in Study 3 and Baek, et al., (2017).



BIBLIOGRAPHY

Abraham, A., Pedregosa, F., Eickenberg, M., Gervais, P., Mueller, A., Kossaifi, J., … Varoquaux, G. (2014). Machine learning for neuroimaging with scikit-learn. *Frontiers in Neuroinformatics*. https://doi.org/10.3389/fninf.2014.00014

Adolphs, R. (2009). The social brain: neural basis of social knowledge. *Annual Review of Psychology*, *60*, 693–716. https://doi.org/10.1146/annurev.psych.60.110707.163514

Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: the medial frontal cortex and social cognition. *Nature Reviews Neuroscience*, *7*(4), 268–277. https://doi.org/10.1038/nrn1884

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of Other in the Self Scale and the Structure of Interpersonal Closeness. *Journal of Personality and Social Psychology*, *63*(4), 596–612. https://doi.org/10.1037/0022-3514.63.4.596

Baek, E. C., & Falk, E. B. (2018). Persuasion and influence: what makes a successful persuader? *Current Opinion in Psychology*. https://doi.org/10.1016/j.copsyc.2018.05.004

Baek, E. C., Scholz, C., O’Donnell, M. B., & Falk, E. B. (2017). The Value of Sharing Information: A Neural Account of Information Transmission. *Psychological Science*, *28*(7), 851–861. https://doi.org/10.1177/0956797617695073

Banissy, M. J., Kanai, R., Walsh, V., & Rees, G. (2012). Inter-individual differences in empathy are reflected in human brain structure. *NeuroImage*, *62*(3), 2034–2039. https://doi.org/10.1016/j.neuroimage.2012.05.081

Barasch, A., & Berger, J. (2014). Broadcasting and narrowcasting: How audience size affects what people share. *Journal of Marketing Research*, *51*(3), 286–299. https://doi.org/10.1509/jmr.13.0238

Bartra, O., McGuire, J. T., & Kable, J. W. (2013). The valuation system: A coordinate-based meta-analysis of BOLD fMRI experiments examining neural correlates of subjective value. *NeuroImage*, *76*, 412–427. https://doi.org/10.1016/j.neuroimage.2013.02.063

Bateman, A. W., & Fonagy, P. (Eds.). (2012). *Handbook of Mentalizing in Mental Health Practice*. Arlington, VA: American Psychiatric Publishing, Inc.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2014). lme4: Linear mixed-effects models using Eigen and S4. R package version 1.1-7, http://CRAN.R-project.org/package=lme4. *R Package Version*.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*(3), 497–529. https://doi.org/10.1037/0033-2909.117.3.497

Baumeister, R. F., Maranges, H. M., & Vohs, K. D. (2018). Human self as information agent: Functioning in a social environment based on shared meanings. *Review of General Psychology*, *22*(1), 36–47. https://doi.org/10.1037/gpr0000114

Bebbington, K., MacLeod, C., Ellison, T. M., & Fay, N. (2017). The sky is falling: evidence of a negativity bias in the social transmission of information. *Evolution and Human Behavior*, *38*(1), 92–101. https://doi.org/10.1016/j.evolhumbehav.2016.07.004

Berger, J. (2014). Word of mouth and interpersonal communication: A review and directions for future research. *Journal of Consumer Psychology*, *24*(4), 586–607. https://doi.org/10.1016/j.jcps.2014.05.002

Bolander, W., Satornino, C. B., Hughes, D. E., & Ferris, G. R. (2015). Social Networks Within Sales Organizations: Their Development and Importance for Salesperson Performance. *Journal of Marketing*, *79*(6), 1–16. https://doi.org/10.1509/jm.14.0444

Bond, R. M., Fariss, C. J., Jones, J. J., Kramer, A. D. I., Marlow, C., Settle, J. E., & Fowler, J. H. (2012). A 61-million-person experiment in social influence and political mobilization. *Nature*, *489*(7415), 295–298. https://doi.org/10.1038/nature11421.A

Bürkner, P.-C. (2013). brms : An R Package for Bayesian Multilevel Models using Stan. *Journal of Statistical Software*, *80*(Plummer), 1–28. https://doi.org/10.18637/jss.v080.i01

