Persuasion neuroscience: New potential to test dual-process theories

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Although interest in various topics in social psychology has waxed and waned over the years, "persuasion must surely be among the 'nearest and dearest' to the heart of our discipline" (Kruglanski, Thompson, & Spiegel, 1999; p. 293). Indeed, the study of persuasive influence has been a mainstay in the field since the early 20th century. Whether it was a matter of keeping kids off crime (Blumer & Hauser, 1933), convincing housewives to use cheaper cuts of meat (Lewin, 1943), or encouraging citizens to buy war bonds (Cartwright, 1947), legislators hoped to encourage everyday Americans to change their attitudes and habits for the good of the country, and they needed the most effective advertising to get the message across. With mass communication enjoying an exponential boom and recent burgeoning of social science research, academics were ideally positioned to embark on widespread systematic investigation of propaganda, both enhancing basic research and providing practical prescriptions to the media.

Research in the mid 20th century took an important first step in establishing the boundary conditions of persuasive influence, delving into the subtle nuances of effective message features, characteristics of persuasive spokespeople, and individual differences in propensity to be persuaded. However, this work yielded inconsistent results. People sometimes expressed overt attitude changes and consequently behaved in line with their expressed attitudes, but they often did not (Ajzen & Fishbein, 1977). Out of this inconsistency grew an interest in implicit attitudes, and with it, a whole host of new questions. Could someone's "true" attitudes be accessed, and if so, would it actually be possible to change them? Could they predict behavior better than explicit measures?

Dual-process theories, which highlight both automatic and controlled routes to persuasion, grew in part to address questions like these under a more comprehensive framework, and with them came new methods in an effort to get inside the black box of implicit attitudes. As

with any new branch of research, some of these paradigms were quite successful in unleashing new explanatory power, while others have not held up over time. For instance, the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1988)—despite some criticism (Blanton, Jaccard, Christie, & Gonzales, 2007)—has remained a very influential measure in prejudice research. In contrast, marketers thrilled with the possibilities of subliminal advertising soon learned that the effects were often quite limited (Strahan, Spencer, & Zanna, 2002; Karremans, Stroebe, & Claus, 2006).

As another common method to assess the precursors of both explicit and implicit attitudes, fMRI methodology may prove to be particularly attractive to persuasion researchers because it allows scientists to assess implicit processes indirectly without interrupting explicit processes—that is, participants can respond to stimuli in the scanner while their neural responses to the stimuli are recorded, either in parallel with explicit evaluation, or without the need for such explicit judgments. Importantly, some of these neural responses contain very different information than the explicit judgments. Coming full circle, the extant fMRI literature on persuasion has focused largely on topics such as public service announcements (Falk, Berkman, & Lieberman, 2012; Wang et al., 2013), health campaigns (Falk et al., 2010; Chua et al., 2009; Chua et al., 2011), and entertainment media (Stallen et al., 2010; Falk et al., 2013), topics closely aligned with the early focus on mass media in this field.

What next steps are needed to further explore the use of fMRI and other new technology in the persuasion toolkit? A more formal integration of existing behavioral theory and testing via neuroimaging is at hand. Already, we have begun to think about how existing dual-process frameworks may or may not map on to neural function the more we learn about it, and whether alternative models might be more appropriate (e.g., Langleben et al., 2009; Shrum et al., 2012).

This chapter will cover a brief history of the development of dual-process and alternative theories in behavioral research on persuasion, provide an overview of the fMRI work that has been conducted in this domain, and provide suggestions on how future neuroimaging work might be employed to provide greater insight into established theories and application. In so doing, we hope to highlight the ways in which this work might inform modern-day message designers big and small, from those hoping to change attitudes about burning issues such as smoking cessation to those aiming to boost box office earnings on their next film.

Supporting the war effort: The early days

An area of concern once relegated to ad men, persuasive messaging became of huge interest to government officials and social scientists alike beginning during the inter-war period and surging during World War II. World War I represented the first formal mass media approach to propaganda, and analysis of its effectiveness during the post-war period raised serious concerns about potential brainwashing effects (Jowett, 1987). It was initially thought that viewers of persuasive media passively received the information as truth, such that intense mass media efforts would create a nation completely homogeneous in opinion. For example, concern over the detrimental effects of movies on children prompted the Payne Fund Studies, which ran from 1929 to 1932 and focused on the direct relationship between media consumption and serious effects such as crime, sleep disruption, and attitudes toward various racial groups (e.g., Blumer, 1933; Blumer & Hauser, 1933; Charters, 1933; Cressey & Thrasher, 1934; Dale, 1935a; Dale, 1935b; Dysinger, & Ruckmick, 1933; Peterson & Thurstone, 1933; Renshaw, Miller, & Marquis, 1933). Similarly, work on the effects of the fictional radio broadcast "The War of the Worlds" emphasized how the alien invasion drama caused sizeable effects on listeners' attitudes

and behaviors (Cantril, 1952). Despite early interest in how seriously media could warp people's minds, such theories were quickly criticized as discounting the public's ability to resist persuasive appeals (Hovland, Janis, & Kelly, 1953). Subsequently, work in this domain shifted instead to attempting to uncover what makes some messages more effective than others. In the wake of World War II, U.S. defense agencies enlisted the counsel of social psychologists to conduct experiments on wartime persuasive efforts.

