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Stories Collectively Engage Listeners' Brains: Enhanced Intersubject Correlations during Reception of Personal Narratives

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Audiences' engagement with mediated messages lies at the center of media effects research. However, the neurocognitive components underlying audience engagement remain unclear. A neuroimaging study was conducted to determine whether personal narratives engage the brains of audience members more than non-narrative messages and to investigate the brain regions that facilitate this effect. Intersubject correlations of brain activity during message exposure showed that listening to personal narratives elicited strong audience engagement as evidenced by robust correlations across participants' frontal and parietal lobes compared to a nonpersonal control text and a reversed language control stimulus. Thus, personal narratives were received and processed more consistently and reliably within specific brain regions. The findings contribute toward a biologically informed explanation for how personal narratives engage audiences to convey information.

Keywords: Media Neuroscience, Engagement, Personal Narratives, fMRI, Intersubject Correlation

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Every day, millions of listeners tune in to consume personal stories shared on popular radio shows and podcasts. Personal narratives, or the accounts of someone's lived experience, are a widely used message format for conveying important information to audiences in a way that is immediate and intuitive. It is well documented that narratives can have a substantial impact on the thoughts and emotions of listeners, and these effects are thought to be contingent on the ability of narratives to engage listeners more deeply or in qualitatively different ways than other forms of messages (Busselle & Cutietta, 2019; Green, Strange, & Brock, 2003; Slater & Rouner, 2002). Prior research on narratives has examined this phenomenon from

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the perspective of individuals' subjective experience, which is as an outcome or effect. This study takes a different approach, focusing on the neural processes as listeners' brains become engaged by stories and how their brains start to exhibit similar responses that are collectively shared across the entire audience. Specifically, we examine whether personal narratives evoke more strongly shared brain responses compared to non-narrative messages, suggesting a novel way to assess the reception of narratives and elucidate the neurocognitive engagement they produce in individual listeners and aggregate audiences.

The concept of engagement in the literature on narratives and cognitive neuroscience

The term engagement has been used across contexts and with different interpretations. This ranges from more colloquial uses in fields like education, social media, or rhetoric (e.g., engaging classes, user engagement, or engaging speakers), not discussed here, to scientific constructs like narrative engagement in the communication literature on narratives (Busselle & Bilandzic, 2009). Narrative engagement has also been linked to several psychological states such as absorption or transportation (Slater & Rouner, 2002). Attempts to explicate these concepts have advanced research on narratives, but key questions remain regarding their measurement and discriminant validity. Also, it is important to note that each of these concepts is typically measured after media use and refers to an outcome state or effect on an individual's subjective experience, but it remains unclear how engagement arises as audiences receive and process a narrative over time. This invites complementary research to characterize reception processes via instrumentation that does not rely on first-person introspection that occurs after the experience, such as neural measurement of audience responses.

Recently, the term engagement has also appeared in the neuroscientific literature, but the same term is used in a different way. Studies on the processing of mediated messages, such as entertaining stories, health messages, or political speeches, conceptualize engagement as a form of selective attention toward messages based on their content (Dmochowski et al., 2012; Imhof et al., 2020; Schmälzle et al., 2015). Thus, the focus is on neurocognitive processing and not engagement as an experience (Cummins, 2000). Understood this way, engagement can be linked to the notion of emotion-laden or motivated attention (as conceptualized in clinical psychological research on emotion; Lang, Bradley, & Cuthbert, 1997), which differs from attention that is driven purely by physical features (e.g., saliency) or attention that is deployed due to explicit tasks (e.g., instructed attention). By contrast, the term engagement in the neuroscience literature is linked to postperceptual brain processes, which are recruited when the content of a message is intrinsically relevant to recipients and prompts enhanced and sustained processing of the message (Schmälzle et al., 2015).

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These streams of research on engagement in communication science and cognitive neuroscience were developed independently and the interpretations of engagement are not identical. While the literature on narrative engagement focuses on the experience of being engaged as a psychological outcome, the neuroscience literature focuses on processes that constitute engagement of specific brain systems over time during message processing, but does not speak to experiential aspects.

However, there also exist key parallels between these two streams of research that offer a path toward integration. Specifically, both literatures seem to agree that engagement is related to attention. For example, research on narrative engagement based on a mental models framework uses a scale that contains a factor named *attentional focus*, which aims to measure attention via self-report (Busselle & Bilandzic, 2009). Similarly, the cognitive neuroscience research discussed above centers around the concept of engagement as a variant of motivated attention (Dmochowski et al., 2012; Hasson et al., 2008; Schmälzle et al., 2015).

Beyond this consensus about the role of attention, the different approaches also share the assumption that social–motivational content and presentations of characters promote engagement. Specifically, according to a mental model's perspective, listeners construct fictional worlds from narratives; however, these worlds tend to be pale and uninteresting if they lack characters who feel, suffer, hope, and succeed (Oatley, 2002). Indeed, it is very difficult to imagine stories that have no social content or elicit social interpretations (Heider & Simmel, 1944). Similarly, at the core of the Limited Capacity Model of Motivated Mediated Message Processing is the concept of motivation (LC4MP; Fisher et al., 2018; Huskey et al., 2020; Kranzler et al., 2019; Lang, 2009), which is intimately interwoven with social cues and steers attention to social content (Birmingham & Kingstone, 2009). Again, this work has strong links to the neuroscientific literature on attentional prioritization of motivationally relevant signals, which ranges from simple cues, like faces and vocal signals, to pictures of sex, violence, or need-related stimuli like spotting food while hungry, and up to complex socio-moral content like stories dealing with autonomy, competence, and relatedness (Tamborini et al., 2010; Tamborini, 2013).

