

INVESTIGATING NEURAL CORRELATES OF POSITIVE AFFECT USING FUNCTIONAL
MAGNETIC RESONANCE IMAGING AND NATURALISTIC STIMULI

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DEDICATION

To my parents, Kim and Dianne Sullivan, for always encouraging me to pursue my ambitions
and raising me to appreciate the privilege of education.

ABSTRACT

Positive affect is the extent to which an individual experiences positive moods, encompassing a broad scope of positive emotions including happiness, joy, optimism, interest, and contentment (Lyubomirsky et al., 2005; Qi et al., 2021). Previous research using simplistic stimuli has struggled to form a consensus on a general model of positive affect in the brain. Of current significance in the field of cognitive neuroscience is the utilization of naturalistic stimuli to better emulate “real-world” experiences. Previous research has demonstrated that movies can evoke robust correlations in brain activity across participants, suggesting a shared processing pattern for naturalistic stimuli (Hasson et al., 2004; Jääskeläinen et al., 2008). Nevertheless, amidst this shared overarching response of integrated brain regions, individual differences in processing arise, influenced by specific personality traits (e.g., paranoia: Finn et al., 2018). In line with this, a behavioural study by Sullivan & Ekstrand (2021) showed that participants with higher positive affect scores had significantly higher correlations in a keypress response task than those with lower positive affect scores. To explore deeper, the current study employs the Naturalistic Neuroimaging Database (NNdB) (Aliko et al., 2020, v2.0) to examine the impact of different levels of self-reported positive affect on neural synchrony during movie viewing and functional magnetic resonance imaging (fMRI). Results showed that individuals with higher levels of positive affect exhibited greater neural synchrony in higher-order cognitive regions such as the bilateral precuneus, inferior frontal gyrus (IFG), posterior cingulate cortex (PCC), and superior temporal gyrus (STG), while individuals with lower levels of positive affect exhibited greater synchrony in rudimentary audiovisual regions such as the bilateral planum temporale (PT), STG, fusiform gyrus (FG), and lateral occipital cortex (LOC). Overall, this study contributes valuable insights into the influences of positive affect trait levels on neural

synchrony, emphasizes the importance of using naturalistic stimuli in neuroscience research, and furthers our understanding of how individuals process “real-world” stimuli.

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LIST OF ABBREVIATIONS

ACC	Anterior Cingulate Cortex
AG	Angular Gyrus
FDR	False Discovery Rate
FEF	Frontal Eye Fields
FG	Fusiform Gyrus
fMRI	Functional Magnetic Resonance Imaging
IFG	Inferior Frontal Gyrus
IPS	Intraparietal Sulcus
ISC	Intersubject Correlation
ITG	Inferior Temporal Gyrus
LG	Lingual Gyrus
LME	Linear Mixed Effects
LOC	Lateral Occipital Cortex
MFG	Middle Frontal Gyrus
MNI	Montreal Neurological Institute
MTG	Middle Temporal Gyrus
NNdB	Naturalistic Neuroimaging Database
OFC	Orbitofrontal Cortex
PCC	Posterior Cingulate Cortex
PFC	Prefrontal Cortex
PT	Planum Temporale
SFG	Superior Frontal Gyrus
SMG	Supramarginal Gyrus
SPL	Superior Parietal Lobule
STG	Superior Temporal Gyrus
TPJ	Temporoparietal Junction

CHAPTER 1: GENERAL INTRODUCTION

1.1 Positive Affect and Positive Emotion

Positive affect is the extent to which an individual experiences positive moods and encompasses a broad scope of positive emotions, including happiness, joy, optimism, interest, and contentment (Lyubomirsky et al., 2005; Qi et al., 2021). Furthermore, it refers to feelings of these emotions in day-to-day life— that is, how an individual feels on average— which differs from positive affect as a state, in which the state refers to the presence of these emotions at a specific and distinctive moment (Okely et al., 2017). People with higher trait levels of positive affect experience positive emotions more commonly in daily life compared to those with lower positive affect, who experience positive emotions less often and negative emotions more often (Qi et al., 2021). Additionally, higher trait levels of positive affect are known to contribute to better quality of life and health outcomes, particularly healthy daily habits including higher amounts of exercise, balanced diets, and better sleep patterns (Cohen & Pressman, 2006). Higher trait levels of positive affect have also been linked to lower levels of stress (including lower levels of stress hormones, such as cortisol: Cohen & Pressman, 2006) and lower mortality risk (Okely et al., 2017).