Hovland, Lumsdaine, and Sheffield (1949) ran a series of studies for the Experimental Section of the Research Branch in the War Department's Information and Education Division, investigating whether the Army's newfound interest in using film for persuasive purposes indeed achieved its desired outcomes. One film collection of interest was the "Why We Fight" series shown to soldiers, which the authors deemed "the largest-scale attempt yet made in this country to use films as a means of influencing opinion" (p. 21). With such films, the perception of media changed from a means of simply transmitting information to a means of truly changing the attitudes, goals, and motivations of an audience. Contrary to prior fears about mass indoctrination, these early studies illustrated that while these films changed attitudes about some specific issues detailed in the films, they did little to change more general attitudes toward war or boost soldier morale.

These studies were more influential in generating hypotheses about what message features might make an argument more or less effective, which in effect forms the basis for much of the work in persuasive messaging to date. In one landmark study within the same collection, for instance, the researchers examined the effect of presenting both sides of an argument as opposed to only one side. They found that although both-sided arguments and one-sided arguments are equally persuasive overall, both-sided arguments tend to be more persuasive for

individuals who are initially opposed to the argument at hand, while one-sided arguments tend to be more persuasive for individuals who already endorse the argument at baseline. One exception to the effectiveness of both-sided arguments, however, occurs when there are strong refutations for the counterargument. Already some foreshadowing of dual-process thinking can be seen in the authors' explanation for these results —they posited that initially opposed participants may not be convinced by one-sided arguments because they would be triggered to simply "rehearse their own position and seek new ways of supporting it" rather than to think deeply about the persuasive message (Hovland et al., 1953, p. 203). Presenting both sides, the authors reasoned, may prevent this effect and cause those participants to consider the argument more thoughtfully. Such thinking aligns with later dual-process accounts in positing conditions under which message recipients might engage automatic or more deliberative processing in forming evaluations about a message.

After the war, these researchers started a wave of experimental inquiry into persuasive messaging. Hovland and colleagues developed the Yale Communication Research Program, which focused on how people learn message content and consciously accept or reject it (Hovland, Janis, & Kelley, 1953; Fiske & Taylor, 2008). Hoping to improve on prior research that simply compared effectiveness of different messages without delving into underlying causality, they called for an "increased emphasis on the isolation of basic factors related to general theoretical formulations" (Hovland, Janis, & Kelley, 1953; p. 4). Specifically, they examined which features of the message source, the message itself, the recipient, and the modality affect attitude change. For instance, they found that high credibility sources are more persuasive than low credibility sources, mild fear appeals are more persuasive than moderate or high fear appeals (but for more recent evidence to the contrary, see Earl & Albarracin, 2007),

and that role playing support for an argument leads to more attitude change than simply reading the argument. Interestingly, however, dual-process-like accounts are present in the authors' conclusions regarding remaining issues in persuasion theory. Specifically, they distinguished among attention, comprehension, and acceptance of messages, noting that factors that cause attention to be high or low may affect how well messages are comprehended and subsequently accepted or rejected. They called for more testing of these moderating factors and theory building that might encompass a process involving all three steps (attention, comprehension, and acceptance).

Although some foreshadowing of dual-process accounts can be seen in this era, in general work from this time emphasized conscious attitudes. For instance, in cognitive response analysis, an examination of participants' reported cognitions—particularly counterarguments—in response to a persuasive message were related to the amount of subsequent attitude change (Brock, 1967). A mediational path was hypothesized wherein high or low counterarguing mediated the relationship between the stimulus message and a cognitive attitude change response (Fiske & Taylor, 2008). Similarly, in McGuire's chain of persuasion, steps such as attention, comprehension, and retention were required for persuasion to take place (1969, 1976; Fiske & Taylor, 2008). Although Hovland, Janis, and Kelley (1953) acknowledged that overt opinions may not always correspond with covert or implicit opinions and that implicit opinions may in fact guide behavior more, they reserved these discrepancies for more controversial domains ("e.g., preferences relating to perverse sexual practices or hostile evaluations of authority figures," p. 8). For relatively benign issues, they argued that reported attitudes are generally sufficient markers of internal cognitive response. These theories were instrumental in providing the groundwork for modeling persuasion; however, growing interest in implicit processes

throughout the 60s and 70s sparked a new wave of persuasion theories, and with them, shifting paradigms.

Emergence of dual-process models to persuasion

At the time that dual-process models began to emerge, existing findings on attitude change were largely inconsistent, putting the field "in a state of disarray, to say the least" (Petty & Wegener, 1999; p. 41). Factors such as expert sources or negative affect were hypothesized to have consistent effects but often produced opposing findings in different contexts (e.g., Kelman & Hovland, 1953; Sternthal, Dholakia, & Leavitt, 1978; Zanna, Kiesler, & Pilkonis, 1970; Leventhal, 1970). As cognitive psychology developed in the latter half of the century, the assumption of limited cognitive capacity began to guide theory regarding attitude formation and change, providing a parsimonious explanation for why effects could vary under different conditions (Bruner, Goodnow, & Austin, 1956; Moskowitz, Skurnik, & Galinsky, 1999). In particular, the thought was that in order to conserve capacity, we use mental shortcuts to process incoming information more efficiently. As applied to persuasive influence, this 'least effort principle' suggests that when provided with a new persuasive message, individuals initially accept the information as true, and only through exertion of extra cognitive processing do they find potential flaws and consider the argument with more nuance (Gilbert, Krull, & Malone, 1990). While this exact argument has been tempered somewhat, the basic idea remains in dual-process theories of persuasion that because of limited cognitive capacity, we sometimes rely on mental shortcuts to assess the validity of a message when we are otherwise cognitively taxed or unmotivated to exert extra effort.