In sum, although the term engagement has been used by different fields and at different levels of abstraction—from neural response to subjective experience—there is agreement that it is related to attention and that social–motivational information is among the content variables that are apt to promote it. This study capitalizes on the parallels between these two bodies of research by examining *how* personal narratives engage the brains of audiences. A personal narrative can be distinguished by the inclusion of content that describes and highlights event sequences leading to and resulting from a protagonist's personal motivations. In the present context, personal motivations refer to exigencies that compel protagonists to behave in a manner that benefits others (i.e., an altruistic motivation) or benefits themselves (i.e., egoistic behavior; Tamborini & Weber, 2020). The rationale is that narratives in which a protagonist, that is, a social agent, serves as the focal point of the story

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and moves through a sequence of events or interactions with other characters represent a message format that is likely to capture and sustain attention of recipients (Mar & Oatley, 2008; Zillmann, 2000). Therefore, personal narratives should induce neural responses that are distinguishable from nonpersonal descriptions.

Brain systems involved in processing personal narratives

When an individual listens to a narrative, the sounds that enter the ear are converted into neural signals and are analyzed along a gradient of information processing from sensation to perception and ultimately comprehension (Mesulam, 1998; Figure 1a). To elucidate this idea in a communication context, it is useful to first consider the nature of narrative messages, which have a hierarchical structure. For example, a radio broadcast or podcast consists of physical sound waves at the lowest abstraction level, which have properties such as amplitude or frequency. Intermediary and higher abstraction levels comprise individual words that refer to concepts and entities, words within the context of sentences that describe specific events, and sentences within paragraphs that drive the story forward (Kintsch & Mangalath, 2011). The brain systems that process narratives utilize this structure and make sense of it: Auditory sensory processes analyze the frequency and other properties of the sound waveform, linguistic processes extract words from sentences and access their meanings, and higher-order cognitive and emotional responses promote story comprehension, including social–cognitive inferences and responses. Although this is a simplified picture of systems that include feedback loops and

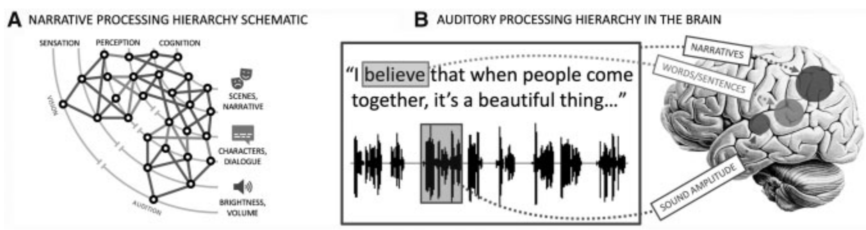

Figure 1 Hierarchy of message content and brain processing. (A) To investigate the commonalities of message reception in the brain, we consider how the brain processes a message along a hierarchy from low-level sensory stimuli (blue) to perceptual cues (green) to higher-order cognitive and affective information (red) inferred from the iterative integration of sensory and perceptual streams. (B) Brain regions vary in the types of information they are sensitive to processing and the timescale over which they process information. The primary auditory cortex rapidly processes incoming sound information, the output of which is sent to adjacent regions that parse these signals as words, which are then passed to more distributed regions higher up the processing hierarchy for interpreting sequences of words as a meaningful sentence.

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other complexities, research from cognitive science, linguistics, and recent cognitive neuroscience supports this general model.

The hierarchical process memory framework offers a theoretical account of how this extraction of meaning over progressively more abstract representations is implemented in the brain. According to the hierarchical process memory framework (Hasson, Chen, & Honey, 2015), every brain region is viewed as part of a "working" memory/information integration system, but regions differ in (a) the type of information they are sensitive to and (b) in their ability to integrate such information over shorter or longer periods of time. For example, lower-level auditory regions are geared to perform specific transformations of the auditory input and do so instantaneously. As signals move up the neural hierarchy, the regions respond to more abstract input and set up a temporal context such that the region "holds" information related to the prior information (Figure 1b). For instance, with regard to narratives, the stream of acoustic sounds to which the auditory cortex responds ("hearing") is subsequently relayed onto speech-related cortical regions to recognize language ("listening"). Sequences of parsed words are then passed on to regions that integrate the individual words into sentences, which are in turn integrated into meaningful paragraphs ("comprehension"). Notably, as information is passed higher up through the hierarchy, the more widely it is distributed across brain networks. From this perspective, story-level or narrative representations can be viewed as sitting at the apex of the hierarchy, or the highest level of abstraction where every story can be understood as a coherent informational unit comprised of sequential and carefully orchestrated individual elements (e.g., from top to bottom: story-level plot, subplot, chapters, paragraphs, sentences, words, syllables, and sounds).

Personal narratives include descriptions of experiences or challenges that the characters must overcome. This necessitates social–cognitive and semantic systems for processing and understanding a narrative. Research on semantic systems in the brain (Binder et al., 2009) has classically been associated with activity in the temporal lobes, but more recent evidence shows that extracting meaning from language and stories involves widely distributed brain activity that encompasses higher-order linguistic and extra-linguistic regions such as the anterior temporal lobe (aTL), the dorsomedial prefrontal cortex (dmPFC), and precuneus. These regions link word-meaning with brain systems involved in episodic construction, affect, and working memory (Ferstl et al., 2008; Huth et al., 2016). As a story unfolds, it may also prompt the audience to consider their lived experiences and cue memories, thoughts, or emotions (Buckner & Carroll, 2007; Oatley, 2012). This is akin to social cognitive processes such as autobiographical memory or theory of mind, which are associated with regional activity in the medial prefrontal cortex (mPFC), the bilateral temporoparietal junction (TPJ), and the posterior cingulate cortex (pCC; Mar, 2011; Spreng, Mar, & Kim, 2007).

