Original Article

Converging Crowds and Tied Twins

Audience Brain Responses to the Same Movie are Consistent Across Continents and Enhanced Among Twins

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Abstract: Recent work using neuroimaging has shown that brain responses to a movie are similar across viewers. These similar responses emerge because the movie recruits brain systems involved in sensory (e.g., responding to the flickering lights on screen), perceptual (e.g., identifying the characters' faces), and social-cognitive processing (e.g., following and understanding the story, social, and affective responses) – separately in each individual brain, but collectively across the audience. Here we compare brain response similarities during an engaging, social, and nonverbal 5-minute Pixar movie across two levels: First, we show that at a macro-level, the movie-evoked brain responses among the current audience from Australia are correlated with the brain responses to the same movie watched by an audience from the USA. Second, we investigate whether twins, who maximize the preexisting similarity two individual audience members can have, exhibit more similar brain responses to the same movie. We find that shared responses measured in an audience from Australia were highly correlated with responses from an audience watching the same movie in the USA. Second, we find that twins (who are genetically more similar and usually raised in a similar environment) exhibit more strongly aligned brain responses compared to non-twin participants. These results support our predictions about the role of pre-existing similarities among audiences for brain-to-brain coupling during movie reception. Moreover, they suggest that brain-to-brain similarities in response to movies contain information about similarities at the social level.

Keywords: social cognition, audience response, communication neuroscience, twin studies, genetics

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Have you ever watched a movie with a friend and wondered if your brains respond similarly? Now consider having a twin – a sibling who was born on the same day and usually raised in the same environment. Would their brain activity more closely resemble yours than that of a stranger? And would people watching the same movie in another continent also show similar responses? This paper examines these questions. Understanding how the same media stimulus can elicit convergent brain responses among individuals offers new perspectives on the neural basis of collective audience reactions to mass communication and entertaiment media.

The paper is organized as follows. First, we introduce the framework that uses neuroimaging to measure how viewers' brains respond similarly to a movie's time-varying content. Next, we describe the extended neurocognitive network model, which explains why brains respond so similarly during movie reception. We then introduce the current study, which compares brain response similarities during an engaging movie across two levels: First, we show that at a macro-level, the movie-evoked brain responses among an audience from Australia are correlated with the brain responses to the same movie watched by an audience from the USA. Second, we delve into the micro-level and investigate whether twins, who maximize the preexisting

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similarity two audience members can have[1], exhibit more similar brain responses to the same movie.

Background

When different people watch the same movie, they all respond to the same sensory information, which prompts a host of similar neurocognitive responses (Hasson et al., 2008; Nastase et al., 2019; Schmälzle, 2022), including similar sensory-perceptual responses and similar inferences about events and characters (Zillmann, 2010). Of note, there can also be individual differences in how viewers respond to the same input based on preexisting knowledge structures that are specific to individuals or groups (e.g., Leong et al, 2020, Schmälzle et al., 2013), but these are overlaid on responses that are shared across all recipients. In sum, when audiences view the same movie, their brains will respond similarly in many regions that are involved in sensory reactions, perception, as well as social and cognitive processing.

With neuroimaging, we can examine these similarities in how media content engages viewers' brains. Neuroimaging records brain activity on a moment-to-moment basis and simultaneously from multiple brain regions (Floyd & Weber, 2020; Huskey et al., 2020; Schmälzle & Meshi, 2020), allowing researchers to interrogate brain responses to movies. This includes how a movie's flickering lights stimulate sensory systems, how images of faces are recognized by perceptual systems, or how peoples' social-cognitive systems allow them to tune into the storyline and respond to characters' fates and interactions.

Theory and Method for Examining Shared Audience Brain Responses During Movie Viewing

Over the past decades, studies have begun to capture brain responses during movie viewing (Aliko et al., 2020; Hasson et al., 2008; Kauttonen et al., 2018; Richardson et al., 2018), and some have explicitly focused on the inter-subjective similarities that movies evoke among viewers (Hasson et al., 2004, 2012). A method called inter-subject correlation (ISC) analysis compares viewers' brain responses recorded over the duration of a movie. The resulting ISC maps reveal which brain regions respond similarly to the same movie, exhibiting a collectively shared audience response. This ISC approach was originally developed in neuroscience to examine natural vision (Hasson et al.,

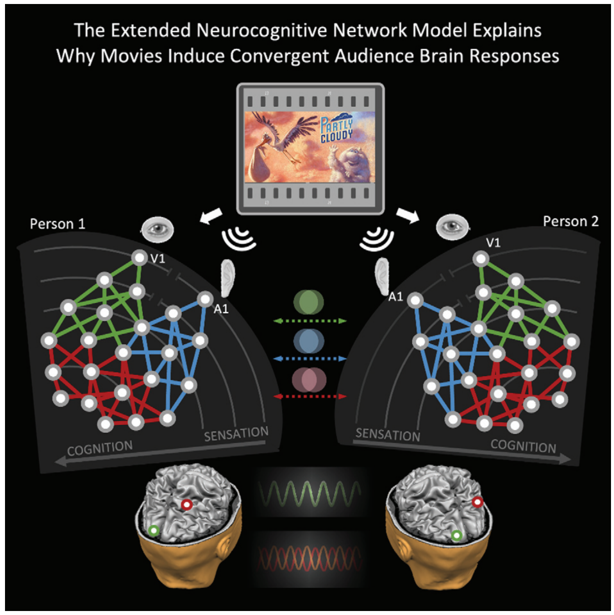

Figure 1. Illustration of the extended neurocognitive network model, which explains why the same movie evokes shared brain responses. See text for details.

2004), but it has since then found many applications in media neuroscience to examine social-cognitive and affective audience responses to movies (Schmälzle & Grall, 2020a).

A recently proposed model, the extended neurocognitive network model (Schmälzle, 2022), explains these shared brain responses (measured via ISC analysis; see Figure 1). Specifically, this model is based on the neurocognitive network model (Mesulam, 1998, 2012), a theory of brain function that describes the flow of information in the brain from sensation (e.g., light impinging on the retina in the eye) to perception (e.g., recognizing a face as belonging to a character) to cognition (e.g., taking the perspective of a person in conflict with a close friend). The model describes a distributed network organization in which information flows along gradients that span from concrete to abstract features (for example, concrete features include seeing edges and lines; abstract concepts include understanding that an image comprised of many edges-and-line features actually depicts a table), as well as from unimodal visual or auditory channels to multimodally integrated conceptual representations (e.g., seeing a gun in one image frame, hearing a bang a second later, and then making the inference that a shot has been fired, which in turn means that somebody might have been killed). This neurocognitive network model provides a general theory of brain function, but the original

[1] Please note that we study twins, who share a genetic makeup. However, the twins in our study were also raised in similar environments. Thus, this study is about the degree of similarity, which is higher among twins who were also raised in a similar environment; our goal here is not to disentangle the relative influences of genetic and environmental factors in shaping convergent audience responses.

model only applies to a single brain but not to multiple brains forming an audience.

