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Creating Buzz: The Neural Correlates of Effective Message Propagation

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Abstract

Social interaction promotes the spread of values, attitudes, and behaviors. Here we report on neural responses to ideas that are destined to spread. Message communicators were scanned using fMRI during their initial exposure to the to-be-communicated ideas. These message communicators then had the opportunity to spread the messages and their corresponding subjective evaluations to message recipients, outside the scanner. Successful ideas were associated with neural responses in the mentalizing system and the reward system when first heard, prior to spreading them. Similarly, individuals more able to spread their own views to others produced greater mentalizing system activity during initial encoding. Unlike prior social influence studies that focus on those being influenced, this investigation focused on the brains of influencers. Successful social influence is reliably associated with an influencer-to-be's state of mind when first encoding ideas.

Keywords

social influence, mass media, social interaction, social behavior, neuroimaging

Disciplines

Cognitive Psychology | Communication | Experimental Analysis of Behavior | Social and Behavioral Sciences

Comments

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RUNNING HEAD: EFFECTIVE MESSAGE PROPAGATION

Creating buzz:
The neural correlates of effective message propagation

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Abstract

Social interaction promotes the spread of values, attitudes, and behaviors. Here we report on neural responses to ideas that are destined to spread. Message communicators were scanned using fMRI during their initial exposure to the to-be-communicated ideas. These message communicators then had the opportunity to spread the messages and their corresponding subjective evaluations to message recipients, outside the scanner. Successful ideas were associated with neural responses in the mentalizing system and the reward system when first heard, prior to spreading them. Similarly, individuals more able to spread their own views to others produced greater mentalizing system activity during initial encoding. Unlike prior social influence studies that focus on those being influenced, this investigation focused on the brains of influencers. Successful social influence is reliably associated with an influencer-to-be's state of mind when first encoding ideas.

Key words: Social influence, Mass media, Social interaction, Social behavior, Neuroimaging

What differentiates ideas that bomb from ideas that buzz? Although “buzz” began as an onomatopoeia for the sound a bee makes, since the 16th century it has had a variety of social meanings including the act of calling someone on the phone, the sounds a crowd makes when roused, or the spreading of a rumor. Today, buzz most often refers to the excitement that spreads around an idea, person, or product. The generation of buzz not only requires a compelling idea but also people who are motivated and able to spread the idea effectively. Like all mental representations, however, these ideas live in the human brain and depend on effective social communication for their dissemination.

Research on the factors guiding the creation of this type of “buzz” has focused on processes that characterize the spread of information from person to person (Katz, 1957; Rogers, 1995), the relationship between message communicators and message recipients (Bangerter & Heath, 2004; Brown, Barry, Dacin, & Gunst, 2005; De Bruyn & Lilien, 2008), message characteristics (Berger & Milkman, 2012), and social network characteristics (Bakshy, Karrer, & Adamic, 2009; Hill, Provost, & Volinsky, 2006; Leskovec, Adamic, & Huberman, 2006). A large body of social psychological literature focusing on persuasion and social influence from the perspective of message recipients also speaks to the processes through which people may be influenced to adopt new ideas or recommendations (Asch, 1955; Chaiken, Liberman, & Eagly, 1989; Cialdini & Goldstein, 2004; Hovland, Janis, & Kelley, 1953; Petty & Cacioppo, 1986). Yet there is less direct evidence about the underlying psychological mechanisms that precede message propagation from the perspective of the message communicator. This is perhaps due to individuals’ notoriously imperfect ability to introspect on such processes (Nisbett & Wilson, 1977).