Previous research on motivated attention provides additional insight into the brain systems involved in processing personal narratives. Although a preponderance

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of neuroscientific research at the intersection of affect and motivation focuses on negatively-valenced emotions like fear, the two regions that are consistently reported across domains, tasks, and stimuli include the anterior cingulate cortex (aCC) and mPFC (Etkin, Egner, & Kalisch, 2011; Roy, Shohamy, & Wager, 2012). Moreover, states of motivated attention are associated with amplified processing across the cortical hierarchy (Pessoa, 2018; Schupp et al., 2007). However, almost all relevant studies on these topics have presented rather simple stimuli such as sequences of isolated words or images, which are very distinct from the content-rich, continuous stream of connected speech offered by a personal narrative when presented in a natural fashion. To more firmly grasp the neurocognitive components of engagement, audience brain responses must be measured while listeners consume personal narratives and compared against nonpersonal narratives to reveal presumed attentional differences commanded by social–motivational content.

Measuring collective engagement across the brains of listeners

Intersubject correlation (ISC) analysis offers an effective method for audience response measurement in the brain by measuring the degree to which a message has recruited the regional brain activity of an audience as a whole (Hasson et al., 2004). The brain activity measured from any individual brain region during message reception can be conceptually decomposed into three signals: (a) a common signal driven by the message that is shared across viewers, (b) an idiosyncratic signal driven by the message that is unique to each individual, and (c) noise (Nastase et al., 2019). Correlating the time series of brain activity resulting from functional Magnetic Resonance Imaging (fMRI) across brain regions and audience members isolates the common signal, and thus ISC provides a tool to probe the ability of a given message to recruit neural processes that are collectively shared across multiple recipients (Schmälzle & Grall, 2020a).

Mounting evidence shows that ISC can serve as an index of the degree to which a message collectively engages an audience (Schmälzle & Grall, 2020a; Figure 2). Sensory regions such as the visual and auditory cortex show strong correlations when individuals view or hear the same movie or speech. If participants cannot comprehend a narrative, such as when it is in an unknown language or the sentence structure has been scrambled, ISC remains localized to those sensory regions (Honey et al., 2012; Lerner et al., 2011). This aligns with the hierarchical process memory framework outlined above such that lower levels of the hierarchy are dedicated to the immediate processing of sensory cues but not integrating multiple cues to decode symbolic information. Therefore, regions like the primary auditory cortex will show strong alignment across audience brains fairly quickly after the onset of a story. However, when meaning can be inferred from a narrative, this recruits common brain activities in postperceptual and associative regions. As audience members come to extract similar meaning, this will lead to a gradual alignment of brain responses in those regions involved in higher-order processing. Not only that, but

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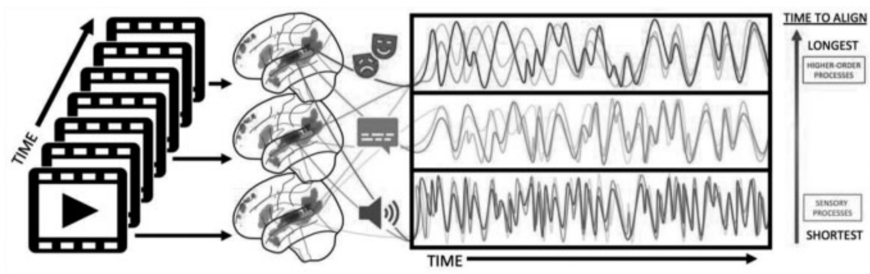

Figure 2 Collective alignment of audience brain responses. Listening to a narrative activates brain networks dedicated to sensory, perceptual, and higher-order processes synthesize the incoming information over time. When a narrative engages many individuals, this leads to aligned brain responses not only in sensory and perceptual networks but also networks associated with cognitive and affective processing. Because these networks are sensitive to different types of information and integrate information over different timescales, this leads to variation in how fast these regions show strong correlations. Sensory cortex will have the shortest time to align and will stay aligned due to instantaneous signal processing while higher-order regions will take longer to align and will fluctuate based on engagement due to accumulating more information over time.

ISC strengthens with dedication of attentional resources (Ki, Kelly, & Parra, 2016; Regev et al., 2018). Furthermore, when the narrative content is considered more powerful or more emotional, this also leads to stronger correlations across fronto-parietal cortex (Hasson et al., 2008; Nummenmaa et al., 2014; Schmälzle et al., 2015). Altogether, this suggests that the presence of ISC across the frontal and parietal lobes critically depends on some degree of dedicated attentional and affective processing, or engagement, with the message.

This study

In summary, personal narratives have specific content features that facilitate engagement in individual recipients and by extension the minds of audiences. However, it remains unclear what happens in the brains of audience members who consume personal narratives. Although there are a few neuroimaging studies that examined brain responses during the processing of narratives, the potential for theoretical synergy between mass communication, narrative theory, and the ISC framework has not yet been realized. Moreover, existing studies have focused on cognitive processes, such as comprehension or memory formation, rather than the role of the convergent audience responses brought about by personal narratives. Previous studies suggest that intersubject correlations of brain activity can be used to measure the degree to which a temporal message, like a narrative, prompts shared brain responses across recipients who are exposed to the same narrative. Thus, ISC constitutes a form of engagement at the level of neurocognitive responses, thereby offering

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a way to assess whether personal stories evoke more strongly shared responses across the brains of audience members and where in the brain such an effect would occur.

Based on the theories and research presented above, we reasoned that personal narratives would induce overall more similar neural processes, or stronger ISC, across the brains of listeners compared to nonpersonal or non-narrative messages. Beyond this general prediction, to which we refer as H1a, it is possible to posit more specific regional hypotheses regarding the semantic and social content present in personal narratives. As outlined above, listening to any common message should lead to ISC in sensory regions associated with basic linguistic and auditory function including the superior and middle temporal gyri (Hickok & Poeppel, 2007). The motivated processing of relevant stimuli, however, should prompt stronger ISC in aCC and mPFC (Etkin et al., 2011). Furthermore, the presence of characters and descriptions of their actions should evoke ISCs in regions involved in social cognitive processing and extracting meaning over time including the aTL, TPJ, mPFC, pCC, and precuneus (Baek, Scholz, & Falk, 2020). We, therefore, predict that personal narratives as compared to non-narrative messages will promote stronger ISCs particularly in brain regions associated with motivated, semantic, and social–cognitive processing (H1b).