A recent article thus proposed an extension of this model in which multiple brains process the same media (Schmälzle, 2022). The central idea is that individual viewers' brains are similar in terms of structure and function, and that this similarity explains why we see similar brain responses when audiences view the same movie. Indeed, similarity is a fundamental notion across the natural, social, and cognitive sciences (Centola, 2015; Edelman, 1998; Lorenz, 1981): All humans are genetically similar; our brains share the same gross-anatomical organizational principles, much like our bodies, faces, and other human body parts. Because structure is a prerequisite for function, structural similarity between our brains gives rise to similar functional abilities, like our general capacities for face recognition, language comprehension, empathy, and others (Fuster, 2003; Hasson et al., 2020; Mantini et al., 2012). In conclusion, a conserved brain architecture underlies functions that are shared by all people. This implies that processing the same information, like an incoming movie, will cause comparable reactions in different brains.[2]

Taken together, the extended neurocognitive network model explains why we see inter-subjectively correlated brain responses when people view the same movie. First, the same sensory information arrives in similar sensory systems (e.g., the retina, the visual cortex), evoking similar sensory responses across viewers' brains. Second, perceptual responses are induced (e.g., the fusiform face region responding to a close-up shot of a character); this also happens separately in different brains, but similarly across the audience as an aggregate. Finally, to the extent that movies prompt similar social-cognitive processes in people, we can also expect shared brain activity in regions involved in social and cognitive processes (e.g., the medial prefrontal cortex, mPFC, the anterior cingulate cortex, ACC, or the temporo-parietal junction, TPJ; Decety & Lamm, 2007; Lieberman, 2010).[3]

The evidence to date supports this general model. For instance, we find the strongest ISC responses in sensory cortices (Hasson et al., 2004; Schmälzle & Grall, 2020b), and inter-subjectively correlated responses extend into higher-level systems associated with story cognition (Imhof et al., 2017; Schmälzle et al., 2015; Yeshurun et al., 2017). However, besides such general support, many specific predictions remain to be tested. Here, we will focus on two

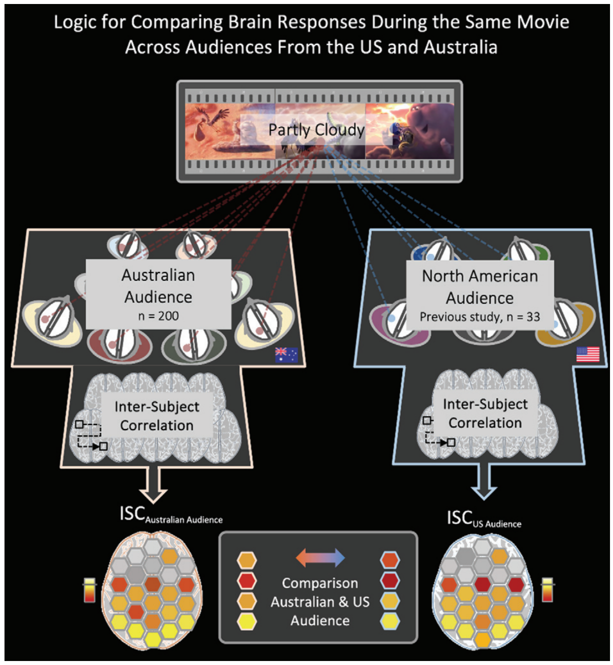

Figure 2. Rationale for Audience-to-Audience Comparison. The same movie should evoke correlated brain responses along a continuum from sensation to cognition. ISC is computed within each audience, and the overall pattern of ISC is compared between the two.

levels to compare brain response similarities: First, we will compare macro-level similarity of two audiences viewing the same movie (one in Australia, the other in North America); Second, we will examine at the micro-level whether twin-pairs exhibit higher similarities than random people when viewing the same movie.

Motivation for Examining How Audiences Respond Similarly to a Social Movie

The extension of the neurocognitive network model to study media-evoked brain responses revolves around the notion of similarity: The same media content will evoke responses along the continuum from sensation to cognition, and to the extent that the brains of audience members are similarly built, operate similarly, or have been trained similarly, they will exhibit similar responses. Typically, this all is studied by comparing brain responses across individual viewers. However, this reasoning also applies at the audience level. If movie-goers in one cinema watch a movie,

[2] To avoid misunderstanding: The notion of similarity is different from identity. We are not claiming that all brains respond exactly the same way and that movie viewing causes identical psychological experiences. However, we are claiming that without these neural commonalities, communication (a word derived from the Latin "communis", meaning "shared") would be impossible.

[3] Again, this is not to say that there cannot be individual differences in responding. For instance, some people may cry during a drama movie, others may not, and audience members may feel varying levels of sadness and so forth. However, these individualities are overlaid on shared responses driven by the plot, that is, that more or less everyone will become sad during sad story moments, although not everyone may cry.

and another group in another cinema sees the same movie, would not we expect a similar response? What if the cinema locations were in different continents, such as North America and Australia? In the upcoming study, we will address this question by comparing brain response similarities to the same movie across continents (see Figure 2). However, before introducing the study, we will next turn to the micro-level, and specifically to the case of twins, where we can expect pre-existing similarities among individual audience members to be elevated.

Motivation for Examining How Twins' Brains Respond to a Social Movie

Twins provide a near-ideal test case to assess predictions from the extended neurocognitive network model. Identical twins start from the same fertilized egg and thus initially share the same genome, whereas fraternal twins share about 50% of the genome, like normal siblings (Prescott & Kendler, 1995). Above and beyond these genetic similarities, twins are usually also raised in shared environments – the same family, house, and neighborhood, which exposes them to congruent environmental influences. As a result, twins exhibit many similarities, and in the case of identical twins, even faces and bodies look similar, and they have the same biological sex and similar brain structure (Peper et al., 2007).

Twins also exhibit many similarities in conduct, temperament, and cognitive performance (Plomin & Ho, 2017). These ideas have stimulated the interest of media scholars in examining twins' media habits, selection decisions, or how they respond to games (Hassan, 2023; York, 2020). However, to our knowledge, there are no studies examining twins' brain response similarities when viewing movies.

In conclusion, pre-existing similarities should promote similarities at the functional level during media reception (see Figure 3). Therefore, twins' brains should react to the same movie more similarly than the brains of non-twins. And, speaking to the audience-to-audience level similarity, we can expect that US and Australian audiences should exhibit convergent brain responses to the same movie (see Figures 1, 2, and 3).

The Current Study and Hypotheses

This study examines how viewing the same movie evokes similar brain responses among audience members. It focuses on audience-to-audience similarity across continents and on the very special case of twins as a micro-audience with higher-than-average pre-existing similarity.

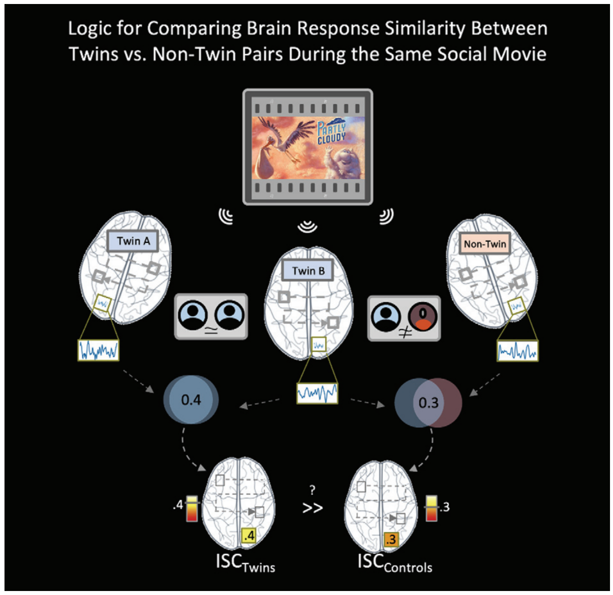

Figure 3. Rationale for twin-comparison: Twins should exhibit higher ISC (more similar brain responses) than non-twins while viewing the same social movie. Due to their unique combination of shared genes and congruent environmental influences, twins maximize the similarity that two people can have. The extended neurocognitive network model predicts that underlying similarities (including structural similarities, shared knowledge structures, and shared dispositions), when engaged by the incoming movie, will lead to similar functional brain responses. Therefore, twin-pairs should exhibit enhanced ISC. Of note, we focus here on twins in general, which includes both identical and fraternal twins, the former being even more similar than the latter. For reasons explained in the methodology section, there are data restrictions on the dataset that prevent a direct comparison between the twin subtypes. Therefore, the main comparison is between twins and non-twins.