The Heuristic-Systematic Model (HSM), for instance, relies on the sufficiency principle, arguing that when encountering a message, individuals optimize between minimal effort and addressing current motivational concerns; specifically, when making a judgment, people will exert effort until their actual confidence about an opinion reaches the sufficiency threshold, or their desired confidence (Chaiken, Giner-Sorolla, & Chen, 1996; Chaiken, Liberman, & Eagly, 1989; Simon, 1976; Chen & Chaiken, 1999). Therefore, it acknowledges that the processes outlined in prior models like McGuire's chain of persuasion may very well happen, but only when people are sufficiently motivated and have adequate capability (Chaiken, 1980; Chen & Chaiken, 1999; Eagly & Chaiken, 1993). Sufficient motivation might include accuracy, defensiveness, or impression management motives (Chaiken, Liberman, & Eagly, 1989). Provided the required motivation and ability are available, the model posits, people engage in systematic processing of a message and evaluate the pros and cons of the message's arguments. The likelihood of systematic processing can be increased by certain factors, such as evaluating a topic of high personal relevance, evaluating messages that affect important consequences, being the only person responsible for evaluating the message, or being told that the majority opinion differs from one's own (Fiske & Taylor, 2008). Systematic processing involves greater attention to the valence and quality of the message, and it results in greater memory of message details, promoting lasting attitude change (Axsom, Yate, & Chaiken, 1987; Mackie, 1987; McFarland, Ross, & Conway, 1984). Should sufficient motivation or ability not be available, people engage in heuristic processing, instead relying on well-engrained rules of thumb to guide their appraisal of the message. These heuristics include shortcuts such as message length, source attractiveness, or source expertise (Mackie & Worth, 1989; Wood, Kallgren, & Preisler, 1985). Importantly, the

HSM posits that systematic processing involves conscious thought but that heuristic processing may be either conscious or unconscious (Chen & Chaiken, 1999).

Similarly, the Elaboration Likelihood Model (ELM) specifies conditions under which people might evaluate a message more or less deeply (Figure 1; Petty & Cacioppo, 1981, 1986; Petty & Wegener, 1998). According to the ELM, people are motivated to hold correct attitudes; therefore, the extent to which they are persuaded depends on the strength of the arguments in a message, but again only when they have sufficient motivation and ability to process the message. Conditions affecting motivation can include situational variables such as personal relevance of the topic, or individual differences such as uncertainty orientation or need to evaluate (Sorrentino, Bobocel, Gitta, Olso, & Hewitt, 1988; Sorrentino & Hancock, 1987; Sorrentino & Short, 1986; Jarvis & Petty, 1996; Tormala & Petty, 2001). As with the HSM, when these conditions are not met, people rely on peripheral cues to evaluate the message. Indeed, studies that have tested these moderating variables have indicated that persuasive outcomes can vary widely based on which route (central or peripheral) is operating in response to the message. For instance, one study found that argument quality is a greater predictor of attitude change when the issue is personally relevant (central route), but celebrity endorsement is a greater predictor when the issue is not personally relevant (peripheral route; Petty, Cacioppo, & Schumann, 1983). The ELM also postulates that cues are not consistently only central or peripheral; they can be either based on context. For instance, source attractiveness would be a peripheral cue for an advertisement about a car, but it could serve as a central cue for a beauty product; empirical work indicates that this is the case for products such as shampoo (Petty & Cacioppo, 1980) and razors (Kahle & Homer, 1985).

While it is not our intention to detail the distinction between the ELM and HSM, a few differences are worth noting. First, the ELM argues that greater motivation and processing ability push an individual toward central processing and away from peripheral processing, while the HSM allows for both modes (systematic and heuristic) to be highly influential when motivation and ability are high. Second, the ELM posits that a drive toward accuracy is the major motivational force toward deeper processing, which the HSM delineates three types of motives (accuracy, defense, and impression) and treats motivation as orthogonal to depth of processing (Chen & Chaiken, 1999).

Out of these more general dual-process models, others have developed specifically for particular domains of persuasion. For instance, the Persuasion Knowledge Model is tailored for persuasive processes in marketing research (Figure 2; Friestad & Wright, 1994; Shrum et al., 2012). A central tenet of this model is that consumers start to identify persuasion tactics in marketing over time and adapt in kind based on personal motivations. Any given "persuasion episode" consists of an agent's persuasion attempt and the target's evaluation along two dimensions: 1) perceived effectiveness, and 2) perceived appropriateness. Motivation to activate knowledge of persuasion is found to increase with factors such as unfamiliar agents, having experienced similar persuasion tactics prior, and use of unusual persuasion tactics. It can be decreased when the agent is perceived to be providing leeway and when the agent is not perceived as relevant in the target's relationships. Empirical testing of this theory has found that consumers do in fact develop schemas regarding persuasion tactics specific to different product categories and that these schemas affect how they process persuasive messaging in these different domains (Hardesty, Bearden, & Carlson, 2007; Friested & Wright, 1995). However, awareness of tactics does not necessarily render them ineffective. Chan and Sengupta (2010)

found, for instance, that implicit attitudes toward a marketer using flattery are more positive than explicit attitudes, and further are better predictors of behavioral intentions than explicit attitudes. In contrast, a study on product placement revealed that extremely salient placements reduce brand attitudes (Cowley & Barron, 2008).