Method

Participants

Thirty-three students (20 females, mean age 20.5 years) from the university participated for financial compensation. Recent research on power and ISC analyses suggests that a sample size of 20 participants is sufficient for stable measurement of group-level ISC, but this improves the closer that number gets to $N = 30$ (Pajula & Tohka, 2016; Schmälzle et al., 2017). Experimental personnel recruited participants through advertisements across the university, and all participants were screened through survey and in-person meeting to ensure right-handedness, English as a first language, and standard MRI eligibility. Imaging data associated with listening to a particular stimulus were excluded due to technical issues (e.g., in-scanner headphone malfunction) or if the participant fell asleep. There were 23 participants who provided data for listening to all stories in their entirety without technical error. All procedures were approved by the institutional ethics review board.

Stimuli

The experimental stimuli consisted of four personal narratives, one non-narrative control (a description from a VCR manual), and one audio control (reversed speech). Personal narratives were taken from *This I Believe*, a radio show turned podcast produced by a nonprofit organization of the same name. A collection of these stories was chosen based on prior identification as prototypically impactful in

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nature (Allison & Gediman, 2006) and subsequently pretested in an online survey to identify the stories that fit the criteria for ongoing research on inspiration. Each of the four personal narratives includes a protagonist and event structure, and each narrator describes one of their core beliefs and the life events that lead them to that belief. The first focuses on overcoming "obstacles" from an athlete with Parkinson's disease delivering the Olympic torch (Muhammad Ali's narrative as recorded by his wife[1]). The second emphasized the beauty of a "community" coming together from a young man recounting his younger, disabled brother's first home run in baseball. The third focused on living life with "no regret" from a mother diagnosed with cancer. The fourth narrative emphasized stepping out of your "comfort zone" from a Hollywood producer who interviews diverse strangers. The stories are similar in that they are personal narratives about beliefs, but they represent a wide variety of life experiences from a local little-league baseball game to the Olympics. The stimuli were additionally assessed using Linguistic Inquiry and Word Count analysis (LIWC; Pennebaker et al., 2015) and Valence Aware Dictionary and sEntiment Reasoner analysis (VADER; Hutto & Gilbert, 2014) as described in Supporting Information.

For the comparison message, it was important to induce variation of motivated attention as it is driven by the content of messages. To achieve this, a 3-minute recitation of a VCR manual was used as *non-narrative* control. This creates a perceptually similar input of continuous language, but the message is devoid of any social content or event structure and therefore less motivationally engaging. This VCR text is similar to comparison stimuli used in prior work (Hasson et al., 2008), and exemplifies a descriptive message. However, as described in the procedure below, all participants were told that they had to respond out loud in the scanner after listening to each story. Therefore, participants had an external goal to attend to the content of each message enough to respond, but the content itself was left to naturally facilitate engagement. An additional control message consisted of a unique *This I Believe* essay that was played in reverse to maintain structural auditory stimulus features without any semantic content. The reversed speech audio control serves the purpose of isolating ISC beyond what is shared when an audience listens to a common auditory stimulus, and it is useful to ensure ISC findings are not due to low-level stimulus features. This type of control stimulus has been included in similar paradigms (Schmälzle et al., 2015). In that same vein, using the descriptive VCR text as a comparison serves the purpose of honing in on the neural similarity that arises due to message content that facilitates processing and drives motivated attention beyond the neural similarity that arises whenever an audience listens to a message that they can comprehend. The order of presentation was pseudo-randomized across participants to avoid confounds due to sequence effects. We successfully collected imaging data from all 26 participants listening to the "no regrets" and "comfort zone" stories, but only 25 of those participants listened to the "non-narrative" and "reversed-speech audio control" and 24 listened

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to the "obstacles" and "community" stories. The common denominator of participants for whom there is data from all six stories is 23 participants.

Procedure

Participants were screened for fMRI eligibility through an online survey and an in-person preparation meeting with experiment personnel. The project was described as a neuroimaging study on how people tell personal stories. On the day of the scan, participants completed the consent forms and a short prescan self-report survey assessing mood and life satisfaction. In the scanner, participants first underwent an anatomical scan. For the functional scans, participants were instructed to keep their eyes closed and listen to the stories, all of which were preceded by a short neutral text to reduce transient effects. In a series of pilot scans using unique narrative stimuli, the survey and imaging procedure was tested and refined to ensure there were no constraints on participants other than to listen to each narrative.

For each of the six functional runs, participants first listened to the 3-minute long message. The stories were presented using PsychoPy software and high-fidelity MR-compatible earphones (PSTNet Persaio). During the auditory lead-in to every narrative, participants were directed to close their eyes. After each narrative, participants were directed to open their eyes and respond to a single item which asked, "This story told me something important" on a 5-point scale ($1 = \text{not at all}$, $5 = \text{very much}$). Following the question, participants were cued to recall the narrative for 20 seconds, and then prompted to speak out loud into a microphone in the scanner for 30 seconds on how the narrative made them feel. After the scan, participants filled out a postscan survey about the stories. Participants were then debriefed, compensated, and thanked for their time. Two weeks after the scan, participants were emailed to complete a survey assessing their memory of the stories and additional questions regarding the potential influence of the stories. The pre- and postsurvey and in-scanner talk-aloud data were recorded for use in another research project and therefore not featured in the analysis plan.

MRI acquisition and preprocessing

Imaging data were acquired using a 3T GE Signa HDx system. High resolution T1-weighted images were acquired using a MPRAGE sequence (184 slices, slice thickness = 1 mm, matrix = 256×256, FOV = 25 cm, flip angle = 8°). Functional images were recorded using an EPI sequence (TR = 2,000 ms, TE = 25 ms, flip angle = 76°, matrix = 64×64, FOV = 22 cm, slice thickness = 3.0 mm, 36 slices). The protocol consisted of six functional runs of roughly 5 minutes each with 144 volumes collected for each run. Following conversion of DICOM images to NIFTI format and organization according to the brain imaging data structure (BIDS; Gorgolewski et al., 2016), preprocessing was carried out using fMRIprep (Esteban et al., 2018). Functional data underwent slice-time correction, coregistration of

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functional and anatomical scans, and nonlinear normalization into a common MNI reference system.