Despite having limitations of its own (Poldrack, 2008), functional magnetic resonance imaging (fMRI) can measure neural responses in the moment that participants are initially processing messages, interrogating several neurocognitive networks simultaneously. fMRI has been used successfully to study a number of different social influence processes from the perspective of the message recipient, including conformity (Campbell-Meiklejohn, Bach, Roepstorff, Dolan, & Frith, 2010; Klucharev, Hytonen, Rijpkema, Smidts, & Fernandez, 2009; Klucharev, Munneke, Smidts, & Fernandez, 2011), responsiveness to social tagging of stimuli (Klucharev, Smidts, & Fernandez, 2008; Mason, Dyer, & Norton, 2009; Plassmann, O'Doherty, Shiv, & Rangel, 2008; Zaki, Schirmer, & Mitchell, 2011), and other persuasive inputs (Falk, Berkman, Mann, Harrison, & Lieberman, 2010; Falk, Berkman, Whalen, & Lieberman, 2011; Falk et al., 2010). However, little is known about the mechanisms that prompt communicators to share ideas in a persuasive manner to begin with. Are the processes from the perspective of message communicators distinct from those of the message recipient? As an initial step toward better understanding these processes, we used fMRI to investigate the neurocognitive processes in the minds of message communicators, set in motion by ideas destined to spread successfully to others through positive recommendations on the part of the message communicator.

Antecedents of Successful Message Propagation

When a message communicator is first exposed to an idea that s/he will ultimately spread or recommend, two kinds of neurocognitive processes are likely to set this successful propagation in motion. First, for ideas that are destined to spread, the communicator is likely to value the idea, either because s/he connects with the idea, or imagines that others might. This process may recruit brain regions supporting reward and positive evaluations such as

ventral striatum and ventromedial prefrontal cortex (VMPFC). Second, successful message propagation “hinges on the ability of the recommender to accurately predict the recipient’s interests and preferences” (Subramani & Rajagopalan, 2003). This type of mentalizing most commonly recruits the dorsomedial prefrontal cortex (DMPFC) and the temporal parietal junction (TPJ). These regions have been implicated in successful communication between a speaker and listeners during narrative (Stephens, Silbert, & Hasson, 2010).

In this initial investigation of the neural bases of social influence from the perspective of the influencer, rather than the influenced, we focused on the *buzz effect*. This reflects the greater neural activity present when a message communicator is first encoding an idea that is likely to be spread successfully by the message communicator. Successful spreading of an idea is operationalized as a message communicator passing on an idea to a message recipient in such a way that the message recipient wants to recommend the idea further, to others.

We also examined two component processes that may contribute to successful propagation. The *intention effect* reflects the neural activity present during the message communicator’s initial encoding of an idea to the extent that the message communicator intends to recommend the idea. The *salesperson effect* reflects the neural activity present during message communicators’ initial encoding of ideas that is higher in those message communicators who are better at persuading others to evaluate ideas the same way they, the communicators, do. We hypothesized that the intention effect would be associated with regions associated with reward, whereas the salesperson effect should be associated with brain regions within the mentalizing network. Finally, the buzz effect measured in the current investigation should be associated with both reward and mentalizing regions, as the motivation and ability to propagate the message go hand in hand.

In this study, message communicators (who pretended to be ‘*interns*’ at a television studio) viewed ideas for television pilots during an fMRI scanning session and considered whether they would pass them on to message recipients (‘*producers*’) for further consideration. After scanning, interns gave video interviews about each pilot show idea. These interviews, but not the original pilot descriptions, were then shown to producers in a separate behavioral testing session. Based on only the videotaped interviews, producers indicated whether they would pass the idea on to others.

Methods

Participants

Interns. Twenty participants were recruited from an undergraduate subject pool and through mass emails and posted fliers; one participant was dropped due to technical difficulties (final $n=19$; 11 female, mean age = 20.55, $sd = 6.17$). All participants were right-handed, and spoke English fluently. Related to fMRI safety, participants were: not claustrophobic, metal-free, not pregnant/breast-feeding. Potential participants were excluded if they were currently taking psychoactive medication.

Producers. Seventy-nine participants (57 female, mean age = 20.54, $sd = 3.82$) were recruited from an undergraduate subject pool and through mass emails and posted fliers. None of the “producers” knew the “intern” whose video he or she rated.

Materials and Procedure

In our paradigm, an initial group of participants referred to as “interns” pretended to be working at a television studio and provided recommendations to their boss, the “producer”, about which shows should be considered for further development and production.