Burt, R. S. (2004). Structural Holes and Good Ideas 1. *American Journal of Sociology*, *110*(2), 349–399. https://doi.org/10.1086/421787

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. https://doi.org/10.1016/j.cub.2010.04.055

Cappella, J. N., Kim, H. S., & Albarracín, D. (2014). Selection and transmission processes for information in the emerging media environment: Psychological motives and message characteristics. *Media Psychology*, *3269*(June 2015), 1–29. https://doi.org/10.1080/15213269.2014.941112

Cascio, C. N., O'Donnell, M. B., Bayer, J., Tinney, F. J., & 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. https://doi.org/10.1509/jmr.13.0611

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.

Centola, D. (2011). An experimental study of homophily in the adoption of health behavior. *Science*, *334*(6060), 1269–1272. https://doi.org/10.1126/science.1207055

Chevalier, J. A., & Mayzlin, D. (2006). The Effect of Word of Mouth on Sales: Online Book Reviews. *Journal of Marketing Research*, *43*(3), 345–354. https://doi.org/10.1509/jmkr.43.3.345

Chua, H. F., Ho, S. S., Jasinska, A. J., Polk, T. A., Welsh, R. C., Liberzon, I., & Strecher, V. J. (2011). Self-related neural response to tailored smoking-cessation messages predicts quitting. *Nature Neuroscience*, *14*(4), 426–427. https://doi.org/10.1038/nn.2761

Chung, Y. S., Barch, D., & Strube, M. (2014). A meta-analysis of mentalizing impairments in adults with schizophrenia and autism spectrum disorder. *Schizophrenia Bulletin*, *40*(3), 602–616. https://doi.org/10.1093/schbul/sbt048

Cialdini, R. B., Demaine, L. J., Sagarin, B. J., Barrett, D. W., Rhoads, K., & Winter, P. L. (2006).

Managing social norms for persuasive impact. *Social Influence*, *1*(1), 3–15. https://doi.org/10.1080/15534510500181459

Cialdini, R. B., & Goldstein, N. J. (2004). Social influence: compliance and conformity. *Annual Review of Psychology*, *55*(1974), 591–621. https://doi.org/10.1146/annurev.psych.55.090902.142015

Cooper, N., Garcia, J. O., Tompson, S. H., O'Donnell, M. B., Falk, E. B., & Vettel, J. M. (2018). Time-evolving dynamics in brain networks forecast responses to health messaging. *Network Neuroscience*, *3*(1), 138–156. https://doi.org/10.1162/netn_a_00058

Cox, R. W. (1996). AFNI: Software for analysis and visualization of functional magnetic resonance neuroimages. *Computers and Biomedical Research, an International Journal*, *29*(3), 162–173. https://doi.org/10.1006/cbmr.1996.0014

Dietvorst, R. C., Verbeke, W. J. M. ., Bagozzi, R. P., Yoon, C., Smits, M., & van der Lugt, A. (2009). A Sales Force–Specific Theory-of-Mind Scale: Tests of Its Validity by Classical Methods and Functional Magnetic Resonance Imaging. *Journal of Marketing Research*, *46*(5), 653–668. https://doi.org/10.1509/jmkr.46.5.653

Dufour, N., Redcay, E., Young, L., Mavros, P. L., Moran, J. M., Triantafyllou, C., … Saxe, R. (2013). Similar brain activation during false belief tasks in a large sample of adults with and without autism. *PLoS ONE*, *8*(9). https://doi.org/10.1371/journal.pone.0075468

Dunbar, R. I. M. (2008). Why humans aren't just Great Apes. *Issues in Ethnology and Anthropology*, *3*(3), 15–33.