After accounting for the auditory lead-in and the HRF lag, time series data corresponding to the listening portion of each run were extracted using NiftiMasker (Abraham et al., 2014) with a functionally resampled voxelwise mask derived from the MNI152NLin2009cAsym anatomical image. During masking, the data were smoothed with an isotropic full-width half-maximum kernel of 4 mm, and the following variables were included as regressors for each participant: six motion parameters, six principal components (aCompCor) estimated from combined subcortical, CSF, and WM masks calculated in T1w space, and three cosine regressors for high-pass filtering with 128s cut-off. Inspection of extracted brain activity time series showed noticeable transient responses at the onset of each story in auditory and visual cortex, which are known to influence correlation analyses because they produce high-amplitude outliers. To ensure analysis quality, ISC analysis was carried out on the data corresponding to the last 2 minutes and 20 seconds of every story, which were not affected by transients. The final output of preprocessing and inspection was six functional runs corresponding to each narrative (70 TRs/volumes for each voxel).

Analysis plan

ISC analysis was used to assess whether personal narratives more strongly engage the brains of audiences compared to the control messages (H1a) and wherein the brain this effect occurs (H1b). As discussed above, ISC analysis assesses the extent to which a time-varying stimulus, such as an audio narrative, aligns the regional brain responses across viewers. ISC is computed as the average correlation $R = \frac{1}{N}\sum_{j=1}^{N} r_j$ where *rj* is the correlation between the voxel time course from one subject and the average time course from the corresponding voxel of all other subjects (Hasson et al., 2004; Honey et al., 2012; Nastase et al., 2019). This procedure was repeated for all voxels and resulted in a brain map representing the extent to which each brain region responded similarly across individuals throughout the narrative. ISC maps were computed for each narrative. To test whether the correlations were significantly different from zero for individual narratives, ISCs were calculated using phase randomization with 1,000 iterations per voxel (Kumar et al., 2020). This procedure computes a null distribution using Fourier transformations to disrupt the temporal alignment of the signal while maintaining the same power spectrum.

Next, we tested for differences in ISC between personal narratives and VCR text and the reversed speech. To do this, individual-level ISC maps were computed by comparing the brain activity time courses from each individual against the average time course of the remainder of the group. An "all narratives" ISC map was created for each participant by averaging the ISCs for each voxel across the four personal narratives. Similarities across the personal narratives were confirmed by post hoc analyses of the texts (LIWC text analysis and VADER sentiment analysis, see

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Supporting Information) to support our decision to average ISC across personal narratives. We thus averaged ISC values across all personal narratives after computing ISC for each story separately to assess the differences that persist between any personal narrative and the descriptive text and reversed speech control. The computed differences between the "all narratives" and non-narrative or reversed speech ISC maps were submitted to a nonparametric bootstrapping procedure to test for significance (Chen et al., 2016).

One additional analysis step was taken to further access H1b and the regional variation in ISC along the auditory processing hierarchy. Data were masked and extracted from spheres centered on a set of coordinates derived using a combination of reviewed literature and Neurosynth.org (Yarkoni et al., 2011). Specifically, data were extracted from the primary auditory cortex, superior temporal gyrus, TPJ, and precuneus to assess ISC along the auditory processing hierarchy. All phased-randomized ISC maps and the bootstrapped differences maps were corrected for multiple comparisons using a voxelwise false discovery rate threshold of $q < .05$ (Benjamini & Hochberg, 1995). All analyses were carried out using python 3.7 using a combination of modules from nilearn, brainIAK, and custom-written tools (Abraham et al., 2014). All materials and analysis scripts are available on OSF (https://osf.io/s4tcj/?view_only=d8c37190f3844d658a1f8c7a9a52f462).

Results

The in-scanner ratings indicated that all personal narratives were evaluated as higher in importance. Averages of the in-scanner ratings showed the narratives about living life with no regrets ($m = 4.16$, $SD = .85$) and community coming together ($m = 4.10$, $SD = .72$) were rated the highest, next the narrative about overcoming obstacles ($m = 3.81$, $SD = .82$), the narrative about challenging comfort zones ($m = 3.38$, $SD = 1.23$), and lastly the VCR text ($m = 1.88$, $SD = 1.13$) and reversed speech ($m = 1.13$, $SD = .42$). Within-subjects t-tests revealed that participants considered the personal narratives to be telling them more important information than the reversed speech (t-values = 10.7–16.7, p's $< .001$) and the VCR text (t-values = 4.4–7.9, p's $< .001$).

As an initial treatment check to assess whether personal narratives promoted collective engagement across audience brains, a phase-randomized ISC analysis was conducted for each individual story. As expected, all narratives evoked some degree of similarity and thus collectively shared temporal activity patterns across the brains of their recipients. As shown in Figure 3, in line with the fact that the stimuli were narrated stories, the auditory cortex showed strong, widespread ISC values centered around primary auditory cortex no matter the message type (e.g., bilateral primary auditory cortex ISCs in response to the averaged personal narratives was r's = .25–.30, p's $< .001$, coordinates = $\pm 58, -16, 4$, where r refers to average value within an 8 mm sphere extracted around that coordinate). Notably, the ISC maps