Similarly, theories of narrative persuasion developed in the communication and consumer research literature to explain how stories may cause incidental attitude changes even though they are often not explicitly persuasive (Green & Brock, 2000; Slater & Rouner, 2002; Gerrig, 1993). While not couched in a dual-process framework per se, this work often draws parallels to the ELM and HSM while making important distinctions—indeed, Slater refers to his model as the "extended ELM" (2002). For instance, while the ELM and HSM emphasize the degree of cognitive processing as an important factor influencing persuasive outcomes, theories around narrative emphasize a qualitatively different construct of engagement with or immersion into the narrative as the crucial factor of influence, typically called "transportation" (Slater & Rouner, 2002; Green & Brock, 2000; Escalas, 2004). The degree of transportation can be influenced by a number of factors including personal identification with story characters (Basil, 1995; Rubin, Perse, & Powell, 1985; Zillmann & Bryant, 1994), or, to a lesser extent, issue involvement (Slater, 1997; Slater, 2002), but essentially these scholars argue that narratives that promote higher transportation increase persuasive impact by *decreasing* tendencies typically associated with deeper cognitive processing in the persuasion literature such as counterarguing (Slater & Rouner, 2002). The effect of transportation on persuasive outcomes even holds regardless of whether the narrative is described as fiction or non-fiction (Green & Brock, 2000). Therefore, although transportation theory borrows dual-process elements in terms of hypothesizing factors that increase connection to a narrative or decrease counterarguing efforts, it posits transportation

as a unifying process promoting persuasion rather than outlining dissociable routes. Interestingly, foreshadowing some of the findings in persuasion neuroscience, this work highlights the important of personal connection to the narrative, in terms of both homophily with characters and identification with the story's themes (Slater & Rouner, 2002). Though not stated outright, then, these data dovetail nicely with imaging work supporting the importance of value to self as a mechanism toward persuasive outcomes.

Alternatives to dual-process models

While dual-process models were developed to provide a parsimonious explanation for diverging results in prior work, more recent alternative models have attempted to simplify these explanations even further under a single-process framework. Perhaps the best known is Kruglanski's Unimodel, which treats automatic and deliberative modes as special cases of the same information processing procedure (Kruglanski & Thompson, 1999; Kruglanski, Thompson, & Spiegel, 1999). Based on the lay epistemic theory (LET; Kruglanski, 1989), which suggests a more general process for the formation of subjective knowledge, the unimodel views persuasion as a process of hypothesis testing affected by various factors: 1) the structure of evidence for or against the hypothesis, and 2) cognitive, 3) ability, and 4) motivational capacities which determine depth and direction of inference (Kruglanski, Thompson, & Spiegel, 1999). Peripheral cues and message content are both treated more generally as pieces of evidence that can be used simultaneously in hypothesis testing through a process akin to syllogistic reasoning. Essentially, the unimodel argues that persuasion occurs in an 'if-then' fashion; given relevant evidence (whether peripheral cues or substantive message content), individuals evaluate the probability of the argument being true. If this probability is above a certain threshold, they are subsequently

persuaded. While dual-process models tend to rank message arguments as more relevant to deep consideration of an argument's quality, the unimodel posits that both types of persuasive evidence can be greatly or minimally relevant depending on the context. Revisiting prior dual-process work through a single-process lens, unimodel proponents find that message arguments were often confounded with length (i.e., longer than peripheral cues) and ordinal position (i.e., presented after peripheral cues), which could explain why they were more difficult to process for reasons other than merely being message arguments (Petty, Cacioppo, & Goldman, 1981). When controlling for these external variables in later studies, these researchers find support for the notion that peripheral/heuristic cues and message content may be functionally equivalent (e.g., Pierro et al., 2005; Kruglanski et al., 2006).

A neurocognitive approach to persuasion

With decades of multi-process and single-process theory building in the behavioral literature now available, neuroimaging researchers are ideally positioned to add value to the ways in which these different accounts have modeled the cognitive underpinnings of persuasion, both on a theoretical level and on a practical level. First, imaging methods allow us to temporally map specific cognitive processes occurring over the course of exposure to and consideration of a message (Izuma, 2013). Second, they avoid issues of the inability of participants to accurately introspect and report attitudes that are predictive of subsequent behaviors (Wicker, 1969; Nisbett & Wilson, 1977). Third, as will be covered below, fMRI studies have demonstrated a power to significantly predict persuasion-related outcomes over and above self-report (Falk et al., 2010; Falk et al., 2011). Finally, and perhaps most unique, they allow the researcher to interrogate multiple processes at once without interrupting the participant—in other words, we are able to

assess participants' gut reactions to a message during message exposure, before we would traditionally have the chance to ask them their explicit opinion (at which point they have had time to process their thoughts and form a conscious attitude to some extent). Furthermore, we can examine these cognitive processes without requiring participants to make any response at all, although the option to pose questions to participants in the scanner is still of course available. We can also examine the relationship between these initial gut reactions and subsequent outcomes such as delayed memory (Langleben et al., 2009). This provides a naturalistic experience more akin to how individuals process messages in everyday life, without immediately being probed for an opinion, which may contaminate responses (Wilson & Schooler, 1991).