Television Pilot Stimuli. Preliminary pilot show ideas were generated by an independent group of undergraduates in response to a prompt in which they were asked to “Pretend you are pitching a new TV show idea to a network.” From this pool of show descriptions, 24 show ideas were selected as final stimuli based on further pilot testing and assessment by the research team; show ideas were selected to appeal to a wide range of audiences and to have comprehensible plots. The language of the pilot television show descriptions was then edited by the research team to standardize grammar, spelling, description length and complexity (mean words/ description=56, sd=6). An image representing the show was also paired with the description.

Intern Procedure. Using fMRI, we monitored neural activity in each intern’s brain while the intern was presented with ideas to recommend to their boss, the producer, who was ostensibly too busy to review all of the proposals (Figure 1a, 1b). Each participant viewed and heard 24 descriptions of television show ideas, proposed by other undergraduate students (3 runs; 8 blocks/ run; 310 seconds/ run totaling 465 volumes). Directly following exposure to each idea, interns rated how likely they would be to recommend the idea to the producer (1-4; Definitely would not → Definitely would; the regressor used for the *intention* effect). Then, following the fMRI session, each intern was videotaped discussing the merits of each idea as though responding to the producer’s inquiry, and finally provided additional quantitative ratings, including whether they would watch each show themselves (Full scale items included: *I would watch this show; I would tell a friend about this show; If I were the producer in charge, I would produce this show; The description of this show is persuasive; This concept is novel*, with response options from *strongly disagree* to *strongly agree*).

Producers' Materials and Procedure. The videotaped interviews served as the stimuli for a second, separate, group of participants (the “producers”; Figure 1a, 1c). The structure of the procedure completed by producers was similar in many ways to the procedure completed by interns. The primary difference was that instead of viewing a standardized set of written show idea descriptions, each producer was randomly assigned to view the video tapes of one intern, who reviewed the different show ideas. All videos from the interns were cut into clips to allow the order of the ideas to be randomized across participants, and to ensure that all video-taped discussion of each show was presented sequentially (i.e. if an intern discussed a particular show at more than one time point during video-taping, those clips were played sequentially to develop one continuous description of the show). Following each idea description by the intern, the producers rated their intentions to further recommend the show idea (1-5; Definitely not → Definitely would).

For each intern who completed the MRI portion of the study, we collected ratings from multiple producers (mean=4; Figure 1a), to get an aggregate index of how successful each intern was in propagating interest about each show to a number of different individuals (the producers who watched that intern’s tape). Thus, we were able to track how influential each intern was by correlating their idiosyncratic intentions to propagate each idea with the analogous preferences of their producers (the *salesperson effect*), as well as which ideas were successfully propagated across producers (the *buzz effect*), regardless of which intern’s interview was watched. After completion of data collection with both groups of participants, we conducted a series of whole brain analyses correlating neural activity during the interns’ initial exposure to the pilot show ideas with relevant outcomes from both interns and producers.

fMRI Data Acquisition. Imaging data were acquired using a Trio 3 Tesla head-only MRI scanner at the UCLA Ahmanson-Lovelace Brainmapping Center. Head motion was minimized using foam padding and surgical tape; goggles were also fixed in place using surgical tape connecting to the head coil and scanner bed. Three functional runs were recorded for each participant (echo-planar T2-weighted gradient-echo, TR=2000ms, TE=30 ms, flip angle=75°, matrix size=64x64, 33 axial slices, FOV=220mm, 4mm thick; voxel size =3.4x3.4x4.0 mm). A high-resolution T1-weighted magnetization prepared rapid acquisition gradient echo (MP-RAGE) scan was also acquired in the coronal plane (TR=2300ms; TE=2.47ms; FOV=256 mm; slice thickness=1.0 mm; 160 slices; voxel size=1.3x1.3x1.0 mm; flip angle=8°). The data were pre-processed and analyzed using Statistical Parametric Mapping (SPM5, Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK).

Statistical Analysis

fMRI Preprocessing. Functional images were realigned to correct for motion, and coregistered with the MP-Rage Structural scan. The MP-Rage was normalized into standard stereotactic space (Montreal Neurological Institute, MNI), and these parameters were applied to the functional data. The resulting images were smoothed with an 8mm Gaussian kernel, full width at half maximum.