Previous research suggests that positive affect can influence various cognitive processes, such as attentional engagement, emotional processing, and task performance. Traits associated with positive affect, such as amusement, happiness, and contentment, have been shown to broaden attentional focus during film viewing by increasing performance in a visual processing behavioural task comparing attention to local vs. global stimuli (Frederickson & Branigan, 2005). Similarly, individuals that reported experiencing positive moods had greater success in visuospatial attention tasks and semantic tasks, specifically in the Eriksen flanker test and remote

association semantic search task (Rowe et al., 2007). The Eriksen flanker test measures participants' visuospatial attention by providing central visual targets with peripheral "flankers" that are either targets or non-target distractors. The remote association semantic search task measures participants' semantic retrieval by presenting three visual cue words with which a single target word must be identified. Results from the study by Rowe et al. (2007) show that positive mood induction broadens visuospatial attention and semantic thought processes. Further, positive moods have been shown to increase attention to global stimuli while decreasing attention to local stimuli (Basso et al., 1996). This overall broadening effect of positive affect on attention and cognition may influence the way individuals experience and react to their everyday environments, suggesting that personality traits may shape the way an individual sees the world.

However, previous research examining positive affect in the brain has predominantly focused on the elicitation of positive emotions, rather than examining positive affect as a trait. For example, Habel et al. (2005) employed functional magnetic resonance imaging (fMRI) to examine differences in brain activation based on whether the participant experienced positive versus negative emotions. To induce positive moods, they presented participants with a series of photos expressing specific facial expressions, from a dataset created by Schneider et al. (1994), in which actors displayed emotions for happy, sad, and neutral conditions while having their picture taken. Participants viewed each photo at their own pace and were asked to mimic feeling the emotion they observed in the photo. Specifically, the researchers asked participants to try to become happy, using the provided photos to guide their feelings. Results from this experiment indicated that positive emotions in the positive (happy) condition were associated with heightened activation in the dorsolateral prefrontal cortex (PFC), posterior cingulate cortex (PCC), precuneus, inferior frontal gyrus (IFG), and cerebellum when compared to the negative

(sad) condition. Similarly, Saarimäki et al. (2016) utilized short films to induce emotions and fMRI to examine neural activity patterns. Results showed that neural networks involved in processing positive emotions included the dorsal PFC, amygdala, PCC extending into the precuneus, and middle temporal gyrus (MTG). Further, in a meta-analysis by Gu et al. (2019) examining the neural basis of basic emotions, they found that happiness and pleasure were associated with activity in the ventromedial PFC and bilateral precuneus, and surprise was associated with activity in the amygdala, ventromedial PFC, and cingulate gyrus.

While positive emotions have been relatively well explored in the literature, the neural correlates of positive affect as a trait are less well understood. Machado & Cantilino (2017) conducted a meta-analysis to investigate the neural correlates of positive affect, and found that positive affective states and positive valence emotions were most commonly associated with increased neural activity in the PCC, inferior temporal gyrus (ITG), MTG, amygdala, and left prefrontal regions such as the IFG. However, this meta-analysis also showed that there was vast variability across the studies, with variable methods of inducing positive moods in participants. Further, although this analysis was focused on positive affect, they included studies examining both positive affect as well as positive emotions. Thus, there is a lack of consensus in previous research on the specific neural correlates of positive affect as a personality trait. However, the areas most commonly associated across positive affect in this study were the PCC, ITG, MTG, amygdala, and IFG.