To the point of this chapter's discussion of dual- and single-process models, it is unlikely that participants unfamiliar with theories of persuasion would be able to articulate what kinds of cues or information are affecting their attitudes—not to mention that asking them to do so could easily affect depth of processing. Even if we can assess some of the causal factors of distal behaviors by manipulating certain variables (e.g., argument strength, issue involvement), the cognitive processes involved in individuals' final computation of their attitudes, ratings on a scale, or other judgments remain inaccessible. Rather, by unobtrusively tracking the networks engaged in message processing, we may gather an objective proxy of route(s) to persuasion as they occur in real-time. The review below covers the early literature combining persuasion and neuroimaging and then suggests some ways in which neuroimaging methods might inform ongoing debates.

Following a long tradition in persuasion research of manipulating source expertise, Klucharev, Smidts, and Fernandez (2008) performed one of the first persuasion neuroscience investigations. Replicating behavioral work, they found that source expertise and attractiveness

in advertisements for various products are associated with greater purchase intentions. However, their major advance involved the neural correlates associated with an expertise-by-purchase intention interaction. Specifically, they found that perceived source expertise impacts activation in the caudate nucleus and medial prefrontal cortex (MPFC) in Brodmann area (BA) 10, which predicts positive attitudes toward the products. They interpreted these findings to suggest that the persuasive impact of expert sources may lie in their ability to modulate "perceived value, trust or risk-reward tradeoffs" (p. 364). Moreover, this paper was seminal in highlighting the ways in which a neuroscience approach to persuasion can supplement prior work. Relevant to this chapter's focus on dual-process thinking, the authors suggested that "whereas under low elaboration expertise is generally considered to work as a peripheral cue, on the neural level expertise appears to activate a combination of three processes: more semantic processing and elaboration on the celebrity-object combination (leading to) a deeper encoding of the object, and an emotional induction of trust to the object" (p. 363). Thus, these initial findings suggested that prior distinctions between peripheral cues and deeper message content may not map on quite as cleanly to neurocognitive evaluations of an attitude object. However, it is important to note that the study did not explicitly set out to evaluate dual-process accounts of persuasion and thus was not positioned make definitive claims about them.

Shortly after these initial findings, an upsurge of additional work began to identify consistent neural correlates of persuasive influence, often manipulating factors traditionally used in behavioral persuasion research. For instance, Chua et al. (2009) contrasted high and low tailoring (i.e., adaptation to the particular needs and interests of the message recipient) of smoking cessation ads. In this initial investigation, they found that MPFC (BA9 & 10) and precuneus (BA7) activity is associated with self-reports indicating that the messages are more

self-relevant. Citing prior work indicating that self-relevant health messages tend to be particularly effective (Stretcher, Shiffman, & West, 2006; Dijkstra, 2005), they argued that these regions may in turn be predictive of persuasive outcomes such as behavior change. Additionally, they suggested that self-relevant thinking "promotes elaboration, organization of encoded information, and enhanced memory and helps people choose which motivational and behavioral representations would guide behavior" (p. 167), which seems at least on some level to align with dual-process thinking in that activating self-relevant constructs might support central route processing.

Moving beyond using brain activity as an outcome, the next wave of research examined whether activity in certain regions could in fact *predict* downstream behavior change. Initial work in our lab demonstrated that activation in an a priori MPFC Region-of-Interest (ROI, overlapping BA10/11) during viewing of sunscreen ads predicted sunscreen use in the following week (Falk et al., 2010). Particularly informative, a cross-validation approach revealed that this MPFC activation predicted, on average, 23% more of the variance in this behavior than did self-reported intentions to wear sunscreen. In effect, this study not only extended support for the notion of a tenuous/imperfect connection between self-reported intentions and behavior but further provided an alternative method that might better predict long-term behavior change from a thin slice of time during receipt of persuasive messages (Wicker, 1969).

Later work confirmed the effectiveness of this "brain-as-predictor" method by using a behavior that is much harder to change (smoking cessation vs. sunscreen use) and using a more accurate gauge of behavior change (carbon monoxide levels for smoking cessation vs. self-reported sunscreen use; Berkman & Falk, 2013). Falk et al. (2011) again found that activity in an MPFC ROI during message receipt successfully predicts behavior change, this time

operationalized as smoking cessation behavior up to a month after initial exposure to anti-smoking ads (Figure 3). Moreover, adding this neural activity to an existing model predicting behavior change from self-reported intentions, self-efficacy, and ability to relate to the message doubled the variance explained, significantly increasing predictive ability.

Chua and colleagues found additional support for downstream behavioral effects of initial neurocognitive processing with evidence indicating that activation in DMPFC (BA9, 10) and precuneus (BA31, 7) is associated with tailored messages, and moreover that this activation during tailored messages predicts smoking cessation 4 months later (Chua et al., 2011). Similarly, Wang et al. (2013) manipulated argument strength (AS) and message sensation value (MSV) in smoking cessation advertisements and found that high AS and DMPFC activation are significantly associated with lower cotinine levels (i.e., less smoking) one month later. Again, they suggested that self-relevant processing may be a focal mechanism in behavior change, noting the relationship between DMPFC activity and forming intentions for future behavior (den Ouden et al., 2005; Buckner & Carroll, 2007). However, they made a slightly different argument than Chua and colleagues with respect to dual-process thinking in that they viewed self-relevant cognition as oppositional to devoting attention to the stimulus at hand. They found that the highest *deactivation* in DMPFC occurs during the high AS/high MSV ads, during which they suggested that participants may be devoting the most attention to the external stimulus (i.e., the ad) and the least to intention formation (i.e., self-relevant cognition), ultimately leading to less behavior change.