Individual behavioral effects. We computed descriptive statistics of the length of the interns' post-scan interviews, as well as whether some shows were systematically liked more than others according to the intraclass correlation coefficient (ICC), grouping by shows. ICCs were calculated using the `mult.icc` function from the `multilevel` package (Bliese, 2008) in R (R Development Core Team, 2011). Finally, the interns' intentions to propagate each idea

were correlated with each intern's own show preferences which were collected in a survey completed after the scan.

Individual Level fMRI Effects. Three separate design matrices were then created for each intern, modeling activity that was greater during the task (while encoding the show descriptions in the scanner) than during rest, and correlating this task-related activity with each of the constructs of interest. A random-effects analysis was conducted for each effect, averaging across participants at the group level:

The Buzz Effect. The interns' task-related activity (activity during exposure to show ideas compared to rest) was correlated with the ultimate success of each show idea, as indicated by the average idea preferences of all producers. This analysis was conducted for each intern at the single-subject level.

The Intention Effect. The interns' task related activity was correlated with the intern's specific preferences as indicated by intentions to recommend each idea (modeled as a parametric modulator at the single subject level).

The Salesperson Effect. The correlations between each intern's intentions and the preferences of the producers within their sphere of influence were entered as regressors in a group level (random effects model) of the neural activity associated with the intention effect described above. Higher correlations indicate greater success convincing the producers of the merits of the intern's preferred ideas.

All whole-brain results are reported at a threshold of $p < .005$, with a $k=60$ voxel extent¹, corresponding to corrected $p < .005$ based on a Monte Carlo Simulation implemented using

¹ This threshold ($k=60$) could filter out small but relevant brain activations. Therefore, an exploratory analysis was conducted within limbic regions (striatum and amygdala) using a threshold of $k=20$, but did not find such activations.

AlphaSim in the software package AFNI (Ward, 2000). All coordinates are reported in MNI space.

Results

Participant behavior

Interns varied in the average amount of time they spent discussing shows (mean=40secs, sd=12secs), and correspondingly, in the number of words contained within each of their show descriptions (mean=72 words/show, sd=19), however, this variation was not systematically associated with other individual differences in influence (i.e. the salesperson effect). We also examined whether some shows were systematically liked more than others according to the ICC, grouping by shows. The ICC for intern intentions was relatively low (.139), as was successful propagation across producers (the so-called “buzz” effect, .158), indicating that different interns, and the different groups of producers, respectively, expressed interest in propagating different shows. This suggests that effects observed capture influence processes beyond everyone merely liking the same shows. Similarly, interns’ liking for shows only accounted for 12% of the variance of producers’ intentions to propagate the message further.

The Buzz Effect

The ultimate success of an idea being recommended in such a way that it reached from message communicators to message recipients (i.e. beyond interns to producers), was computed by averaging across the ratings of all producers in our study to determine which ideas were successful (re-recommended), regardless of the message communicator. This index was used as a parametric modulator of the neural response to each pilot idea for each intern. This analysis allowed us to examine which brain regions were increasingly active as

each intern was exposed to ideas that were ultimately successful in being propagated across the group of producers as a whole. As predicted, this *buzz effect* was associated with increased activity in neural regions previously associated with reward processing (i.e. ventral striatum) and with mentalizing (TPJ and DMPFC) (Table 1; Figure 2a).

The Intention Effect

The *intention effect* was assessed by using each intern's stated intention to propagate each idea as a parametric modulator of their neural response to each pilot idea. This allowed us to examine which brain regions were increasingly active to ideas that interns explicitly expressed increased interest in propagating, directly following exposure to each idea. Although this analysis did not produce activity within the reward system, it did produce activations in medial prefrontal cortex (MPFC) and precuneus/posterior cingulate cortex (PC/PCC) commonly associated with self-relevance processing (Lieberman, 2010) (Table 1; Figure 2b). We also examined the extent to which intentions to recommend shows were correlated with each intern's own show preferences ("I would watch this show"; collected post-scan), and found that these metrics were highly correlated² ($r_{\text{avg}}=.68$, $t(18)=21.03$, $p<.001$).