Similarly, Rohr et al. (2013) sought to identify both positive and negative affect networks using resting state functional connectivity in an attempt to model both positive and negative affect networks. The researchers used the Positive and Negative Affective Schedule (Watson, 1988) to measure participants' trait levels of positive affect in conjunction with resting-state

fMRI and seed-based functional connectivity analyses. Interestingly, results from this study showed a negative correlation between positive affect trait levels and functional connectivity between both cortical and subcortical regions, including the precuneus, PCC, medial PFC, somatosensory cortices, superior parietal lobule (SPL), cerebellum, thalamus, caudate, putamen, and insula. Thus, this study provided insight into trait-based positive affect by directly targeted positive affect as a personality trait by using a behavioural questionnaire to assess trait levels, rather than inducing positive emotions or moods.

1.2 Naturalistic Stimuli

While positive emotions have been studied for decades, there are limitations that need to be addressed as the field grows and attempts to better understand positive emotion and positive affect. A central goal of cognitive neuroscience focuses on understanding how the brain processes the complex, multimodal world around us. However, previous research addressing these processes has often presented participants with isolated, sparse stimuli (for example, static images of shapes against a blank background, a single voice dialogue with no background noise, and images of two-dimensional objects rather than the three-dimensional object itself) in order to identify which areas of the brain are responsible for processing different types of information (Nastase et al., 2020; Sonkusare et al., 2019). Contemporarily, the field is interested in how the brain processes information in the natural world— how it combines, interprets, deciphers, and responds to the complex mix of stimuli it is continuously supplied with.

Increasingly, the importance of real-life context in cognitive neuroscience has been stressed in the growing field of naturalistic neuroscience. This field argues that, in order to study the cognitive brain in its natural environment, we should use stimuli that are more “true-to-life” in our experimental approach. Previous research has generally favoured strict experimental

control, using simplistic stimuli to understand how the brain processes specific classes of stimuli (Bartels & Zeki, 2003). However, sparse, simple, and controlled stimuli that have been used in the aforementioned studies (Habel et al., 2005; Saarimäki et al., 2016) are not complex enough to represent the reality of everyday experiences (Aliko et al., 2020; Hinde et al., 2018). While this increases experimental control and internal validity in the study, the ability to generalize to the real world becomes limited. In the context of positive affect, the limitations of simplistic stimuli may be related to the variability in previous research and the lack of consensus of positive affective brain regions.

One source of stimuli that are thought to better encapsulate the complexity of real-life are audiovisual movies (Hinde et al., 2018; Kauppi et al., 2010; Redcay & Moraczewski, 2020; Sonkusare et al., 2019; Vanderwal et al., 2019; Zhang et al., 2021). These stimuli bring together the multimodal cues that are present in reality— including complex scenes, motion, visual and auditory cues, and social interactions between characters— and present them to participants simultaneously. Previous research using fMRI has established audiovisual movies as a useful tool in examining neural synchrony— that is, a synchronization of brain activity across individuals as they undergo a common experience (Hasson et al., 2004; Kauppi et al., 2010; Sonkusare et al., 2019; Wilson et al., 2008). More informally, this refers to the ability of brains to “tick together” during certain affective experiences (Nummenmaa et al., 2012).

1.3 Understanding Neuroimaging Data in the Real-World

However, integrating naturalistic paradigms in neuroimaging can be difficult— the data are very complex and thus, highly difficult to analyze and interpret. One proposed mechanism to approach naturalistic neuroimaging data is to use Intersubject Correlation (ISC) Analysis (see Figure 1.1), which is often used in conjunction with movie viewing paradigms (Hasson et al.,