Esteban, O., Markiewicz, C. J., Blair, R. W., Moodie, C. A., Ayse, I., Erramuzpe, A., … Gorgolewski, K. J. (2018). FMRIPrep : a robust preprocessing pipeline for functional MRI, *5*, 1–20. https://doi.org/10.1101/306951

Falk, E. B., Cascio, C. N., O'Donnell, M. B., Carp, J., Tinney, F. J., Bingham, C. R., … Simons-Morton, B. G. (2014). Neural responses to exclusion predict susceptibility to social influence. *The Journal of Adolescent Health : Official Publication of the Society for Adolescent*

Medicine, *54*(5 Suppl), S22-31. https://doi.org/10.1016/j.jadohealth.2013.12.035

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. https://doi.org/10.1177/0956797612474670

Falk, E. B., O'Donnell, M. B., & Lieberman, M. (2012). Getting the word out: Neural correlates of enthusiastic message propagation. *Frontiers in Human Neuroscience*, *6*(November). https://doi.org/10.3389/fnhum.2012.00313

Falk, E. B., & Scholz, C. (2018). Persuasion, influence and value: Perspectives from communication and social neuroscience. *Annual Review of Psychology*, *69*. https://doi.org/10.1146/annurev-psych-122216-011821

Fiske, S. T., Cuddy, A. J. C., & Glick, P. (2007). Universal dimensions of social cognition: warmth and competence. *Trends in Cognitive Sciences*, *11*(2), 77–83. https://doi.org/10.1016/j.tics.2006.11.005

Franke, G. R., & Park, J.-E. (2006). Salesperson Adaptive Selling Behavior and Customer Orientation: A Meta-Analysis. *Journal of Marketing Research*, *XLIII*(4), 693–702. https://doi.org/10.1509/jmkr.43.4.693

Frith, C. D., & Frith, U. (2006). The Neural Basis of Mentalizing. *Neuron*, *50*(4), 531–534. https://doi.org/10.1016/j.neuron.2006.05.001

Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *358*(1431), 459–473. https://doi.org/10.1098/rstb.2002.1218

Gray, H. M., Gray, K., & Wegner, D. M. (2007). Dimensions of mind perception. *Science*. https://doi.org/10.1126/science.1134475

Happé, F. G. E. (1994). An advanced test of theory of mind: Understanding of story characters' thoughts and feelings by able autistic, mentally handicapped, and normal children and adults. *Journal of Autism and Developmental Disorders*, *24*(2), 129–154.

https://doi.org/10.1007/BF02172093

Kampe, K. K. W., Frith, C. D., & Frith, U. (2003). “Hey John”: Signals conveying communicative intention toward the self activate brain regions associated with “mentalizing,” regardless of modality. *The Journal of Neuroscience*, *23*(12), 5258–5263. https://doi.org/10.1002/hbm.21164

Kilduff, M., & Day, D. V. (1994). Do Chameleons get ahead? The effects of self-monitoring on managerial careers. *Academy of Management Journal*, *37*(4), 1047–1060. https://doi.org/10.2307/256612

Kilduff, M., Mehra, A., Gioia, D. A., & Borgatti, S. (2017). Brokering Trust to Enhance Leadership: A Self-Monitoring Approach to Leadership Emergence. In *Networks* (Vol. 35, pp. 221–240). https://doi.org/10.1007/978-3-319-45023-0_11

Kim, H. S. (2015). Attracting views and going viral: How message features and news-sharing channels affect health news diffusion. *Journal of Communication*, *65*, 512–534. https://doi.org/10.1111/jcom.12160

Klein, J. G. (1991). Negativity Effects in Impression Formation: A Test in the Political Arena. *Personality and Social Psychology Bulletin*, *17*(4), 412–418. https://doi.org/10.1177/0146167291174009

Klucharev, V., Hytönen, K., Rijpkema, M., Smidts, A., & Fernández, G. (2009). Reinforcement Learning Signal Predicts Social Conformity. *Neuron*, *61*(1), 140–151. https://doi.org/10.1016/j.neuron.2008.11.027

Klucharev, V., Smidts, A., & Fernandez, G. (2008). Brain mechanisms of persuasion: How “expert power” modulates memory and attitudes. *Social Cognitive and Affective Neuroscience*, *3*(4), 353–366. https://doi.org/10.1093/scan/nsn022