The stimulus is an animated movie titled Partly Cloudy, which depicts a friendship and its challenges between two animated characters. This movie has been used in a previous study that measured brain responses in the USA (Richardson et al., 2018); the current study is based on a new dataset of brains responses to the same movie in an Australian audience, specifically a sample of twins (Strike et al., 2023).

The framework outlined above yields the following predictions. First, as for the previous study that found inter-subject correlations across the US-audience (Grady et al., 2022), we expect that the Australian audience members' brain activity will be correlated while they process the movie. This should be evident throughout the brain, encompassing, for example visual cortex, but also regions involved in salience processing, executive attention, and social cognition. Second, we expect that the inter-subjectively correlated brain activity will be similar across the two inter-continental audiences. Hence, we hypothesize:

Hypothesis 1a (H1a): Shared brain responses (i.e., positive and statistically significant ISC) during movie viewing will be present in the current audience, encompassing regions involved in sensory and perceptual processing, but also extend into higher regions involved in social cognition and story comprehension.[4]

Hypothesis 1b (H1b): The pattern of shared brain responses (ISC) for the Australian audience will be correlated with the results for the US audience.[5]

Next, moving from the audience-to-audience to the individual-to-individual comparison, we examine the twins as a two-person mirco-audience in which members are more similar to each other when they encounter the movie. This leads to the prediction that twins' brain processes while watching a social movie should be more similar than those of two non-twins (see Figure 1).

Hypothesis 2 (H2): Twins will exhibit more similar brain responses during movie reception.

Although the general hypothesis that twins should exhibit higher ISC is straightforward ($ISC_{twins} > ISC_{random\ others}$), it is not completely clear where in the brain such similarities should be maximal. On the one hand, one may anticipate that enhanced ISC could be present throughout the brain because twins may be more comparable than unrelated individuals in many aspects of neurocognitive functioning (e.g., visual-sensory functions in early visual brain regions, perceptual functions in the occipito-temporal cortex, and higher-level processes related to comprehension, social cognition, and attention, which involve distributed networks of the frontal and parietal lobes). On the other hand, it is also plausible that certain functional-anatomical hotspots are more prominent than others. For instance, it could be that systems underpinning social-cognitive functions, preference structures, and personal memories, might be more contingent on the twin vs. non-twin status. If true, then this could result in highly shared brain responses across all people in sensory and perceptual regions (driven by a shared movie), whereas subsequent processes (e.g., socio-emotional responses) could depend more on pre-existing similarities. In this case, we could expect that regions like the temporoparietal junction (involved in social cognition) exhibit particularly strong effects among twins compared to non-twins. This motivates the research question:

Research Question 1 (RQ1): If ISC for twins is increased, where in the brain are these effects most pronounced?

Method

This study leverages a public dataset, the Queensland Twin Adolescent Brain (QTAB) dataset, which contains fMRI recordings from twins watching a film titled *Partly Cloudy* (https://www.youtube.com/watch?v=5VRc8poIwU4; Strike et al., 2023). Additionally, to examine H1b, we incorporate data from another dataset (Richardson et al. 2018) that showed the same film to a sample in Boston (USA) while recording fMRI. Both datasets are available on the OpenNeuro platform (QTAB, Australia: ds004146, Boston, USA: ds000228). Below, we keep the description of the main QTAB study methods rather short, and we refer to previous publications and the Electronic Supplementary Materials (ESM 1) for further details on both datasets.

Partly Cloudy Movie Viewing Dataset From Queensland, Australia

Participants

Overall, 206 neurologically normal adolescent twin pairs were recruited in Australia through twin registries and participated in the QTAB study. However, the movie-viewing session was only included for a subset of twins. We restricted our sample to right-handed individuals because of known brain differences between right and left-handed individuals. This led to a final sample of 200 twins or 100 twin pairs[6] (M_{age} = 12.43; SD = 1.53).

Stimulus and Procedure

Partly Cloudy is a 5-min short, silent animation movie that has been used to engage theory-of-mind or mentalizing processes (Richardson et al., 2018). In short, it tells the story of

[4] Regions involved in visual-sensory and -perceptual processing include the visual cortex, occipito-temporal regions, and also regions along the dorsal visual pathway. Regions involved in social cognition and story following include those encompassing the entire default mode, saliency, and executive networks.

[5] Please see the Methods and ESM 1 for additional details on differences between the US and Australian datasets and the way in which this hypothesis is tested using a comparison of the spatial pattern of ISC at the audience level.

[6] Of note, while the fMRI data portion of this dataset is publicly available, there is a private dataset that includes additional biological and psychological information about the participants, and the zygosity status of the twins (i.e., whether they are monozygotic/identical or dizygotic/fraternal twins) is part of this private dataset. Our analytical focus here is on the twin vs. non-twin comparison, including both the MZ and DZ twins. In ESM 1, we offer a complementary analysis that compares twins that are definitely fraternal (which we can know from the data) and a group that contains mostly identical twins.

Gus, a cloud who creates babies for storks to deliver. Unfortunately, Gus has the habit of creating babies with unusual features. His assigned delivery stork is Peck, and the two form a social relationship. However, that relationship is challenged when Peck – being repeatedly hurt by Gus' unusual babies – leaves Gus. This makes Gus feel socially isolated and causes him to cry, which Peck observes. In a heartwarming scene, Peck returns to and reunites with his friend Gus, and the film ends with the two being together with a newfound appreciation for their friendship and important delivery work.[8]

fMRI Acquisition and Processing

Detailed information about fMRI procedures can be found in the data paper (Strike et al., 2023) and in ESM 1. In brief, data were recorded while participants viewed the 5-min movie with a 3T MRI-scanner, a TR of 0.8 seconds, yielding 380 volumes. We downloaded the original dataset and preprocessed all data using fMRIprep-21.0.2 (Esteban et al., 2019). Further analyses were carried out using functions from the nilearn-0.10.0, BrainIAK 0.11, and nltools-0.5.0 packages (Abraham et al., 2014; Chang et al., 2018; Kumar et al., 2020) as described below.

FMRI data recorded during movie viewing were extracted using a nilearn-masker. Specifically, for each participant, we extracted time-series from a parcellation that contained 293 regions. These regions included the 268 whole-brain-parcellation by Shen and colleagues, which were amended with subcortical regions from the Pauli-atlas (for reward-related regions), and the ascending-arousal-system atlas (Edlow et al., 2012; Pauli et al., 2018; Shen et al., 2013). Combining these yielded 293 regions from which we extracted functional brain activity during movie viewing. Data were high-pass filtered at 0.01 Hz, detrended, and *z*-scored. Thus, for each participant, we obtained a matrix comprising 380 samples (time points) and 293 regions. These data (i.e., a matrix of 293 × 380 × 200 viewers) formed the input for inter-subject correlation analysis, described below.