Finally, work in our lab extended this predictive approach beyond behavior change in the participants directly in the study to entire regions of the U.S. exposed to the ads that study participants saw (Falk et al., 2012). In this study, participants viewed ads for three different

smoking cessation campaigns in the scanner and made predictions about which campaign would fare best. Calls to a smoking cessation hotline were then tracked in response to each campaign. While participants' (and experts') rank predictions about the relative effectiveness of each campaign were inaccurate, activity in the MPFC ROI successfully predicts which campaign was the most, intermediate, and least effective (Figure 3). Additionally, this study suggests important implications for the relationship between dual-process models and emerging neurocognitive thought about persuasion. Specifically, it included a self-report measure to gauge self-relevance ("To what extent can you relate to this advertisement?"), but the measure did not mediate the relationship between neural activity and behavior change. Therefore, rather than reflecting a conscious, deliberative evaluation of self-relevance, MPFC activity may be indexing a more implicit process. Indeed, this region has been implicated in a variety of automatic processes such as implicit valuation and affective judgments (Damasio, 1996), implicit preference processing (McClure et al., 2004), implicit self-relevance (Moran, Heatherton, & Kelley, 2009; Rameson, Satpute, & Lieberman, 2010), consideration of self-relevant goals (D'Argembeau et al., 2010), and implicit value signals of choices and preferences (Hare, Malmaud, & Rangel, 2011; Knutson et al., 2007). And, in a similar vein as the smoking cessation results, Berns and Moore (2012) found that although adolescents' subjective ratings of songs does not correlate with the songs' population-wide commercial success, activity in the ventral striatum is significantly associated with album sales. It seems plausible, then, that in the domain of persuasion, MPFC activity may be indexing implicit self-related processing or value signaling that guides subsequent behavior change rather than indexing a more deliberative process; however, this region has also been considered a candidate for more deliberative types of processing (Satpute & Lieberman, 2006; Lieberman, 2007). Therefore, future work will be needed to reconcile these accounts.

In addition, there is preliminary support for the impact of these regions not only in personal and population-level persuasion, but also in message propagation, or a chain of persuasive influence from person to person. In one study, a group of participants was exposed to a variety of ideas for television pilots, which they could subsequently choose whether or not to recommend to another group of participants who they were told would make the ultimate decision whether or not to put each pilot into production (Falk et al., 2013; Falk, O'Donnell, & Lieberman, 2012). Activity in a group of regions including DMPFC, precuneus, striatum, and temporoparietal junction during initial exposure to the pilots in the first group of participants was significantly correlated with the ultimate success of the show ideas (i.e., average idea preference in the *second* group of participants). Thus, it seems that the importance of regions associated with self-relevant processing, and in addition mentalizing, extends beyond how persuaded an individual is when initially exposed to a message. Rather, activity in these regions among direct message recipients during message exposure predicts how effectively they will spread enthusiasm for the message among those with whom they discuss it (who have never been exposed to the message firsthand).

Persuasion neuroscience and dual-process models: Suggestions for programmatic research

As described in the preceding review, recent work in persuasion neuroscience has taken important first steps to uncover neurocognitive underpinnings of persuasive processes as they occur during message receipt. Notably, these studies have provided one solution to the notorious issue in attitudes research of the fragility of self-report and common inability among participants to accurately introspect (Wicker, 1969; Nisbett & Wilson, 1977). Indeed, they have demonstrated substantial increases in variance in behavior explained over and above traditional self-report

measures (Falk et al., 2010; Falk et al., 2011). The consistency in these studies is promising; across several paradigms, the MPFC repeatedly emerges as playing an important role in predicting behavior change in response to persuasive messages (Izuma, 2013; Chua et al., 2011; Chua et al., 2009; Falk, Berkman, & Lieberman, 2012; Falk et al., 2010; Falk et al., 2011). However, as others have noted, "compared with the long history of research on social influence and attitude change in social psychology, the investigation of neural mechanisms underlying such processes is still in its infancy. An important point that should be emphasized is that people change their opinions for different reasons, and dissociating underlying motivations for attitude change is critical for a clear understanding of the neural basis of attitude change" (Izuma, 2013; p. 459). Indeed, one potential explanation for the predictive power of MPFC in past studies is that this work used largely self-relevant messages (e.g., smoking cessation ads for smokers, sunscreen messages for southern California residents); therefore, self-relevant cognition may have played a particularly important role in persuasion in those contexts. However, with decades of theory-building that details a variety of motivations and contexts for attitude change, it will be important for future persuasion neuroscience research to test and update existing models.