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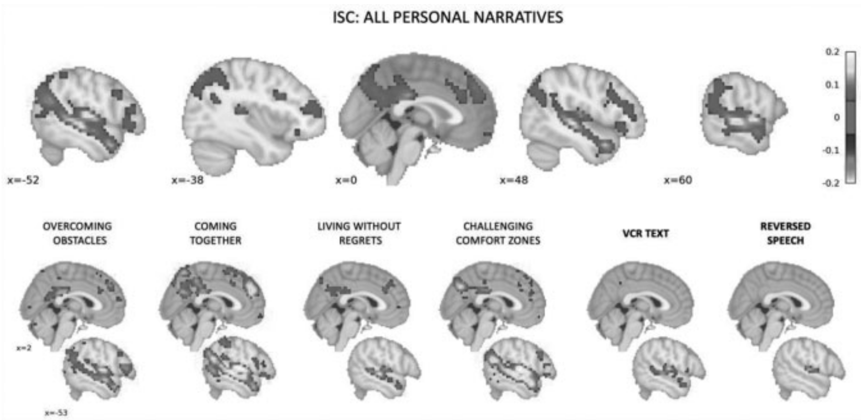

Figure 3 Personal narratives align the brain responses of audiences. The top row shows a brain map of the averaged Pearson's correlations for each voxel for all personal narratives averaged together, with brighter color signifying stronger correlations. The bottom row shows the ISC maps for individual messages, with the theme of each message written above. The reversed speech and VCR text control stories are written in bold. Occipital lobe ISCs are explained by a high amplitude signal change most likely driven by participants closing their eyes at the start of each message. Maps are smoothed for display (fwhm = 6) and additionally thresholded at $r > .05$ on top of previous FDR correction.

corresponding to the four personal narratives show widespread significant correlations throughout the parietal and frontal cortex, which is not the case for the maps corresponding to the reversed speech or VCR text. For the personal narratives, there are strong ISCs centered on the precuneus (r's = .12–.17, p's $< .001$; ±8, −72, 38), posterior cingulate ($r = .16$, $p < .001$; 2, −26, 30), and bilateral TPJ (r's = .12–.16, p's $< .001$; ±54, −56, 20). Other notable regions include the anterior cingulate ($r = .11$, $p < .001$; 4, 32, 32), the dorsal and ventral mPFC ($r = .14$ and .09, respectively, p's $< .001$; 0, 50, 36 and 0, 60, −12), and the bilateral dorsolateral prefrontal cortex ($r = .13$, p's $< .001$; ±46, 16, 30; all reported values corrected for multiple comparisons using FDR threshold of $q = .05$).

To test the prediction that personal narratives promote stronger engagement than non-narrative messages in general (H1a), the differences in ISCs were calculated for each individual for the averaged personal narrative data compared to the VCR text and the reversed speech, respectively. The maps of ISC differences were submitted to a nonparametric bootstrapping procedure to derive significance values, which were subsequently corrected for multiple comparisons (FDR corrected, $q < .05$). In contrasting personal narratives and the reversed speech, stronger ISCs appear along the temporal lobe outside of the primary auditory cortex, and around the posterior medial cortex, anterior cingulate, and dorsolateral prefrontal cortex. Moreover, as shown in Figure 4a, there are several regions throughout the frontal and parietal cortex in which ISCs were stronger for personal narratives

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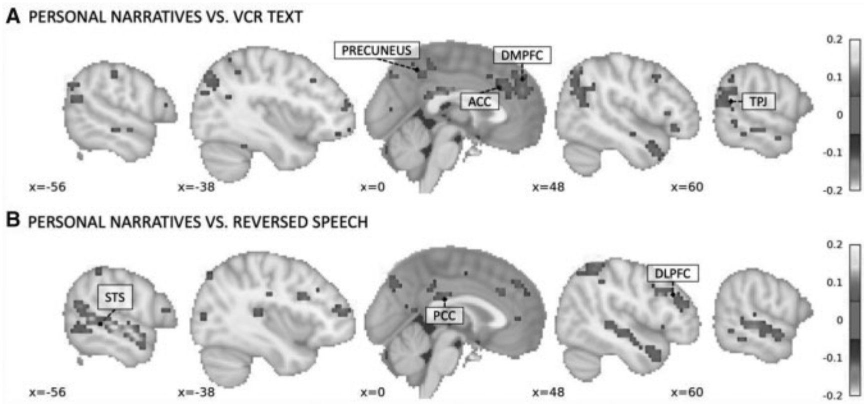

Figure 4 ISC maps contrasting personal narratives with non-narrative messages. The brain maps of *t*-values computed from within-subjects test for differences (FDR, $q < .05$; smoothed for visualization, fwhm = 6 mm) between personal narratives compared (a) the descriptive VCR text and (**b**) the reversed speech audio control. STS, superior temporal sulcus.

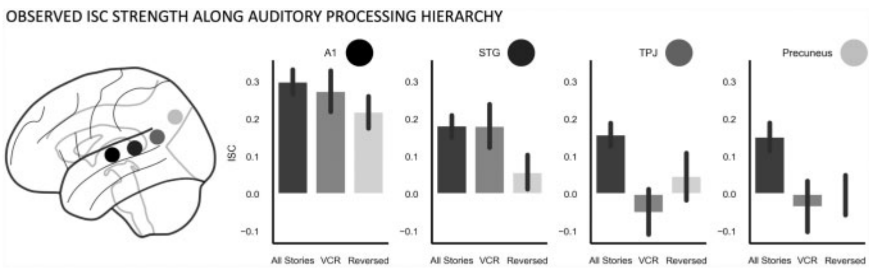

Figure 5 Observed ISC strength along auditory processing hierarchy. ISC values extracted from specific regions along showing strong differences between the personal narratives and VCR text (8 mm spheres; A1 = primary auditory cortex, ±58, −16, 4; STG = superior temporal gyrus, ±62, −36, 10; ±54, −56, 20; precuneus, ±8, −72, 38). These plots show the bilateral ISC values averaged together. Error bars represent the 95% confidence intervals around the ISC values.

compared to the VCR text. In line with the regions predicted in H1b, these include the precuneus, anterior cingulate, posterior cingulate, and TPJ.