Kunda, Z. (1990). The Case for Motivated Reasoning. *Psychological Bulletin*, *108*(3), 480–498. Retrieved from http://synapse.princeton.edu/~sam/kunda90_psychol_bulletin_the-case-for-motivated-reasoning.pdf

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2014). lmerTest: Tests for random and fixed effects for linear mixed effect models (lmer objects of lme4 package). *R Package Version*. https://doi.org/http://CRAN.R-project.org/package=lmerTest

Lee, C. S., Ma, L., & Goh, D. H. L. (2011). Why do people share news in social media? *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *6890 LNCS*, 129–140. https://doi.org/10.1007/978-3-642-23620-4_17

Limbu, Y. B., Jayachandran, C., Babin, B. J., & Peterson, R. T. (2016). Empathy, nonverbal immediacy, and salesperson performance: the mediating role of adaptive selling behavior. *Journal of Business & Industrial Marketing*, *31*(5), 654–667. https://doi.org/10.1108/JBIM-03-2015-0048

Luyten, P., & Fonagy, P. (2015). The Neurobiology of Mentalizing. *Personality Disorders: Theory, Research, and Treatment*, *6*(4), 366–379. https://doi.org/10.1037/per0000117

McLaren, D. G., Ries, M. L., Xu, G., & Johnson, S. C. (2012). A Generalized Form of Context-Dependent Psychophysiological Interactions (gPPI): A Comparison to Standard Approaches. *Neuroimage*, *61*(4), 1277–1286. https://doi.org/10.1038/nmeth.2250.Digestion

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2002). Birds of a Feather: Homophily in Social Networks. *Annual Review of Sociology*, *27*(1), 415–444. https://doi.org/10.1146/annurev.soc.27.1.415

Nook, E. C., & Zaki, J. (2015). Social norms shift behavioural and neural responses to foods. *Journal of Cognitive Neuroscience*, *7*(7), 1412–1426. https://doi.org/10.1162/jocn

Noonan, M. A. P., Sallet, J., Mars, R. B., Neubert, F. X., O'Reilly, J. X., Andersson, J. L., … Rushworth, M. F. S. (2014). A Neural Circuit Covarying with Social Hierarchy in Macaques. *PLoS Biology*, *12*(9). https://doi.org/10.1371/journal.pbio.1001940

O'Donnell, M. B., Bayer, J. B., Cascio, C. N., & Falk, E. B. (2017). Neural bases of recommendations differ according to social network structure. *Social Cognitive and Affective*

Neuroscience, (January), nsw158. https://doi.org/10.1093/scan/nsw158

O'Keefe, D. J. (2017). Persuasion. *The Handbook of Communication Skills*, (10622). https://doi.org/10.4324/9780203007037.ch11

O'Reilly, J. X., Woolrich, M. W., Behrens, T. E. J., Smith, S. M., & Johansen-Berg, H. (2012). Tools of the trade: Psychophysiological interactions and functional connectivity. *Social Cognitive and Affective Neuroscience*, *7*(5), 604–609. https://doi.org/10.1093/scan/nss055

Oh, H., & Kilduff, M. (2008). The ripple effect of personality on social structure: Self-monitoring origins of network brokerage. *Journal of Applied Psychology*, *93*(5), 1155–1164. https://doi.org/10.1037/0021-9010.93.5.1155

Panagopoulos, N. G., & Ogilvie, J. (2015). Can salespeople lead themselves? Thought self-leadership strategies and their influence on sales performance. *Industrial Marketing Management*, *47*, 190–203. https://doi.org/10.1016/j.indmarman.2015.02.043

R Core Team. (2014). R: A Language and Environment for Statistical Computing. *R Foundation for Statistical Computing Vienna Austria*. Retrieved from http://www.r-project.org/

Rimer, B. K., & Kreuter, M. W. (2006). Advancing Tailored Health Communication: A Persuasion and Message Effects Perspective. *Journal of Communication*, *56*(s1), S184–S201. https://doi.org/10.1111/j.1460-2466.2006.00289.x

Rogers, E. M. (2003). Diffusion of Innovations Theory. In *New York: Free Press* (p. 5th ed.). https://doi.org/10.1111/j.1467-9523.1970.tb00071.x