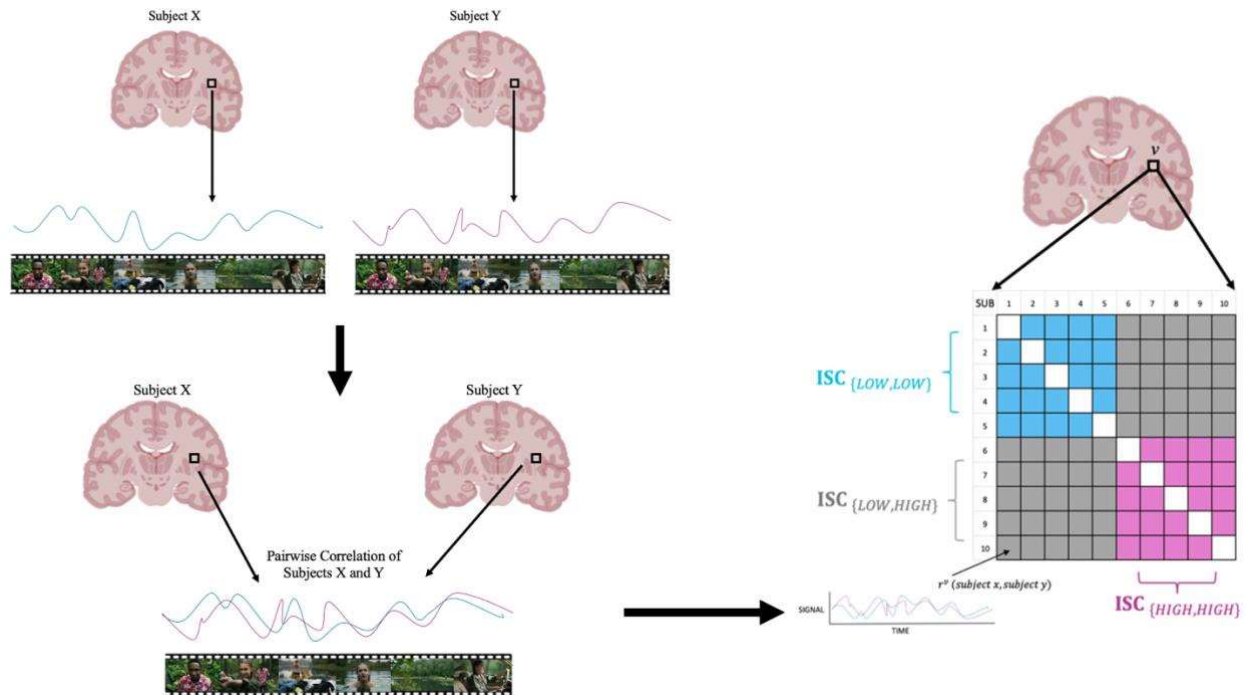
2004; Jääskeläinen et al., 2008; Kauppi et al., 2010; Wilson et al., 2008). ISC uses hemodynamic responses, which is the change in oxygenated vs. deoxygenated blood levels, to examine brain activity. The basis of ISC analysis is to identify brain activity that is shared by a large proportion of individuals. This shared activity is referred to as neural synchrony. In ISC analysis, the Blood Oxygen Level Dependent (BOLD) signal activity of each voxel across the brain is continuously measured throughout the stimulus, reflecting these hemodynamic responses. Essentially, this signal is mapped throughout the entire time-course of the stimulus. These time-course mapped responses are then compared in a series of pairings across the participant group. For each possible pairwise combination, the BOLD activity of each respective voxel is correlated throughout the time-course of the stimulus. This process is repeated for each voxel in the brain, and again repeated for every possible pair of participants, giving rise to overall pairwise correlations for the entire participant group. An average of all pairwise correlations is taken, resulting in an overall average ISC for the group. This average ISC gives rise to neural synchrony, with the aim of identifying all neural activity that is synchronized across a group of individuals throughout the entire time-course of a stimulus (Nastase et al., 2019).