The Salesperson Effect

As a measure of how successful each intern was in cultivating the same preferences in their particular producers as they themselves held, we calculated a "salesperson index", defined as the correlation between each intern's set of intention ratings and the intention ratings made by the producers after viewing that same intern's video. There was substantial

² Intention scores were also highly correlated with other proxies for participant liking measured

variability in the salesperson index ($M=.31$, $SD=.27$, r -averages $=-.31$ to $.61$) indicating that interns varied widely in their ability to persuade their producers to have the same view as their own. A group level analysis using the salesperson index as the primary regressor identified neural regions that were increasingly active in interns who were most successful at propagating their intended ideas. The *salesperson effect* was exclusively associated with interns' bilateral TPJ activity, a primary component of the mentalizing network (Saxe, 2010) (Table 1; Figure 2c).

Discussion

In this first study to examine the brains of those doing the persuading, rather than being persuaded, we report that responses in the brains of initial idea recipients forecast an idea's success beyond initial recipients to others whose brains are never examined and whose eyes are never exposed to the original information. Neural regions associated with successful message propagation overlap with the brain's reward and mentalizing systems, the former of which has been consistently associated with persuasion and influence from the perspective of the message recipient (Ariely & Berns, 2010; Falk, Way, & Jasinska, 2012), and the latter of which suggests additional computations that position individuals to become effective message communicators, and to eventually propagate ideas.

More specifically, in examining neural activity that was associated with the ideas that the interns most successfully spread to producers, (such that the producers also had the intention to spread the ideas further; i.e. the *buzz effect*), we observed activation of the regions most commonly associated with mentalizing (DMPFC, TPJ), as well as VS in the reward system. Activity in the VS may implicitly index the appeal and value of ideas – an index of an idea's overall buzzworthiness or social value and may also implicitly reflect anticipated

reward in sharing the idea with others. Activity in the mentalizing system, by contrast, may position the message communicator to be able to share effectively.

In examining the component processes that preceded successful message propagation, the initial intentions of interns to pass on the shows to others, and the interns' own liking of the shows, were highly correlated suggesting that interns may have relied heavily on their own preferences when indicating their intentions to share the pilot ideas. Consistent with this account, intentions to propagate ideas (the *intention effect*) were associated with midline regions commonly associated with self-relevance and valuation (MPFC, PC/PCC). These are also regions that have been associated with being persuaded to act while encoding health messages (Falk, Berkman, et al., 2010; Falk, et al., 2011). However, actual success in propagating ideas was only modestly correlated with interns' personal preferences, and there was a high degree of heterogeneity in participants' ratings of the shows. This evidence indicates that processes beyond consensus in preferences across participants are necessary to explain the successful message propagation effects observed.

To this end, TPJ was the only region whose activity differentiated the interns who were more successful at propagating their preferred ideas from those who were less successful at this (the *salesperson effect*). It is possible that better message communicators were already thinking about how to make the information useful and interesting to others at encoding, rather than simply taking in the information for one's own sake. Such perspective-taking processes would be brought online to the extent that one considered ways in which the incoming message would be relevant to others. Increased processing of this type could position the message to spread more successfully to others.

As such, these findings may have implications for the spread of ideas, norms, values, or culture itself. Our results are consistent with research demonstrating that the spread of preferences may depend more on the message communicator's social-cognitive abilities and motivations, and less on factors such as deliberative reasoning (Salganik, Dodds, & Watts, 2006). In no analysis did any regions commonly associated with reasoning and related central executive processing emerge for any of the examined effects (Table 1), though the absence of such effects does not rule out the possibility that effective ideas may have resulted in an alternative form of "deeper" or more "elaborative" encoding. Instead, our results are consistent with a prominent role of socio-affective processes in producing social influence, and in particular, suggest that activity in the mentalizing network may augment transmission of ideas.

Our data may also be relevant to social cognition more broadly. It has been suggested that the growth of the prefrontal cortex over primate evolution has been driven by virtual aspects of social cognition (Barrett, Henzi, & Dunbar, 2003). The mental states of others are virtual because they are unseen and inferred from a variety of cues such as context and facial expressions. Many studies have examined the role of the mentalizing network in decoding mental states from contextual and facial cues (Amodio & Frith, 2006). Our study examined a different kind of virtuality; individuals preparing for social encounters that have not yet occurred. Success in such preparation (i.e. successfully preparing to recount show ideas to the producer in a way that the producer would find compelling) was associated with activity in the mentalizing network, further affirming and extending our understanding of the network's role in virtual aspects of social life. Future research is needed to assess whether this hypothesized role of the mentalizing network is specific to the spread of the type of ideas

targeted in our paradigm, or generalizes to other related tasks (e.g. the spread of technical, religious or fashion ideas).