Rozin, P., & Royzman, E. B. (2001). Negativity Bias, Negativity Dominance, and Contagion. *Personality and Social Psychology Review*, *5*(4), 296–320. https://doi.org/10.1207/S15327957PSPR0504

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*. https://doi.org/10.1037/h0077714

Schmälzle, R., Häcker, F. E. K., Honey, C. J., & Hasson, U. (2014). Engaged listeners: Shared neural processing of powerful political speeches. *Social Cognitive and Affective*

Neuroscience, *10*(8), 1137–1143. https://doi.org/10.1093/scan/nsu168

Scholz, C., Baek, E. C., O'Donnell, M. B., & Falk, E. B. (2019). Decision-making about broad- and narrowcasting: a neuroscientific perspective. *Media Psychology*, *0*(0), 1–25. https://doi.org/10.1080/15213269.2019.1572522

Scholz, C., Baek, E. C., O'Donnell, M. B., Kim, H. S., Cappella, J. N., & Falk, E. B. (2017). A neural model of valuation and information virality. *Proceedings of the National Academy of Sciences*, *114*(11), 201615259. https://doi.org/10.1073/pnas.1615259114

Scholz, C., Dore, B., Baek, E. C., O'Donnell, M. B., & Falk, E. B. (n.d.). *A neural propagation system: neurocognitive and preference synchrony in information sharers and their receivers*.

Scholz, C., & Falk, E. B. (2017). The Neuroscience of Information Sharing. In S. Gonzalez-Bailon & F. Welles (Eds.), *Handbook of Communication in the Networked Age*. Oxford University Press.

Schwarzer, G. (2019). *Package 'Meta.' CRAN*. https://doi.org/https://doi.org/10.1007/978-3-319-21416-0

Senecal, S., & Nantel, J. (2004). The influence of online product recommendations on consumers' online choices. *Journal of Retailing*, *80*(2), 159–169. https://doi.org/10.1016/j.jretai.2004.04.001

Sharot, T. (2011). The optimism bias. *Current Biology*, *21*(23), R941–R945. https://doi.org/10.1016/j.cub.2011.10.030

Shaw, J. I., & Steers, W. N. (2000). Negativity and Polarity Effects in Gathering Information to Form an Impression. *Journal of Social Behavior and Personality*, *15*(3), 399–412.

Skerry, A. E., & Saxe, R. (2015). Neural Representations of Emotion Are Organized around Abstract Event Features. *Current Biology*, *25*(15), 1945–1954. https://doi.org/10.1016/j.cub.2015.06.009

Sladky, R., Friston, K. J., Trostl, J., Cunnington, R., Moser, E., & Windischberger, C. (2011). Slice-timing effects and their correction in functional MRI. *NeuroImage*, *58*(2), 588–594.

https://doi.org/10.1016/j.neuroimage.2011.06.078

Sliwa, J., & Freiwald, W. A. (2017). Neuroscience: A dedicated network for social interaction processing in the primate brain. *Science*, *356*(6339), 745–749. https://doi.org/10.1126/science.aam6383

Snyder, M. (1974). Self-monitoring of expressive behavior. *Journal of Personality and Social Psychology*, *30*(4), 526–537. https://doi.org/10.1037/h0037039

Southwell, B. G., & Yzer, M. C. (2007). The Roles of Interpersonal Communication in Mass Media Campaigns. *Communication Yearbook*, *31*(September 2015), 419–462.

Spiro, R. L., & Weitz, B. A. (1990). Adaptive Selling: Conceptualization , measurement, and Nomological Validity. *Journal of Marketing*, *27*(1), 61–69. https://doi.org/10.2307/3172551

Tamir, D. I., & Mitchell, J. P. (2012). Disclosing information about the self is intrinsically rewarding. *Proceedings of the National Academy of Sciences*, *109*(21), 8038–8043. https://doi.org/10.1073/pnas.1202129109

Tamir, D. I., Thornton, M. A., Contreras, J. M., & Mitchell, J. P. (2016). Neural evidence that three dimensions organize mental state representation: Rationality, social impact, and valence. *Proceedings of the National Academy of Sciences*, *113*(1), 194–199. https://doi.org/10.1073/pnas.1511905112