ISCs can then be made and compared between groups of interest. A key factor in analyzing data of this type is non-independence— parametric analysis tools that are often used in statistics (i.e., general linear models, ANOVAs, *t*-tests) cannot adequately handle the complex structure of ISC data because they assume independence of observations (Chen et al., 2016; Chen et al., 2020). To explain further, ISCs are very complex— even though the subjects are independent from each other, their ISC values are not— i.e., even though the BOLD signals for each subject are independent from each other, the correlation between BOLD signals at specific voxels between subjects are not. There is an inherent interrelatedness within each of these ISC

values, and this non-independence must be accounted for. To do so, non-parametric tools such as permutation testing, bootstrapping, or parametric tools that specifically account for the aforementioned complications, such as linear mixed effects (LME) models, can be used (Chen et al., 2016; Chen et al., 2020).

Figure 1.1

Schematic showing the ISC analysis process for arbitrary subjects X and Y.



Note. This figure shows the correlation of BOLD signal time-courses for the same voxel in subjects X and Y, and the correlation matrix that arises for each voxel. This process is repeated for every pairwise combination of participants and for every voxel, eventually giving rise to overall ISC averages for each group.

1.4 The Influence of Personality Traits on Affective Experiences

Perception of, and emotional experience during, naturalistic stimuli (like audiovisual films) can vary significantly— that is, the feelings elicited by the film are not necessarily the same

for every viewer. In other words, while perceptual experiences may be similar, internal and affective experiences may differ. Further, these emotional experiences are not necessarily processed by specific regions in the brain, as there is no unique region that has been found to be solely responsible for a specific emotion (Saarimäki et al., 2016). Similarly, no region has been found to be solely responsible for the experience of positive versus negative stimuli (Lindquist et al., 2016). Rather, the processing and subjective experience of emotions is subserved by distinct networks of brain regions. For example, Saarimäki et al. (2016) used fMRI to examine neural activity patterns for seven basic emotions (anger, disgust, fear, happiness, sadness, surprise, and a neutral condition) using short films and mental imagery. Results showed that each emotion had a different activation pattern even though these regions of activation overlapped spatially. Specifically, these networks included the mPFC, frontal poles, PCC, precuneus, precentral and postcentral gyri, insula, amygdala, and MTG. A key finding in this study is that no region was found to activate exclusively for a single emotion. This supports the idea that emotions have complex activation patterns that rely on similar networks in the brain, however, the interaction of these brain regions may differ based on the emotion.

However, while the overarching response of integrated brain regions appears to be similar for naturalistic stimuli, there are also individual differences in processing that arise based on specific personality traits. For example, Finn et al. (2018) used fMRI and ISC techniques to study participants as they listened to a complex, auditory narrative stimulus. This study sought to examine personality trait-based differences in individual processing, specifically studying trait levels of paranoia. Participants were classified into either a low-paranoia group or a high-paranoia group, determined by their responses to behavioural and personality questionnaires. Results first showed that, in line with previous research, there was synchrony in auditory

processing across participants, as indexed by strong ISCs in the auditory cortices. Further, the results also showed that participants in the high-paranoia group had higher correlations in the left temporal pole, right PFC, and left precuneus than the low-paranoia group. In addition, the high-paranoia group perceived the stimulus as having more negative valence (i.e., perceived the narrative as more suspicious and anxious) than the low-paranoia group. These results suggest that individuals with similarities in paranoia traits both process and perceive stimuli more similarly. Additionally, these findings suggest that specific personality traits (like paranoia) can influence our perception of naturalistic stimuli (see also Bacha-Trams et al., 2018; Chen et al., 2020).

In terms of cognition and perception, positive affect has been theorized to broaden attention, while negative affect can narrow attention (Finicane, 2011; Fredrickson & Branigan, 2005; Fredrickson, 1998; Harmon-Jones et al., 2013; Rowe et al., 2007). These general mechanisms are extended in neural activity— positive affect encourages exploration and deeper thought during stimuli perception, where higher order brain regions are recruited, while negative affect narrows processing in more rudimentary areas (Rowe et al., 2007). Thus, naturalistic stimuli and ISC analysis may be valuable tools to examine the neural correlates of positive affect as a personality trait.