Partly-Cloudy Movie Viewing Dataset From Boston, USA

The sample for the Boston dataset came from a study of child brain development that included a total sample of 155 viewers (Richardson et al., 2018) who watched the same movie: Partly Cloudy. The sample was restricted to exclude the children below the age of 12, leaving 33 viewers (20 female, average age = 24 years). Participants (not twins) were recruited from the local community and were scanned on a 3T scanner with a TR of 2s. Preprocessed data were downloaded and extracted from the 268-node Shen parcellation[7] using the same methods as for the QTAB data, yielding a data matrix of 268 regions (including the same regions as also for the QTAB dataset) × 168 time points (due to the slower acquisition time compared to the QTAB dataset), × 33 viewers. For further information, please refer to ESM 1.

Inter-Subject Correlation Analysis Methods

All raw data are available on the OpenNeuro platform, ISC analysis methods were carried out following previously published procedures (Nastase et al., 2019; Schmälzle & Grall, 2020b), and we document analysis methods in a reproducibility package (https://github.com/nomcomm/partlycloudy2).

To address H1a, we computed ISC analysis between all 200 viewers (i.e., the current movie audience from Australia), correlating the region-wise time courses between every pair of viewers across the full duration of the movie. This yields a pairwise ISC matrix for every brain region, and the ISC for the entire audience was computed as the median of the lower triangular of this pairwise matrix. Statistical significance was assessed using subject-wise bootstrapping (5,000 iterations) of the pairwise similarity matrix. The resulting statistical values were corrected using the FDR procedure ($q = 0.05$) and used to threshold the ISC result maps for display.[8]

Next, to address H1b, we also re-computed and compared ISC results for the audience from the previous study, that is, viewers from Boston (USA) who were watching the same Partly Cloudy movie (Grady et al., 2022; Richardson et al., 2018). To compare the similarity of the resulting ISC maps, we vectorized the 268 common ISC values and compared them via correlation analysis. Moreover, although we only computed this analysis for ISC values that were significant, we also restricted this analysis to higher ISC values (thresholded at a $r_{\text{pairwise}} = 0.1$), again testing for a significant vector correlation.[9]

Then, to address H2, we computed ISC analyses between each pair of twins and compared the resulting twin-ISC to the ISC among the entire sample (i.e., across random,

[7] At the time of this study, we did not extract the subcortical regions that were extracted in the more recent study. These regions are thus excluded when comparing the audience-to-audience similarities.

[8] We also computed ISC statistics using the popular phase-randomization procedures and examine both pairwise ISC as well as leave-one-out-based results. Regardless of the specific methods used, we find the same results.

[9] We provide an analysis based on regional time-series in ESM 1. However, due to the original studies' differences in movie presentation, scanning, and preprocessing parameters, a direct time-series-based comparison is laden with several pitfalls.

non-twin viewers). Additionally, we also compared the twin-ISC to a “control-ISC” that correlated data from a given viewer to another viewer the exact same age and sex. This was done to have viewers who are the same age and sex (twins naturally are of the same age, and in the case of identical twins also the same sex), but don’t share the twin-status except for those two similarity characteristics. Note that compared to the traditional pairwise ISC (“all-to-all”) comparison, the ISC among twins is also pairwise, but there are only 100 twin-pairs (“one-to-one”). Thus, to assess whether twin-ISC was enhanced compared to the non-twins and matched controls, we compared the observed ISC for the twin-to-twin sample to the reference distribution obtained by bootstrapping the ISC among random others. Specifically, instead of subtracting the mean-ISC of random others as is done if a null-distribution is constructed to test a within-sample ISC, we simply compared the observed twin-ISC against the bootstrap distribution of the random others and derived a p-value for this singular ISC value (i.e., every individual is matched against their twin, of which there is only one; see ESM 1 and reproducibility package at https://github.com/nomcomm/partlycloudy2 for more details).

Results

The Social Movie Evokes Shared Brain Responses Among Australian Adolescents (H1a)

Figure 4 shows the results of the ISC analysis computed across the entire audience of 200 viewers, for all 293 regions, and assessing and thresholding the ISC based on its significance as described above. As expected, the movie evokes similar responses across widespread brain regions. Importantly, note that color in this plot does not indicate the strength of activation, but rather illustrates the degree of shared processing, that is, the extent to which regional brain activity resembles the activity in the corresponding region in other viewers. Thus, the brighter the color (yellow to white), the more closely brain responses in that region align with each other across viewers. Figure 4 illustrates that viewing the same movie clearly induces highly significantly shared audience responses in visual-sensory regions, but also in visual-perceptual brain systems and beyond. Importantly, these shared brain responses among audience members also include regions of the so-called default mode or mentalizing network (e.g., TPJ, mPFC, precuneus), the saliency network (e.g., ACC and aINS), and many higher-order regions involved in following, attending to, and responding to the plot.

Highly Similar Results for Audiences from Australia and North America (H1b)

The assumption underlying H1b was that, despite having data from two distinct audiences whose brains were scanned hundreds of kilometers away, years apart, and even using different scanners and scanning protocols, we would expect the same movie material to command similar brain reactions. Figures 4B–4D show the data that support this hypothesis. Specifically, the distribution of strong ISC (in visual cortex, for example), moderate ISC (in regions of the mentalizing network), and weak or nonsignificant ISC (e.g., in regions involved in smell, taste, or motor activity – all not directly addressed by this visual movie) was highly similar across the two audiences. To quantify the degree of similarity, we compared the region-by-region ISC results for both audiences via correlation analysis, finding that the correlation coefficient between the spatial ISC patterns was $r_{(\text{ISCBoston vs. ISCBrisbane})} = 0.91$, which is highly significant ($p < .0001$). Moreover, also after thresholding out lower ISC (i.e., $r < 0.1$), we still find a highly significant correlation of the spatial-ISC distribution ($r_{(\text{ISCBoston vs. ISCBrisbane})} = 0.62$, $p < .0001$). This suggests that the same movie induces similar brain activity into the brains of each audience member, which leads to significant ISC within each audience separately, and that the overall pattern of this ISC is conserved across the audiences from different continents. Additionally, Figure 4 also displays exemplary regional brain activity time-series from a region in parietal/temporo-parietal cortex to demonstrate the brain response similarity among viewers during movie reception (see ESM 1 for more details).

Twins Exhibit More Similar Reactions to the Same Movie Than Non-Twins (H2)

To address H2, which stated that twins would exhibit stronger ISC than non-twin pairs, we computed two separate pairwise ISC analyses among twins and non-twin pairs, respectively. The results of this analysis are presented in Figure 5 and are consistent with H2: We find that ISC among twins is elevated throughout many regions of the brain, as revealed by the fact that the ISC among twin-pairs is significantly higher compared to the ISC obtained by randomly pairing participants.