Our findings also contribute to a small but growing number of studies identifying mentalizing activity with more accurate or effective behavior. Activity within the mentalizing network, under the alternate label *default mode network* (DMN) has frequently been associated with poorer performance and low effort cognition (Mason et al., 2007; McKiernan et al., 2003; Weissman et al., 2006). In contrast, greater speaker-listener coupling in these same brain regions has been associated with better communication between speakers and listeners (Stephens et al., 2010). These mentalizing regions also increase with greater working memory effort when the content of working memory is social (Meyer et al., 2012). The current study also finds that greater activity in mentalizing regions is associated with more desirable outcomes. Message communicators who produced greater mentalizing activity while encoding the pilot television show ideas were more likely to pass on the information in such a way that message recipients were motivated to pass it on further. In future investigations, it will be of interest to determine the extent to which these same regions might forecast the accuracy of message propagation, as well as propagation of neutral information or disliked ideas. In addition, the relatively small sample size in the current investigation limited our analysis possibilities (e.g. for testing interactions), and replication will increase confidence in the robustness of our effects.

Finally, our results suggest that in the initial process of taking in information, people may consider the social currency of being the person who spreads a particular piece of information and plan for ways to successfully share the information with others accordingly. Being seen as the source of good ideas (whether or not they are one's own) has always had

great social value and status benefits, and it has widely been recognized that there are individual differences in the extent to which individuals take on the role of information brokers or idea salesmen (Katz, 1957; Rogers, 1995). New media outlets have made the process of recommendation and idea propagation even more visible and explicit, and have highlighted the importance of understanding how and why ideas spread (e.g. social networking sites such as Facebook and Twitter promote individuals as “information DJ’s”). This current research lays the groundwork for future studies that might inform our ability to construct more compelling, “stickier” messages and identify the mechanisms that lead individuals to be better messengers. More specifically, the activations identified in this research might serve as regions-of-interest in future work using neural activity to prospectively predict the success of messages and message communicators. Ultimately, this work also expands our understanding of the role of the mentalizing network in preparing for social interactions, and may help us understand how our ability to spread information relates to social identity, builds social status, and strengthens social ties.

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Figure Legends

Figure 1. (a) Overview of experimental procedure. The (b) procedures completed by the “interns” in the fMRI scanner and (c) “producers” in the behavioral lab paralleled one another in many ways. However, whereas the interns all viewed identical show descriptions, each producer viewed videotaped show descriptions by only one intern.

Figure 2. Neural regions associated with a) the *Buzz effect* (indexed by the average preferences of producers irrespective of the intern observed); b) the *Intention effect* (indexed by interns’ intentions to propagate messages); and c) the *Salesperson effect* (indexed by the success of interns in promoting their valenced evaluations to a set of producers). Results thresholded at $p < .005$, (whole brain: $k=60$), corresponding to corrected $p < .005$.

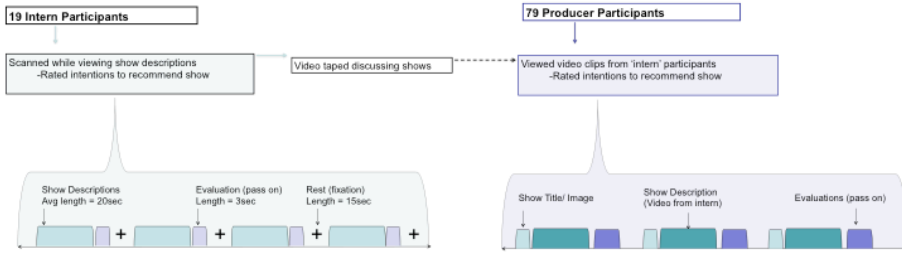
Table 1. Associations between neural activity in the interns' brains and effects of interest. a) The *intention* effect reflects the interns' individual intentions to propagate ideas; b) The *salesperson effect* indexes the interns' success at convincing producers within their sphere of influence of the merits of their intended ideas; c) The *buzz effect* indexes the ultimate success of idea propagation across producers.