1.5 Current Study

The question remains, does positive affect as a trait influence the way in which individuals perceive and process the world around them? In an attempt to answer this question, the current program of research will use neuroimaging data from the Naturalistic Neuroimaging Database (NNdB: Aliko et al., 2020) to better understand the brain regions involved in “real-world” neural processes, and how differences in positive affect may influence neural synchrony

during the processing of emotional stimuli. By studying the brain in a naturalistic paradigm using film stimuli that are more complex than traditional stimuli, we will examine the neural correlates of emotion during more true-to-life processing, thus providing insight into emotional networks active in everyday life. Because we are examining emotion with a more complex, contextualized approach, and with the use of naturalistic stimuli, we may uncover regions of neural synchrony that have not previously been discovered with traditional methods.

To investigate different emotionally affective experiences, the current research examines fMRI data for two contrasting film conditions: one positive emotional valence film (i.e., a romantic comedy), and one negative emotional valence film (i.e., a political thriller). These films are expected to elicit positive affective emotions and negative affective emotions, respectively. Participants also completed the NIH Toolbox Positive Affect questionnaire (Gershon et al., 2013) and will be split into Low Positive Affect and High Positive Affect groups based on their positive affect trait scores. Over the course of four experiments, we will examine differences in neural synchrony associated with low and high levels of positive affect in response to positive and negative emotional valence stimuli. The first experiment will examine differences in neural synchrony between low and high positive affect individuals during viewing of a positive valence film. The second experiment will examine these differences during viewing of a negative valence film. The third experiment will examine neural synchrony in individuals with low positive affect levels between the positive and negative film conditions, while the fourth experiment will examine neural synchrony in individuals with high positive affect levels between the positive and negative film conditions. Our general hypotheses are as follows: First, we hypothesize that synchronized neural networks will differ between individuals with low positive affect and individuals with high positive affect. Second, we hypothesize that individuals with high positive

affect will exhibit greater neural synchrony during viewing of a positive valence film, specifically in regions previously associated with positive emotional processing. Third, we hypothesize that individuals with low positive affect will exhibit greater neural synchrony during viewing of a negative valence film, specifically in regions previously associated with negative emotional processing. Further hypotheses are discussed in more detail in the chapters to follow. Overall, this thesis will explore the effects of positive affect on the processing of positive and negative valence naturalistic audiovisual films, and provide insight into the influence of positive affect on perception of the naturalistic “real-world.”

CHAPTER 2: Neural Synchrony as Modulated by Positive Affect during Audiovisual Film Viewing

Experiment 1

2.1.1 Introduction

Previous research has examined positive affect through the induction of positive moods. For example, Habel et al. (2005) used fMRI to examine whether there were significant differences in activation dependent on valence levels of mood induction. Specifically, participants were directed to mimic feelings of happiness while viewing photos of happy facial expressions during fMRI. Results from this experiment showed that positive emotions in the happy condition were associated with higher activation in the dorsolateral PFC, PCC, precuneus, ITG, and cerebellum. Saarimäki et al. (2016) used fMRI and short films to induce emotions and examine neural activity patterns. Results showed that neural networks processing positive emotions included the dorsal PFC, the amygdala, the PCC extending into the precuneus, and the MTG. In a meta-analysis by Machado & Cantilino (2017), positive affective states and positive valence emotions were most commonly associated with increased neural activity in the cingulate cortex, ITG, MTG, amygdala, and left prefrontal regions such as the IFG. When specifically looking at trait levels of happiness, Luo et al. (2014) found higher activity in the PFC and MTG. Gu et al. (2019) performed a meta-analysis on the fMRI data on basic emotions and found that happiness and pleasure were associated with activity in the ventromedial PFC and bilateral precuneus, and surprise was associated with activity in the amygdala, ventromedial PFC, and cingulate gyrus. Although there is variability across previous studies focusing on fMRI and positive emotions, the similarities that seem to remain consistent include increased neural activity in the ventral and dorsolateral PFC, IFG, precuneus, PCC, and cerebellum.