To provide an alternative summary of these results, we jointly plot all 293 regional ISC values from the twin-pair vs. random pair via a scatter plot. As can be seen, the ISC for twins lies above the diagonal for almost all individual regions, suggesting a general rather than a region-specific effect. This is also supported by the observation that out of the 293 regional comparisons, all but 14 were significant

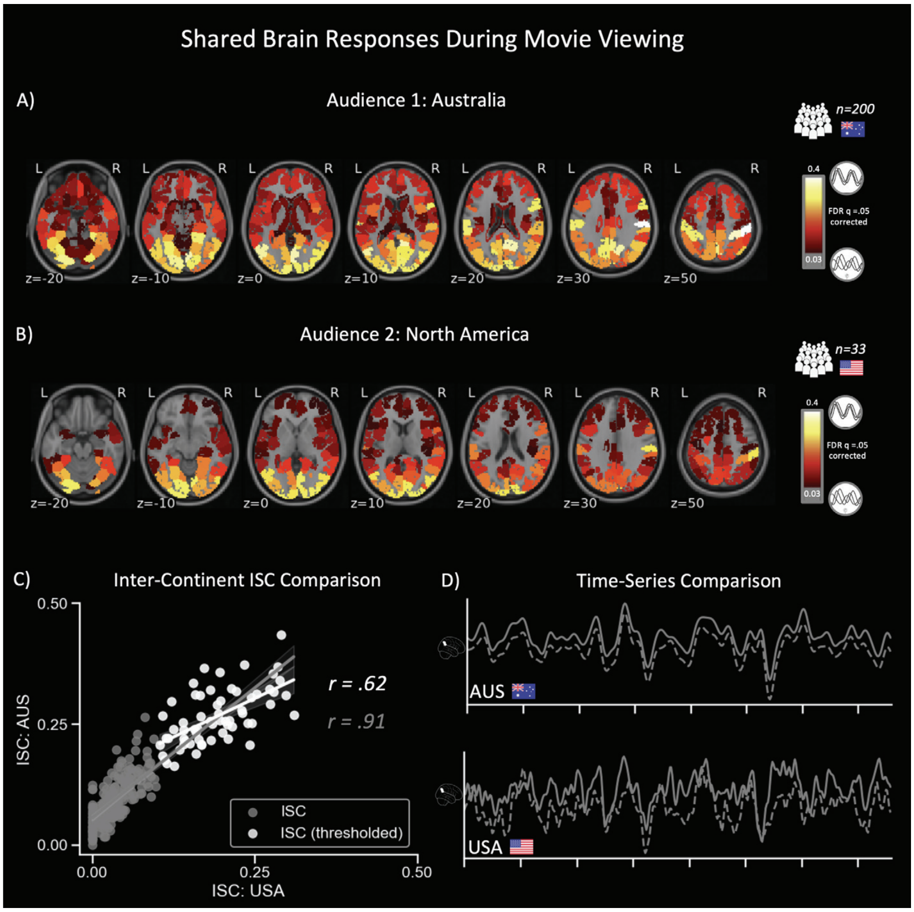

Figure 4. Comparing ISC results across audiences. (A): Shared brain responses among the Australian audience (collected in Brisbane). Results are thresholded based on a bootstrap to test for significant ISC within the group of 200 viewers. (B) Shared brain response among the American audience. Note that due to the smaller sample size for the American audience, some regions do not survive statistical correction, but the spatial pattern of high ISC values in visual regions and lower, but still significant results for, for example, mPFC or TPJ is preserved. (C) Scatterplot comparing results from Australian and American audiences, demonstrating that results are highly consistent across continents. (D) Extracted time-series from a parcel in the temporo-parietal cortex (plotted separately for each half audience, that is 100 vs. 100 for the Australian group and 16 vs. 17 viewers from the American group). As can be seen, the time-series are strongly aligned within each audience and across audiences. Note that the Australian scanner recorded data much faster, leading to more samples.

(when compared against the bootstrapped null distribution and correcting the resulting *p*-values for multiple comparisons). Of note, we find that nominally the TPJ, a key region involved in social cognition, meaning-making, and story processing (Yeshurun et al., 2021), was exhibiting some of the strongest differences in all of these analyses, although this does not mean that this region showed significantly more ISC enhancement than others.

Finally, as another control analysis, we compared the observed twin-ISC against the ISC observed when computing ISC among pairs of viewers who were matched in terms of age and sex. The rationale of this analysis was that twins are naturally of the same age (same birthday) and in the case of identical twins also the same sex. Thus, twins are similar in this regard, and one could argue that any age- and sex-matched control group would exhibit similar effects. However, we find that the ISC among sex- and age-matched control pairs is on par with that of the random others group, suggesting that enhanced ISC among twins is due to more than the two similarity characteristics of age and sex.

Supplementary Analyses

Beyond these main analyses, we carried out two additional analysis streams, one focused on possible structural differences (brain anatomy) and the other on classification or prediction. The first analysis was motivated by the notion that twins' brains might be anatomically more similar, which might drive at least some of the resulting functional differences, even though all brains were normalized into a common MNI space. Empirically we find twins also share more similar brain structure (for details see supplementary results).

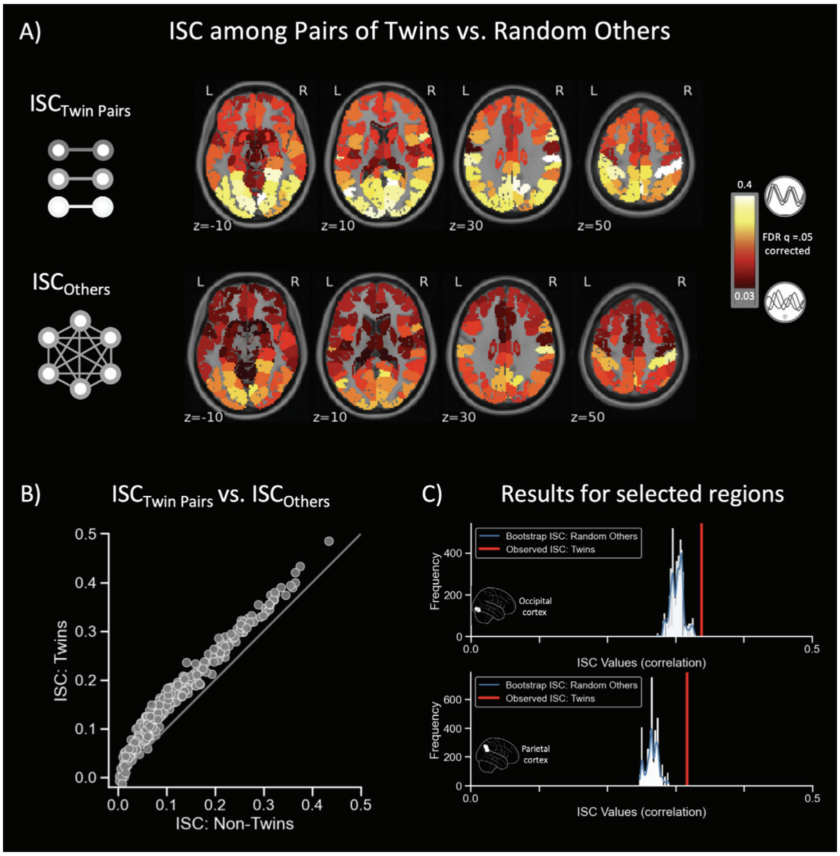

Figure 5. ISC results for pairs of twins vs. random pairings of viewers. (A) ISC results for twin pairs, the panel below the results for random others. Both results are thresholded based on bootstrapping statistics (details see text). (B) Region-by-region comparison of ISC-strength for twin-pairs vs. ISC among non-twins (random others). Individual points in this plot correspond to each of the 293 brain regions. As can be seen, ISC strength for almost all regions is consistently above the main diagonal, suggesting that twin-pairs have higher ISC than controls. (C) Zooming in on two individual regions (occipital and inferior parietal/temporo-parietal cortex): The vertical red line represents the average ISC among the 100 twin pairs. The distribution shows ISC results from the bootstrap ISC analysis among random others to estimate the variability of ISC results. As can be seen, ISC among twins is shifted to the right and falls outside of the distribution's confidence interval.