Theories about persuasive processes have largely taken the form of dual-process models; however, it is unclear how well these theories map onto existing findings in persuasion neuroscience. These recent studies do not—nor were they ever intended to—test or extend models such as the ELM or HSM; however, fMRI could prove a useful tool in extending or updating these theories in its ability to simultaneously investigate a number of networks that would support the multiple routes to persuasion posited in these theories. While the consistency of findings supporting the role of the MPFC in predicting persuasion might suggest promise for a single-process account, it is also possible that multiple routes of processing first interact, with

MPFC activity serving as a final integrated value signal of persuasive impact. For instance, it may be that affective neural systems supporting emotional reactions to message cues and lateral prefrontal regions supporting cognitive processing of message arguments serve as a first pass to integrate these various types of information. Depending on factors outlined in prior theory such as issue relevance and motivation to process, these routes would take on different weights (i.e., be more or less active) and subsequently interact as inputs to the MPFC where final persuasive value signal is indexed. Indeed, such an account would converge nicely with neuroeconomics views of the VMPFC as a calculator of reward value (Hare, Camerer, & Rangel, 2009; Hare et al., 2010; Wallis and Miller, 2003; Padoa-Schioppa and Assad, 2006; Kable and Glimcher, 2007; Plassmann, O'Doherty, & Rangel, 2007; Tom, Fox, Trepel, & Poldrack, 2007; Valentin et al., 2007; Wallis, 2007; Hare et al., 2008; Rolls, McCabe, & Redoute, 2008). In this case, it could be that differentially weighted inputs from deliberative and/or peripheral processing in other networks are synthesized in the MPFC, which indexes how much the arguments are personally rewarding (i.e., persuasive) and in turn motivates message-consistent behavior. Of course, such an account is primarily theoretical at this point; what follows are several suggestions for programmatic testing.

It may first be useful to manipulate factors hypothesized to affect distinct routes in prior work to see where they map onto dissociable neural pathways and where these pathways might converge. For instance, studies could manipulate cognitive load. If, as dual-process accounts suggest, individuals rely more on peripheral cues under high load and more on message arguments under low load, we may see stronger connections between limbic systems and ultimate MPFC signal under high load relative to low load, and conversely stronger connections between lateral prefrontal regions and ultimate MPFC signal under low load relative to high

load. Based on existing work in persuasion neuroscience, we would expect that MPFC activity would still be the strongest predictor of downstream attitudes and/or behavior change; however, this signal may rely differentially on these two streams of input depending on the context. Techniques such as psychophysiological interaction (PPI) analysis could be employed to investigate the relationship between each of these two routes (limbic and lateral prefrontal) and MPFC under varying levels of cognitive load. For instance, we might expect a stronger correlation between limbic and MPFC activity under high relative to low load conditions. Alternatively, a single-process account, which would argue that simply more evidence is taken into account under low load, might predict that activity in both lateral prefrontal and limbic regions would increase as cognitive load decreases because more cognitive resources are available and individuals are considering more of the persuasive evidence (both emotional cues, message arguments, and potentially pieces of evidence) available. The proposed methods allow us to test these distinct accounts simultaneously.

An important trend among extant studies in persuasion neuroscience is that they typically involve self-relevant messages (e.g., anti-smoking messages for smokers). Therefore, in order to test the robustness of MPFC as a predictor of persuasion, researchers may wish to manipulate the degree of self-relevance in the persuasive messages employed. In cases of low self-relevance, dual-process frameworks might anticipate different networks to predict persuasive outcomes under different contexts. For instance, under high motivation to elaborate (e.g., monetary reward), lateral prefrontal regions could interact with limbic regions associated with positive valence/reward (e.g., VS) to predict persuasion. Conversely, limbic regions associated with conflict detection (e.g., ACC) may be indexing counterarguing and may instead predict resistance to persuasion. Under low motivation to elaborate, it may be the simple effect of limbic

reward areas alone that predicts persuasion without interaction with higher order processing seen under elaboration. Again, a single-process account might make different predictions, which could again be tested with the same methods. From this perspective, one might expect parallel parametric increases in both limbic reward and lateral prefrontal regions as high motivation to elaborate increases and individuals are incentivized to consider greater amounts of all types of evidence.

Of course, it may be the case that findings from the proposed work and other studies like it may support new models entirely. It is not our intention to advocate for any one account in particular; rather, we are simply suggesting that the next wave of persuasion neuroscience research may benefit from rigorous testing of dual-process theories, which tend to be the most prominent accounts in behavioral work (Kruglanski & Thompson, 1999). In turn, this work may prove valuable in contributing to the social psychological literature on persuasion as a whole in several ways. First, it improves the temporal specificity with which we can model message encoding and subsequent attitudinal and behavioral change, allowing us to identify particularly influential steps in this process precisely when they occur. Second, it often provides greater predictive ability of distal behavior change over and above the effect of self-report (Falk et al., 2010; Falk et al., 2011). Finally, future directions such as those proposed provide a way to test dual-process vs. single-process theories directly with falsifiable hypotheses for either account.

Summary and conclusions

Persuasion has remained a timely topic in social psychology for close to a century, with good reason. Better understanding the mechanisms underlying persuasive influence is of interest to a wide variety of groups, from health professionals to politicians. In particular, dual-process

models such as the ELM and HSM have made important theoretical contributions (e.g., Chaiken, 1980; Chen & Chaiken, 1999; Eagly & Chaiken, 1993; Petty & Cacioppo, 1981, 1986; Petty & Wegener, 1998). In more recent years, single-process alternatives have been developed, which posit that cues/heuristics and message arguments are simply each special cases of the more comprehensive category of 'persuasive evidence' (e.g., Kruglanski & Thompson, 1999; Kruglanski, Thompson, & Spiegel, 1999). Therefore, these alternatives view processing of all persuasive evidence as occurring on a single continuum. While these models posit implicit cognitive processes underlying persuasion, the evidence involved in building these theories relied heavily on self-report.