The current experiment seeks to identify neural synchrony as modulated by positive affect trait levels during viewing of a positive valence feature-length film. First, participants will be separated into low and high positive affect groups based on their scores via the NIH Toolbox Positive Affect questionnaire (Gershon et al., 2013). Using ISC analysis and LME modelling, synchrony will be compared between the positive affect groups in several ways. First, neural synchrony will be compared between low positive affect individuals vs. high positive affect individuals. More specifically, the first contrast will exhibit where in the brain the low positive affect individuals are responding more similarly to each other than the high-positive affect individuals, and vice-versa, where the high positive affect individuals are responding more similarly to each other than the low positive affect individuals. Next, neural synchrony will be compared between low positive affect individuals vs. the between-group ISCs. This contrast will determine where in the brain the low positive affect individuals are exhibiting more synchrony than the between-group pairings, and vice-versa, where the between-group pairings may be exhibiting greater neural synchrony than the low positive affect individuals. Lastly, neural synchrony will be compared between high positive affect individuals vs. the between-group ISCs. This contrast will determine where in the brain the high positive affect individuals are responding more similarly than the between-group pairings, and vice-versa, where the between-group pairings may be exhibiting greater neural synchrony than the high positive affect individuals.

Our specific hypotheses are as follows: First, we hypothesize that synchronized neural networks will differ between the low positive affect and high positive affect groups. Based on previous research, we anticipate regions associated with positive emotional processing such as the ventral PFC, dorsolateral PFC, PCC, precuneus, IFG, and cerebellum will show greater

neural synchrony in the high positive affect group, as these individuals experience positive moods more frequently than the low positive affect group (Lyubomirsky et al., 2005; Qi et al., 2021). As this paradigm using neural synchrony to measure consistencies in brain activity has been relatively unexplored in the context of positive affect, we may uncover regions not previously associated with positive affect studies that employed resting state functional connectivity, task-based fMRI, or less naturalistic stimuli.

2.1.2 Methods

Participants

We used preprocessed fMRI data from the Naturalistic Neuroimaging Database (NNdB) (Aliko et al., 2021, version 2.0.0) from 20 participants (all right-handed, with normal or corrected-to-normal vision, and no history of hearing or cognitive impairment/illness) who viewed a feature length audiovisual movie. This experiment specifically looked at a positive valence film titled *500 Days of Summer* (Webb, 2009). The participants consisted of 10 females and 10 males, with an average age of 27.70 (Aliko et al., 2020).

Materials and Stimuli

Prior to imaging, participants completed the NIH Toolbox Positive Affect CAT Age 18+ v2.0 questionnaire (Gershon et al., 2013) to measure their positive affect scores. This questionnaire is an assessment within the NIH Toolbox Emotion battery.

The full-length feature film used in this study was titled *500 Days of Summer* (Webb, 2009). The film is categorized in the romance and comedy genres, with a narrative following the highs and lows of a romantic relationship between two characters, totaling 1 hour and 35 minutes in length.

Data Acquisition and Preprocessing

All data acquisition and preprocessing was performed by Aliko et al. (2020). In summary, they used a 1.5T Siemens Magnetom Avanto MRI scanner with a 32-channel head coil to acquire this data. A functional imaging scan (a multiband Echo Planar Imaging (EPI) sequence) was acquired during film viewing with the following measurements: a repetition time (TR) of 1s, an echo time (TE) of 54.8ms, a flip angle 75 degrees, and a 3.2mm isotropic resolution. In addition to the functional imaging data, an anatomical scan (a T1-Magnetization Prepared Rapid Acquisition Gradient Echo scan) was acquired for each participant with the following measurements: a TR of 2.73s, a TE of 3.57ms, and a resolution of 1.00mm³. For the *500 Days of Summer* film, 5470 volumes were acquired. To present the audiovisual films, a mirror-reversing LCD projector and noise attenuating headphones were used for optimal visual and audio quality. Films were presented with as few breaks as possible, but could only play continuously for 45-50 minute segments due to EPI sequence limitations. These breaks, however, were implemented during scenes without character dialogue or key plot information.