Another supplementary analysis examined whether it is possible to use the ISC between two people to predict whether the couple are twins. To investigate this, we created a predictive modeling pipeline that used ISC to classify the target variable (twin vs. no-twin status). Specifically, we used regional ISC as features in a logistic regression model with a leave-one-out cross-validation strategy, and tested model performance against a baseline dummy classifier. As expected, a dummy classifier performed at chance level (50%, balanced dataset, see Supplementary Results for details), whereas the logistic regression model using measured response similarities performed with an accuracy of 67% on average.

Discussion

The present study investigated how the same movie prompts similar and thus collectively shared brain responses among viewers. First, regarding a macro-level audience-to-audience comparison, we examined shared responses to the same movie in two spatially distant samples – one audience in Australia and the other (from a prior study) in North America. We find that the same movie prompts similar spatial patterns of shared brain activity in both audiences. Second, honing in on the micro-level of viewer-to-viewer similarity, we study how pre-existing similarities modulate the shared brain responses, finding that twins respond to the same social movie more similarly compared to non-twins. These two principal findings are discussed next.

Similarities Between Movie-Evoked Brain Responses Across Worldwide Media Audiences

Based on the extended neurocognitive model, which revolves around the notion of similarities among audience members that underlie the shared brain responses to a movie, we predicted that the brains of 200 Australian adolescents (this study's main audience) would respond similarly to the socially engaging movie (H1a). The results strongly support this. Specifically, in line with the visual nature of the movie, ISC among the Australian audience was especially strong in regions involved in vision and broader perceptual systems (e.g., the ventral visual pathway). Importantly, highly significant ISC was also present in higher-level systems associated with social cognition, such as the TPJ, mPFC, and precuneus.

When we compared the current sample's ISC results for the Partly Cloudy movie, we find that the pattern of ISC closely resembles ISC for the audience whose brains were scanned in North America (and years before). This supports H1b. Across the brain, we found that the correlations of ISC amounted to r = 0.91. Such high correlations underscore the value of ISC-based methods for population-based neuroimaging initiatives and suggest potential for clinical and prediction-oriented studies (Falk et al., 2015; Imhof et al., 2017). One caveat, however, is that we only compared the spatial pattern of ISC at the audience level, which is different from e.g. comparing brain activity in one viewer from Boston to that of another viewer in Brisbane. Although this could be done, the differences in how the movie was shown and how neural data were recorded raise some difficulties, but going forward, this is possible (Li et al, 2022). Another open issue is whether audiences from very different cultures would exhibit similar brain responses as well, or which factors (such as education, industrialization, cultural influences, or values, cf. Hopp et al., 2023) would matter most. Doing so systematically will, of course, also require scanning not only different audiences, but also sampling from a broader array of media content. And finally, along the same lines, it will be equally promising to study how brain responses to social content develop (e.g., Aley et al., 2021; Richardson et al, 2018). Despite these open questions, the current approach provides a principled framework to study them. While the current study only allows insights into this particular sample and movie, it is to our knowledge one of the first that demonstrates converging audience responses in an inter-continental comparison. More broadly, it underscores the consilience between media psychology and neuroscience research, which can benefit both disciplines (e.g., Schmälzle & Huskey, 2023; Weber, 2015).

Enhanced Similarity of ISC Among Twins Compared to Non-Twins

Next, moving from the macro-level audience-to-audience comparison to the micro-level of the twin-twin comparison, we find that adolescent twins' brains react to the same movie more similarly than the controls' brains. These results support H2, which was based on the reasoning that the pre-existing similarity between twins would translate into higher similarities in how their brains respond to this socially engaging movie (Figures 3 and 5). Regarding where in the brain such effects would be most pronounced, it appears that it is relatively widespread, present throughout the brain rather than only expressed in a single region (see Figure 5). This indicates that more similar brain responses are present throughout the sensation-to-cognition hierarchy. Thus, not only do sensory systems tune in to the movie more similarly across twins, but this effect is propagated through the hierarchy all the way up to social-cognitive levels, which are key given the social content of this particular movie. Indeed, regions that exhibit stronger ISC among twins include key nodes of the mentalizing network, like the TPJ, the mPFC, and the precuneus, but also regions involved in the extended comprehension system, the executive control and saliency networks (Grall et al., 2021; Schmälzle, 2022; Schmälzle et al., 2015). Hence, even though we cannot know what participants were feeling or thinking while seeing a movie (Schmälzle & Meshi, 2020), the social nature of the movie content, paired with the finding that social-cognitive brain systems were engaged, strongly suggests that the twins' brains processed this movie in a neurotypical manner – and more similarly for each twin pair.

These results are also interesting to consider in light of recent reports that link shared brain responses to similarities at the social level (Baek & Parkinson, 2022). For example, similar brain responses to the same content predict friendship (Parkinson et al., 2018). Other work suggests that social similarities (like being members of the same social group or being close in a social network) are associated with how similar people respond to identical media content (Baek et al., 2021). Finally, regarding message interpretation, people with similar views (about pandemic risk perceptions) responded to the same risk-related information more similarly (Schmälzle et al., 2013), a result that is also seen in other domains such as political communication and story framing (Leong et al., 2020; Yeshurun et al., 2017). Overall, such findings align with the notion that social connections rely on underlying similarities at multiple levels – ranging from basic neuroscience to shared interpretations, traits, and social networks (Baek & Parkinson, 2022). Our findings add to this research insofar as they demonstrate that people with higher pre-existing similarity, twins, exhibit enhanced similarity in brain responses. Although our study is still quasi-experimental in nature (because we cannot manipulate twin status), this still provides support for the causal nature of the effects compared to the mostly correlational findings from prior studies. To sum up, the picture that emerges from this work is one in which individual-level structural similarities (genetics, brain structure, and congruent environmental influences) can be linked to similarities at functional levels (how brains respond to media) and further on to social outcomes (how we are affected by media, what we are receptive to, with whom we affiliate with, or how well we get along with others).

Limitations and Avenues for Future Research

This study is subject to some limitations that should be considered when interpreting the findings. First, data about subjective interpretations and comprehension could provide insights into twins' responses to stimuli, but the QTAB study did not include such measures.

Second, the comparison between-audience ISC comparison (by correlating the two ISC-result-vectors) is subject to limitations regarding spatial autocorrelation, which could lead to inflated statistics. However, the fact that the results hold even when comparing ISC from largely separate brain systems (e.g., visual, auditory, and DMN systems) raises our confidence that the pattern-similarity between cross-continental audiences represents a robust effect. Next, the ISC analysis presented here is based on brain regions rather than voxels, as our analytical focus was at this medium-level granularity. Importantly, while not reported here for space reasons, we also carried out an analysis at the voxel level, and the results support the conclusions drawn here. However, future work could also study more fine-grained voxel-level ISC, including advanced procedures like hyper-alignment or shared response models. Such approaches can also deal with anatomical variability and similarity, which we found to be enhanced in twins (see ESM 1). Given that ISC-analyses are carried out on signals measured in corresponding brain regions, a better anatomical correspondence should, all else being equal, also lead to higher ISC.[10] In sum, additional work is needed to address questions regarding spatial ISC comparisons and their fine resolution.

Relatedly, this also carries over to the predictive model. Although we find that the movie-induced response similarity could predict whether two viewers were twins, this analysis used relatively simple similarity-features. Specifically, it only incorporated the fMRI response similarity from fairly coarse-grained regions and for the entire movie. One could compute more nuanced derivative metrics (like inter-subject functional correlations or ISC in movie segments), and doing so could yield even higher accuracies. Moreover, future work would likely have additional information available, including information about genes, anatomy, health, environmental influences, and test scores. Adding such information into predictive models seems a particularly promising strategy.