Recent neuroimaging methods have provided the extra benefit of being able to interrogate multiple processes at once, tracking activity in neurocognitive networks during message presentation, encoding, and evaluation as they are occurring. Additionally, these methods have shown remarkable predictive power; activity in certain regions, most consistently the MPFC, during message receipt has predicted behavior change weeks later and in populations beyond the immediate sample of participants in the study (Wang et al., 2013; Chua et al., 2011; Falk, Berkman, & Lieberman, 2012; Falk et al., 2011). There is not yet strong evidence to suggest why the MPFC has been such a strong predictor of future behavior, but one possibility is that this region serves to index the personal value of the message-consistent behavior, which in turn guides motivation to enact the behavior. However, because past studies implicating the MPFC largely used self-relevant stimuli, it is unclear whether other networks could also be integral to persuasive processes under different motivations and types of stimuli, and whether such networks might be dissociated into automatic and controlled kinds of processes that map onto existing dual-process models of persuasion. The next step, then, is a systematic attempt to test

these prior theories with new methods developed in the context of persuasion neuroscience. Suggestions for such a program of research are proposed, which manipulate information processing motives and suggest hypotheses that would support dual-process or single-process frameworks. In so doing, it is entirely possible the data would support dual-process models, single-process models, or perhaps implicate new models entirely. The major point we are advocating is for a more structured theory-testing approach as a future direction in persuasion neuroscience. In so doing, we hope to gain a richer and more actionable understanding of Allport's "most distinctive and indispensible concept in contemporary American social psychology" (1935; p. 798).

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Figures

Figure 1. The Elaboration Likelihood Model, reproduced from Petty & Cacioppo, 1986.

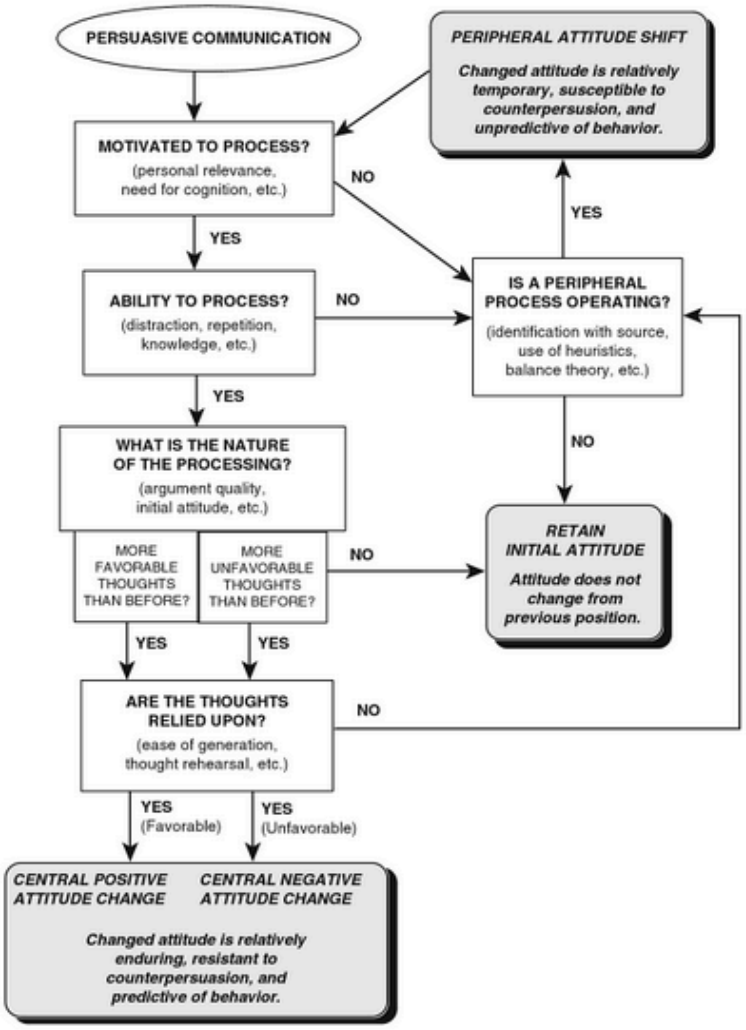

Figure 2. The Persuasion Knowledge Model, reproduced from Friestad & Wright, 1994.

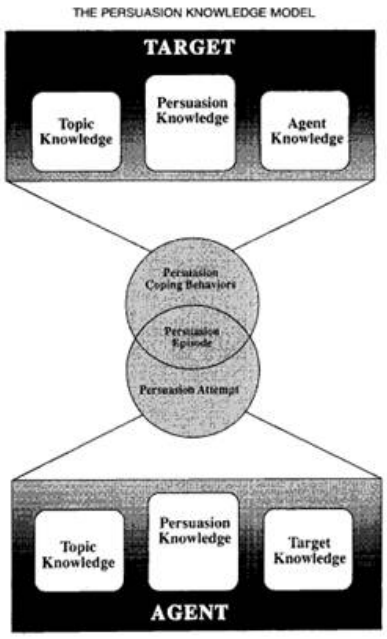

Figure 3. MPFC ROI used in Falk, Berkman, Whalen, & Lieberman (2011) and Falk, Berkman, & Lieberman (2012).