Thornton, M. A., Weaverdyck, M. E., & Tamir, D. I. (2018). The Social Brain Automatically Predicts Others' Future Mental States. *The Journal of Neuroscience*, *39*(1), 140–148. https://doi.org/10.1523/jneurosci.1431-18.2018

Traxler, M. J., & Gernsbacher, M. A. (1992). Improving written communication through minimal feedback. *Language and Cognitive Processes*, *7*(1), 1–22. https://doi.org/10.1080/01690969208409378

Tremblay, S., Sharika, K. M., & Platt, M. L. (2017). Social Decision-Making and the Brain: A Comparative Perspective. *Trends in Cognitive Sciences*, *21*(4), 265–276. https://doi.org/10.1016/j.tics.2017.01.007

Vaish, A., Grossmann, T., & Woodward, A. (2013). Not all emotions are created equal: The negativity bias in social- emotional development. *Psychological Bulletin*, *134*(3), 383–403. https://doi.org/10.1037/0033-2909.134.3.383.Not

Wagner, D. D., Kelley, W. M., & Heatherton, T. F. (2011). Individual differences in the spontaneous recruitment of brain regions supporting mental state understanding when viewing natural social scenes. *Cerebral Cortex*, *21*(12), 2788–2796. https://doi.org/10.1093/cercor/bhr074

Wang, S., Hu, Q., & Dong, B. (2015). Managing personal networks: An examination of how high self-monitors achieve better job performance. *Journal of Vocational Behavior*, *91*(October 2015), 180–188. https://doi.org/10.1016/j.jvb.2015.10.005

Wang, Z., & Su, Y. (2013). Age-related differences in the performance of theory of mind in older adults: A dissociation of cognitive and affective components. *Psychology and Aging*, *28*(1), 284–291. https://doi.org/10.1037/a0030876

Wasylyshyn, N., Falk, B. H., Garcia, J. O., Cascio, C. N., O'Donnell, M. B., Bingham, C. R., … Falk, E. B. (2018). Global brain dynamics during social exclusion predict subsequent behavioral conformity. *Social Cognitive and Affective Neuroscience*, *13*(2), 182–191. https://doi.org/10.1093/scan/nsy007

Welborn, B. L., Lieberman, M. D., Goldenberg, D., Fuligni, A. J., Galván, A., & Telzer, E. H. (2015). Neural mechanisms of social influence in adolescence. *Social Cognitive and Affective Neuroscience*, *11*(1), 100–109. https://doi.org/10.1093/scan/nsv095

Williams, W. C., Morelli, S. A., & Zaki, J. (2018). Interpersonal Emotion Regulation: Implications for Affiliation, Perceived Support, Relationships, and Well-Being Interpersonal Regulation Questionnaire View project Positive applications of social norms View project. *Article in Journal of Personality and Social Psychology*, *115*(2), 224–254. https://doi.org/10.1037/pspi0000132

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, *13*(1), 103–128. https://doi.org/10.1016/0010-0277(83)90004-5

Yarkoni, T., Poldrack, R. a, Nichols, T. E., Van Essen, D. C., & Wager, T. D. (2011). Large-scale automated synthesis of human functional neuroimaging data. *Nat. Methods*, *8*(8), 665–870. https://doi.org/10.1038/nmeth.1635

Yoo, J. H. (2009). The power of sharing negative information in a dyadic context. *Communication Reports*, *22*(1), 29–40. https://doi.org/10.1080/08934210902798510

Zaccaro, S. J., Foti, R. J., & Kenny, D. a. (1991). Self-monitoring and trait-based variance in leadership: An investigation of leader flexibility across multiple group situations. *Journal of Applied Psychology*, *76*(2), 308–315. https://doi.org/10.1037/0021-9010.76.2.308

Zaki, J., Schirmer, J., & Mitchell, J. P. (2011). Social influence modulates the neural computation of value. *Psychological Science*, *22*(7), 894–900. https://doi.org/10.1177/0956797611411057