Finally, the study did not incorporate full-fledged genetics modeling (Knopik et al., 2019; Plomin & Ho, 2017; York, 2020). Given the secondary nature of this analysis, we had no influence on the study design, which was not suited to disentangle genetic and environmental factors. Rather, as we emphasized above, the twins in the QTAB study share not only a more similar genome but were also raised in similar environments (families, houses, etc.). Thus, when they came to the scanning research in Brisbane, their high similarity is not only attributable to genetic factors but also to the shared upbringing and gene-environment interactions. In the field of behavior genetics, powerful twin-study designs compare similarities among adopted twins (raised separately in different families), identical, fraternal twins, and normal siblings (raised jointly in the same family) to parcel out these influences. Given that we could only study twins who were raised in a shared environment, such analyses are not possible and the current conclusions only apply to the comparison between twins vs. non-twins, who undeniably have a more similar genetic makeup, but also hold a wealth of acquired similarities. Considering these limitations, the current results demonstrate that twins respond more similarly to the same movie content, but they can not be attributed to genetics alone.

Summary and Conclusion

Using an animated silent movie developed by Pixar, we examined neurocognitive response similarities among audience members. We find that the same movie evokes similar brain responses across continents. Moreover, we find that twins' brains respond to the same movie more similarly than audience members who are less similar. Owing to the social nature of the movie content and the activation of social cognitive brain systems, the findings suggest that twins processed the movie in a neurotypical way. This approach opens the door for future studies examining how media steer convergent responses in large audiences and how such audience response convergence is shaped by pre-existing similarities among receivers.

Electronic Supplementary Materials

The following electronic supplementary material is available with this article at https://doi.org/10.1027/1864-1105/a000422

ESM 1. Details about the original studies and ISC analysis; Results and Control Analyses.

[10] Although it is unclear how much the higher anatomical similarity among twins matters for the regional-level ISC studied here, which is coarser than the voxel-wise comparisons carried out for anatomy-similarity comparisons.

References

Abraham, A., Pedregosa, F., Eickenberg, M., Gervais, P., Mueller, A., Kossaifi, J., Gramfort, A., Thirion, B., & Varoquaux, G. (2014). Machine learning for neuroimaging with scikit-learn. *Frontiers in Neuroinformatics, 8*, Article 14.

Aley, M., Hahn, L., Tamborini, R., Goble, H., Zhang, L., Grady, S. M., & Baldwin, J. (2021). What does television teach children? Examining the altruistic and egoistic lessons in children's educational television. *Communication Reports, 34*(2), 106–119.

Aliko, S., Huang, J., Gheorghiu, F., Meliss, S., & Skipper, J. I. (2020). A naturalistic neuroimaging database for understanding the brain using ecological stimuli. *Scientific Data, 7*(1), Article 347.

Baek, E. C., Hyon, R., López, K., Finn, E. S., Porter, M. A., & Parkinson, C. (2021). *Popularity is linked to neural coordination: Neural evidence for an Anna Karenina principle in social networks*. ArXiv. https://doi.org/10.31234/osf.io/6fj2p

Baek, E. C., & Parkinson, C. (2022). Shared understanding and social connection: Integrating approaches from social psychology, social network analysis, and neuroscience. *Social and Personality Psychology Compass, 16*(11), Article e12710.

Chang, L., Jolly, E., Cheong, J. H., Burnashev, A., & Chen, A. (2018). *cosanlab/nltools*. Zenodo. https://zenodo.org/doi/10.5281/zenodo.2229812

Centola, D. (2015). The social origins of networks and diffusion. *American Journal of Sociology, 120*(5), 1295–1338.

Decety, J., & Lamm, C. (2007). The role of the right temporoparietal junction in social interaction: how low-level computational processes contribute to meta-cognition. *The Neuroscientist, 13*(6), 580–593.

Edelman, S. (1998). Representation is representation of similarities. *Behavioral and Brain Sciences, 21*(4), 449–467.

Edlow, B. L., Takahashi, E., Wu, O., Benner, T., Dai, G., Bu, L., Grant, P. E., Greer, D. M., Greenberg, S. M., Kinney, H. C., & Folkerth, R. D. (2012). Neuroanatomic connectivity of the human ascending arousal system critical to consciousness and its disorders. *Journal of Neuropathology & Experimental Neurology, 71*(6), 531–546.

Esteban, O., Markiewicz, C. J., Blair, R. W., Moodie, C. A., Poldrack, R. A., & Gorgolewski, K. J. (2019). fMRIPrep: A robust preprocessing pipeline for functional MRI. *Nature Methods, 16*(1), 111–116.

Falk, E. B., Cascio, C. N., & Coronel, J. C. (2015). Neural prediction of communication-relevant outcomes. *Communication Methods and Measures, 9*(1–2), 30–54.

Floyd, K., & Weber, R. (2020). *Handbook of communication science and biology*. Routledge.

Fuster, J. M. (2003). *Cortex and mind*: *Unifying cognition*. Oxford University Press.

Grall, C., Tamborini, R., Weber, R., & Schmälzle, R. (2021). Stories collectively engage listeners' brains: Enhanced intersubject correlations during reception of personal narratives. *Journal of Communication, 71*(2), 332–355.

Grady, S. M., Schmälzle, R., & Baldwin, J. A. (2022). Examining the relationship between story structure and audience response: How shared brain activity varies over the course of a narrative. *Projections, 16*(3), 1–28.

Hassan, T. (2023). Genetic and environmental influences on playing video games. *Media Psychology, 26*(5), 530–550.

Hasson, U., Ghazanfar, A. A., Galantucci, B., Garrod, S., & Keysers, C. (2012). Brain-to-brain coupling: A mechanism for creating and sharing a social world. *Trends in Cognitive Sciences, 16*(2), 114–121.

Hasson, U., Landesman, O., Knappmeyer, B., Vallines, I., Rubin, N., & Heeger, D. J. (2008). Neurocinematics: The neuroscience of film. *Projections, 2*(1), 1–26.

Hasson, U., Nastase, S. A., & Goldstein, A. (2020). Direct fit to nature: An evolutionary perspective on biological and artificial neural networks. *Neuron, 105*(3), 416–434.

Hasson, U., Nir, Y., Levy, I., Fuhrmann, G., & Malach, R. (2004). Intersubject synchronization of cortical activity during natural vision. *Science, 303*(5664), 1634–1640.

Hopp, F. R., Amir, O., Fisher, J. T., Grafton, S., Sinnott-Armstrong, W., & Weber, R. (2023). Moral foundations elicit shared and dissociable cortical activation modulated by political ideology. *Nature Human Behaviour, 7*(12), 2182–2198. https://doi.org/10.1038/s41562-023-01693-8

Huskey, R., Bue, A. C., Eden, A., Grall, C., Meshi, D., Prena, K., Schmälzle, R., Scholz, C., Turner, B. O., & Wilcox, S. (2020). Marr's tri-level framework integrates biological explanation across communication subfields. *Journal of Communication, 70*(3), 356–378.

Imhof, M. A., Schmälzle, R., Renner, B., & Schupp, H. T. (2017). How real-life health messages engage our brains: Shared processing of effective anti-alcohol videos. *Social Cognitive and Affective Neuroscience, 12*(7), 1188–1196.

Kauttonen, J., Hlushchuk, Y., Jääskeläinen, I. P., & Tikka, P. (2018). Brain mechanisms underlying cue-based memorizing during free viewing of the movie Memento. *NeuroImage, 172*, 313–325.