To further assess regional variation in ISC across message conditions along the auditory processing hierarchy (H1b,), data were extracted from regions across the temporal lobe up to the medial parietal lobe and submitted to ISC analysis (Figure 5). As expected, observed ISC values in the primary auditory cortex are strong no matter the message condition (A1: $r$stories = .30, $r$vcr = .28, $r$reversed = .22). The superior temporal gyrus shows stronger ISC for the message conditions

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that have interpretable language (STG: $r_{\text{stories}} = .18$, $r\text{vcr} = .18$) compared to the lack of alignment when listening to reversed speech (STG: $r_{\text{reversed}} = .06$, p's $< .001$). Lastly, ISCs in regions associated with higher-order processing and integrating information on the order of seconds or minutes are significantly stronger in response to narratives (TPJ: $r$stories $= .16$, precuneus: $r$stories $= .15$) compared to the VCR text or reversed speech (TPJ: $r$vcr $= -.05$, $r$reversed $= .05$; precuneus: $r$vcr $= -.04$, $r$reversed $= -.00$; p's $< .001$; FDR corrected).

Discussion

This study investigated the reception of personal narratives using intersubject correlations of fMRI data as a measure of the collective engagement produced by messages. We reasoned that the ability of personal narratives to attract attention of many individual listeners should lead to more consistent engagement of neurocognitive processes across the brains of the audience as a whole. The results support this and thus suggest ISC as a process-based and neural approach to examine how narratives engage audiences and identify specific brain processes that mediate between narrative content and media effects.

All personal narratives, regardless of topic or theme, elicited strong ISCs throughout the frontal and parietal lobes, particularly across regions along the auditory processing hierarchy from the primary auditory cortex extending into the distributed functional networks involved in linguistic and higher-order integrative processes. Listening to any message, no matter if it was a narrative, description, or reversed speech, promoted robust ISC effects in the auditory cortex (see Figure 3), indicating that reception processes in this region were highly similar across people listening to narratives, texts, or even reverse speech. For the reversed speech, however, this ISC was confined to early auditory regions. The descriptive VCR text, on the contrary, which offers discernable language but had no relatable social information or a structure, elicited more widespread ISCs across the temporal lobe but with relatively little spread outside regions involved in language processing. In contrast, personal narratives showed the degree to which narratives, even short ones, can create widespread alignment across the brains of audiences. Specifically, as shown in Figure 3, additional regions that extend well beyond auditory and linguistic systems come online collectively as audience members receive and process personal narratives. This pattern of results, whereby reversed speeches are only able to provoke shared activity in auditory regions, non-narrative spoken language commands similar processes mainly in linguistic regions, but narratives prompt collective engagement of widespread auditory, linguistic, and higher-order brain processes, is consistent with H1a.

In line with H1b, formal comparison of the ISC prompted by personal narratives compared to VCR text demonstrated significantly stronger engagement of audience brains across the dmPFC, dorsolateral prefrontal cortex (dlPFC), aCC, pCC, and the TPJ. These regions are involved in higher-order functions, including self-referential

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thinking, salience processing, social and motivational processes, and memory retrieval, which extends beyond the auditory and linguistic domains, as one would expect is required for understanding a narrative and following it closely over time. These regional findings align well with naturalistic neuroimaging research suggesting that brain networks, originally being identified as highly connected within individuals, operate in a similar fashion across individuals (Simony et al., 2016). In the context of this study, narrative reception demanded linguistic processing, social information processing, emotional information processing, and continuous integration of information over time. Specifically, the dlPFC is often implicated in language comprehension and memory (Binder et al., 2009; Ferstl et al., 2008), the aCC is associated with processing salient emotional cues (Schmälzle et al., 2013), and the TPJ, pCC, and mPFC correspond to nodes of the default-mode network, implicated in the integration of abstract information over longer timescales and social cognition (Lerner et al., 2011; Mar, 2011; Spreng, Mar, & Kim, 2007). The strong regional differences in ISCs between narratives and the descriptive text thus support H1b.

Broader implications: Shared brain processes as a marker of audience engagement

ISC presents a theoretical and methodological key to fulfilling one of the underlying goals of mass communication research: explaining how one message exerts a common influence on many people. A complete understanding of mass communication phenomena requires specifying the mechanisms by which messages produce effects on cognition, emotion, and behavior of audience members. Within this context, the approach presented here focuses on how the same message evokes similar activity in the brains of different receivers as a measure of engagement that supplements previously established self-report measures. This strategy to assess collective audience responses during narrative reception via ISC analysis is relevant and applicable across areas of communication research. These areas include, for instance, emotional trajectories and flow in narratives (Keene & Lang, 2016; Nabi & Green, 2015), media-induced temporal comparisons (Bonus, 2018; Clayton, in press), or self-transcendent, inspirational content (Clayton et al., 2019; Dale et al., 2017), which are all concerned with the effects that messages evoke consistently among multiple recipients. ISC captures the collective engagement of such processes, which can then be linked to particular message features and subsequent behavior. Thus, ISC serves as a through line for explaining mass communication as a process of alignment from shared brain responses to shared behavior (Schmälzle & Grall, 2020a).

Narratives are adept at capturing attention and facilitating comprehension, and they can do so very effectively across many people, thereby inducing a host of cognitive and emotional responses. Decades of communication research show the power of narratives to impact audiences, and this study demonstrates this impact at the level of the brain. As argued here, the identified alignment of neural processing across multiple recipients suggests that personal narratives were more successful at

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engaging the audience. The finding that enhanced ISCs appeared specifically in higher-order brain systems that include the TPJ, precuneus, and mPFC bolsters this interpretation. If differences had been confined to responses in early auditory cortex, then one could attribute them to, say, differences in physical properties. However, differences in regions such as the TPJ, mPFC, or precuneus, indicate that the stronger ISCs to narratives as compared to VCR and reverse text is driven by factors that emerge at the story level rather than lower-level factors (Bucker & Carroll, 2007; Hasson et al., 2015; Schmitz & Johnson, 2007). As such, this work is compatible with media psychological work suggesting that social and moral content of narratives are key ingredients that determine their impact on mass audiences (Tamborini, 2013; Zillmann, 2000). This is also consistent with the larger body of neuroimaging work using natural stimuli like videos, music, or audio stories. For instance, it has been shown that instructing participants to pay explicit attention increases ISC measured via EEG (Ki et al., 2016), that ISC is sensitive to manipulation of story comprehension (Honey et al., 2012), and that emotional videos, powerful speeches, or effective health messages prompt strong ISC effects similar to those observed in this study (Imhof et al., 2020; Nummenmaa et al., 2014; Schmälzle et al., 2015).