Region	Local Max (x y z)	K	t-stat
A. The Intention effect			
MPFC	-3 51 -3	106	3.34
PC/PCC	-3 -57 21	71	3.56
Superior Frontal Gyrus	-21 33 48	98	4.71
Precentral Gyrus	-39 -18 66	154	3.87
B. The Salesperson effect			
TPJ	-54 -51 30	135	5.34
TPJ	45 -57 27	127	5.28
C. The Buzz effect			
TPJ	-48 -51 15	350	3.33
TPJ	51 -60 18	582	4.65
DMPFC	6 54 36	196	4.03
PC/PCC	3 -60 48	411	6.26
Ventral/Dorsal Striatum	-3 9 3	459	6.31
Brainstem	3 -36 -27	91	4.82

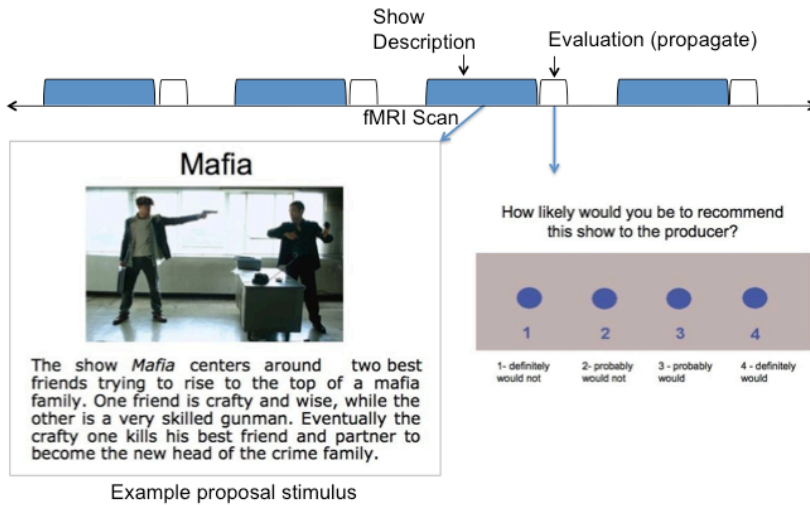
Note: Results thresholded at $p < .005$, (whole brain: $k=60$), corresponding to corrected $p < .005$. MPFC = medial prefrontal cortex; DMPFC = dorsomedial prefrontal cortex; TPJ = temporal parietal junction; PC/PCC = precuneus/ posterior cingulate cortex.

Figure 1.

a. Overview of study procedure



b. Interns: Scanned While Watching Proposals



c. Producers: Watched and Rated Intern Videos

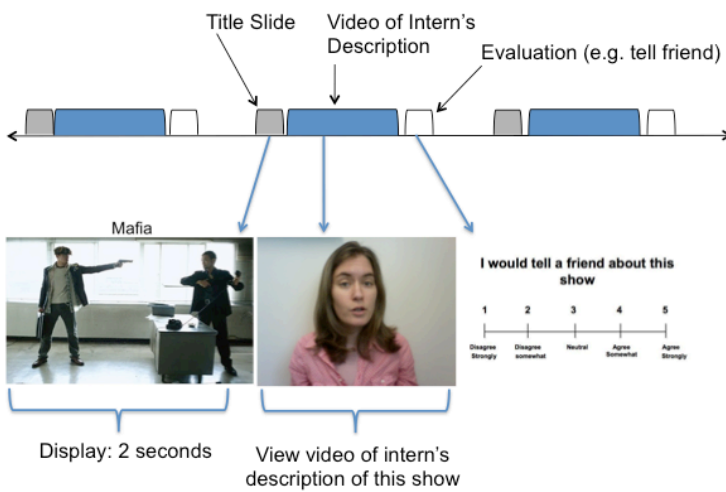


Figure 2.