Knopik, V. S., Neiderhiser, J. M., DeFries, J. C., & Plomin, R. (2019). *Behavioral Genetics*. Macmillan Learning.

Kumar, M., Ellis, C. T., Lu, Q., Zhang, H., Capotă, M., Willke, T. L., Ramadge, P. J., Turk-Browne, N. B., & Norman, K. A. (2020). BrainIAK tutorials: User-friendly learning materials for advanced fMRI analysis. *PLoS Computational Biology, 16*(1), Article e1007549.

Leong, Y. C., Chen, J., Willer, R., & Zaki, J. (2020). Conservative and liberal attitudes drive polarized neural responses to political content. *Proceedings of the National Academy of Sciences of the United States of America, 117*(44), 27731–27739.

Li, J., Bhattasali, S., Zhang, S., Franzluebbers, B., Luh, W. M., Spreng, R. N., & Hale, J. (2022). Le Petit Prince multilingual naturalistic fMRI corpus. *Scientific Data, 9*(1), Article 530.

Lieberman, M. (2010). Social cognitive neuroscience. In S. T. Fiske, D. T. Gilbert, & G. Lindzey (Eds.), *Handbook of social psychology* (5th ed., pp. 143–193). John Wiley & Sons, Inc. https://doi.org/10.1002/9780470561119.socpsy001005

Lorenz, K. (1981). *The foundations of ethology*. Springer Nature.

Mantini, D., Hasson, U., Betti, V., Perrucci, M. G., Romani, G. L., Corbetta, M., Orban, G. A., & Vanduffel, W. (2012). Interspecies activity correlations reveal functional correspondence between monkey and human brain areas. *Nature Methods, 9*(3), 277–282.

Mesulam, M. (2012). The evolving landscape of human cortical connectivity: Facts and inferences. *NeuroImage, 62*(4), 2182–2189.

Mesulam, M. M. (1998). From sensation to cognition. *Brain, 121*(6), 1013–1052.

Nastase, S. A., Gazzola, V., Hasson, U., & Keysers, C. (2019). Measuring shared responses across subjects using intersubject correlation. *Social Cognitive and Affective Neuroscience, 14*(6), 667–685. https://doi.org/10.1093/scan/nsz037

Parkinson, C., Kleinbaum, A. M., & Wheatley, T. (2018). Similar neural responses predict friendship. *Nature Communications, 9*(1), Article 332. https://doi.org/10.1038/s41467-017-02722-7

Pauli, W. M., Nili, A. N., & Tyszka, J. M. (2018). A high-resolution probabilistic in vivo atlas of human subcortical brain nuclei. *Scientific Data, 5*(1), 1–13. https://doi.org/10.1038/sdata.2018.63

Peper, J. S., Brouwer, R. M., Boomsma, D. I., Kahn, R. S., & Hulshoff Pol, H. E. (2007). Genetic influences on human brain structure: A review of brain imaging studies in twins. *Human Brain Mapping, 28*(6), 464–473. https://doi.org/10.1002/hbm.20398

Plomin, R., & Ho, H. (2017). Brain, behavior, and developmental genetics. In K. R. Gibson & A. Petersen (Eds.), *Brain maturation & cognitive development* (pp. 65–89). https://doi.org/10.4324/9781315082028-4

Prescott, C. A., & Kendler, K. S. (1995). Twin study design. *Alcohol Health and Research World, 19*(3), 200–205.

Richardson, H., Lisandrelli, G., Riobueno-Naylor, A., & Saxe, R. (2018). Development of the social brain from age three to twelve years. *Nature Communications, 9*(1), Article 1027. https://doi.org/10.1038/s41467-018-03399-2

Schmälzle, R. (2022). Theory and method for studying how media messages prompt shared brain responses along the sensation-to-cognition continuum. *Communication Theory, 32*(4), 450–460. https://doi.org/10.1093/ct/qtac009

Schmälzle, R., & Grall, C. (2020a). Mediated messages and synchronized brains. In R. Weber & K. Floyd (Eds.), *Handbook of communication and biology* (pp. 107–120). Routledge.

Schmälzle, R., & Grall, C. (2020b). The coupled brains of captivated audiences: An investigation of the collective brain dynamics of an audience watching a suspenseful film. *Journal of Media Psychology, 32*(4), 187–199. https://doi.org/10.1027/1864-1105/a000271

Schmälzle, R., Häcker, F. E., Honey, C. J., & Hasson, U. (2015). Engaged listeners: Shared neural processing of powerful political speeches. *Social, Cognitive, and Affective Neurosciences, 10*(8), 1137–1143. https://doi.org/10.1093/scan/nsu168

Schmälzle, R., Häcker, F., Renner, B., Honey, C. J., & Schupp, H. T. (2013). Neural correlates of risk perception during real-life risk communication. *Journal of Neuroscience, 33*(25), 10340–10347. https://doi.org/10.1523/jneurosci.5323-12.2013

Schmälzle, R., & Huskey, R. (2023). Integrating media content analysis, reception analysis, and media effects studies. *Frontiers in Neuroscience, 17*, Article 1155750.

Schmälzle, R., Lim, S., Wu, S., Bezbaruah, S., & Hussain, S. A. (2024). *Converging crowds and tied twins*: *Audience brain responses to the same movie are consistent across continents and enhanced among twins* [Data, analysis code]. https://github.com/nomcomm/partlycloudy2

Schmälzle, R., & Meshi, D. (2020). Communication neuroscience: Theory, methodology and experimental approaches. *Communication Methods and Measures, 14*(2), 105–124. https://doi.org/10.1080/19312458.2019.1708283

Shen, X., Tokoglu, F., Papademetris, X., & Constable, R. T. (2013). Groupwise whole-brain parcellation from resting-state fMRI data for network node identification. *Neuroimage, 82*, 403–415. https://doi.org/10.1016/j.neuroimage.2013.05.081

Strike, L. T., Hansell, N. K., Chuang, K. H., Miller, J. L., de Zubicaray, G. I., Thompson, P. M., & Wright, M. J. (2023). The Queensland Twin Adolescent Brain Project, a longitudinal study of adolescent brain development. *Scientific Data, 10*(1), Article 195. https://doi.org/10.1038/s41597-023-02038-w

Weber, R. (2015). Brain, mind, and media: Neuroscience meets media psychology [Editorial]. *Journal of Media Psychology, 27*(3), 89–92. https://doi.org/10.1027/1864-1105/a000162

Yeshurun, Y., Nguyen, M., & Hasson, U. (2021). The default mode network: Where the idiosyncratic self meets the shared social world. *Nature Reviews*: *Neuroscience, 22*(3), 181–192. https://doi.org/10.1038/s41583-020-00420-w

Yeshurun, Y., Swanson, S., Simony, E., Chen, J., Lazaridi, C., Honey, C. J., & Hasson, U. (2017). Same story, different story: The neural representation of interpretive frameworks. *Psychological Science, 28*(3), 307–319. https://doi.org/10.1177/0956797616682029

York, C. (2020). Behavior genetics and twin studies: Principles, analytical techniques, and data resources for innovative communication research. In K. Floyd & R. Weber (Eds.), *The handbook of communication science and biology* (pp. 75–90). Routledge.

Zillmann, D. (2010). Mechanisms of emotional reactivity to media entertainments. In K. Döveling & E. A. Konijn (Eds.), *Routledge handbook of emotions and mass media* (pp. 115–129). Routledge.

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Open Data
The authors are willing to share their data, analytics methods, and study materials with other researchers. Data and analysis code are available at https://github.com/nomcomm/partlycloudy2 (Schmälzle et al., 2024).

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