Future research can now build on this foundation to study the specific content features that facilitate a narrative's ability to engage audiences. For example, strong emotional and behavioral responses are more likely when a message "strikes a chord" within an individual (Schmitz & Johnson, 2007; Sherif et al., 1973) and recent work argues that enjoyment effects are related to the intrinsic needs of listeners (Tamborini et al., 2010). To study how audience brain activity aligns across regions and over time as connected to specific features of the content, one might use variations of ISC analysis such as sliding-window ISC analysis, pattern ISC analysis, or ISC analyses in the frequency domain (Kauppi et al., 2010; Schmälzle & Grall, 2020b; Stephens, Honey, & Hasson, 2013). Because such regions like the TPJ, pCC, precuneus, and aCC showed stronger ISC when listening to the personal narratives compared to the VCR text, these regions may be expected to exhibit modulations of ISC strength based on the fit between media content and personal needs of individual receivers, or subgroups who share similar characteristics.

Indeed, some existing neuroimaging work supports this reasoning, although in a different context. Specifically, in a study examining the reception of topical risk communication about the H1N1 swine flu pandemic, recipients for whom the pandemic seemed personally relevant (because they had higher risk perception) showed higher ISC in response to the information than those who were less involved with the issue (Schmälzle et al., 2013). Although speculative, additional evidence in this study supports this idea. The most widespread ISC was elicited by the story about a youth baseball team helping a disabled boy hit his first home run (which received high in-scanner ratings). The other stories mentioned the Olympics, interviewing famous professionals, and developing cancer as an adult. On its face, the baseball story was the most relatable to our participants because it described an event that could have been experienced by an early adult. Given that many of the regions mentioned

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here have been implicated in integrating social and self-related information over time (Simony et al., 2016; Spreng, Mar, & Kim, 2007), future research might try to manipulate message content variables to test whether these regions covary with the degree of personal relevance. If successful, this approach could be used to examine mechanisms of successful message targeting and antecedents of social influence related to issue involvement, a key concept in persuasion research whose mechanisms have been debated for some time (see Johnson & Eagly, 1990; Petty & Cacioppo, 1990).

Strengths and limitations

This study makes a theoretical contribution by establishing a relationship between the type of message an audience consumes and the collective alignment of their brain responses, which also extends the range of existing communication theory by offering a new outcome in the form of ISC as an index of engagement. The cortical processing hierarchy described here offers a biologically-oriented perspective to explain how a message exerts common influence on a heterogeneous audience. Our findings show that personal narratives are able to command a greater "depth of processing" across audience members such that there is ISC across postperceptual and associative regions at the apex of the processing hierarchy. However, this study is limited in that the control messages are not able to isolate and test specific narrative mechanisms to explain this effect. Our study establishes differences in ISC between personal narratives and descriptive text (VCR text) and a common auditory stimulus (reversed speech), but there are many dimensions upon which narratives can vary. Although we posit that personal narratives facilitate the collective alignment of brain function due to the inclusion of a protagonist's personal motivations, future work can add specificity to this notion by, for instance, varying the number of pronouns in a message, varying the perspective (first or third person), or varying the number of focal characters.

Relative to traditional neuroimaging paradigms, this study offers a high degree of external validity by allowing participants to listen to narratives similar to those they would encounter in everyday life without additional in-scanner task demands. However, relative to experimental paradigms in communication research, fMRI and the scanning environment is restrictive and artificial. Thus, the methods used in this study do not capture how engagement happens in the real world when individuals are inundated with a constant stream of messages that vary widely in terms of form and content. Another issue to keep in mind is that brain activity cannot be connected to psychological phenomena in a one-to-one fashion, and that the content of peoples' conscious experience is better assessed via self-report (Schmälzle & Meshi, 2020). However, these are fair trade-offs given the value added by fMRI data and the approach used here. The fMRI measures audience reception processes over time without relying on participant introspection, and thus provides a complementary type of data which, together with established self-report measures, allows us to more

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completely capture the phenomenon of engagement. Furthermore, fMRI allows us to observe audience brain activity, which is a necessary component of communication processes.

With regard to content variety, one strength of this study is its attempt to investigate audience brain engagement in response to positively-valenced message content. A dominant proportion of ISC-based research has focused on negatively-valenced content like suspenseful narratives (Hasson et al., 2008; Schmälzle & Grall, 2020b), messages designed to prompt risk perceptions (Schmälzle et al., 2013), or murder mystery and action movies (Chen et al., 2017). In contrast, the stimuli used here had themes of community, hope, and kindness. Together with previous ISC work on positive states such as moral elevation and admiration (Englander, Haidt, & Morris, 2012), these results suggest that positively-valenced content is effective at motivating attention like negatively-valenced content under naturalistic conditions. This paves the way for further work that might build on recent interest in positive media psychology (Dale et al., 2017) to study the brain-based differences in engagement when induced by content that varies in valence (Nummenmaa et al., 2014).

Conclusion

To conclude, this study investigated the neural underpinnings of engaging personal narratives. Analyses confirmed that personal narratives elicit higher and robust ISCs across the brain compared to a descriptive message and reversed speech. Specifically, ISCs under conditions of engaging, positive, personal narratives were stronger in several regions of the frontal and parietal lobes as predicted including the TPJ, pCC, aCC, dmPFC, and dlPFC. Altogether, this study contributes to explicate the neural processes underlying audience engagement with personal narratives.

Supporting information

Additional Supporting Information may be found in the online version of this article.

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Note

1. Among all participants, only four recognized it as the story of Muhammad Ali.

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