Data in this thesis used version 2.0 of the NNdB, in which AFNI's *3dTproject* was used to concatenate the time series with timing corrections for the multiple data acquisition runs. AFNI's preprocessing pipeline (*afni_proc.py*) (Cox, 1996), a standard preprocessing pipeline to ensure data quality, was then used to perform the following preprocessing steps on all of the data: slice-timing correction (aligning data with the stimulus time-course), despiking (to lower artificially high signals), detrending with regressors (to remove motion), volume registration (spatially aligning acquired volumes), spatial smoothing (smoothing the image by averaging the signal within a 6mm radius), aligning the data to the Montreal Neurological Institute (MNI) format (aligning functional data to an anatomical model), and Independent Component Analysis

(ICA) artifact removal (to improve signal-to-noise ratio and remove aspects like artery and cerebrospinal fluid movement). For further acquisition and/or preprocessing details, see Aliko et al., 2020.

Data Analysis

To examine whether there were significant differences in pairwise ISCs between low positive affect and high positive affect individuals, we first performed a median split analysis to split participants into two groups based on their Positive Affect scores (via the NIH Toolbox Positive Affect CAT Age 18+ v2.0; Gershon et al., 2013). This analysis yielded a Low Positive Affect and a High Positive Affect group of ten participants each. We then performed ISC analysis for each pair of participants both within (i.e., Low-Low, High-High) and between (i.e., Low-High) positive affect groups. AFNI's *3dTcorrelate* was used to create these unique ISC pairings across the 20 participants, resulting in 190 unique pairwise combinations.

In the current research, an LME model is used to identify significant ISC. LME was chosen for multiple reasons: it successfully controls for the false positive rate; it can account for unequal sample sizes; it maintains the integrity of the complex variance-covariance structure of ISCs; and it can model both within-group and between-group variability within the same analysis (Chen et al., 2016; Chen et al., 2020). We modeled the following contrasts: voxelwise ISCs within the low positive affect group (Low-Low Positive Affect); voxelwise ISCs within the high positive affect group (High-High Positive Affect); voxelwise ISCs between the groups (Low-High Positive Affect); the contrast between the within-group ISCs (Low-Low vs. High-High); and the contrasts between the within-group ISCs and between-group ISCs (Low-Low vs. Low-High and Low-High vs. High-High). LME modeling using AFNI's *3dISC* created a file with 12 volumes. This file was then split using in-house python code into each individual volume, which

isolated both the average ISC and t statistic for each group (Low-Low, High-High, and Low-High) as well as each group comparison (Low-Low vs. High-High, Low-Low vs. Low-High, and Low-High vs. High-High). The group comparison t statistic files are bidirectional, with the positive direction corresponding to the Low-Low > High-High contrast, and the negative direction corresponding to the High-High > Low-Low contrast. The same directionality applies to all of the group comparison t statistics (positive direction indicates first listed group > second listed group, and negative direction indicates second listed group > first listed group). The within-group ISC average t -statistics (Low-Low, Low-High, and High-High) were thresholded at a voxelwise false discovery rate (FDR) of $q < 0.001$, while the between-group contrasts (Low-Low vs. High-High, Low-Low vs. Low-High, and Low-High vs. High-High) were thresholded at a voxelwise FDR of $q < 0.05$. A cluster threshold of 5 voxels was also applied to each t -statistic (via AFNI's *clusterize*) to eliminate any clusters of < 5 voxels. The thresholded and clusterized t -statistics were then masked onto the corresponding group average ISC (via *fslmaths -mas* function) and in-house python code was then used to visually represent these masked images as anatomical figures. Cluster tables for each condition were created using FSL's *cluster* function.

2.1.3 Results

Median Split Analysis

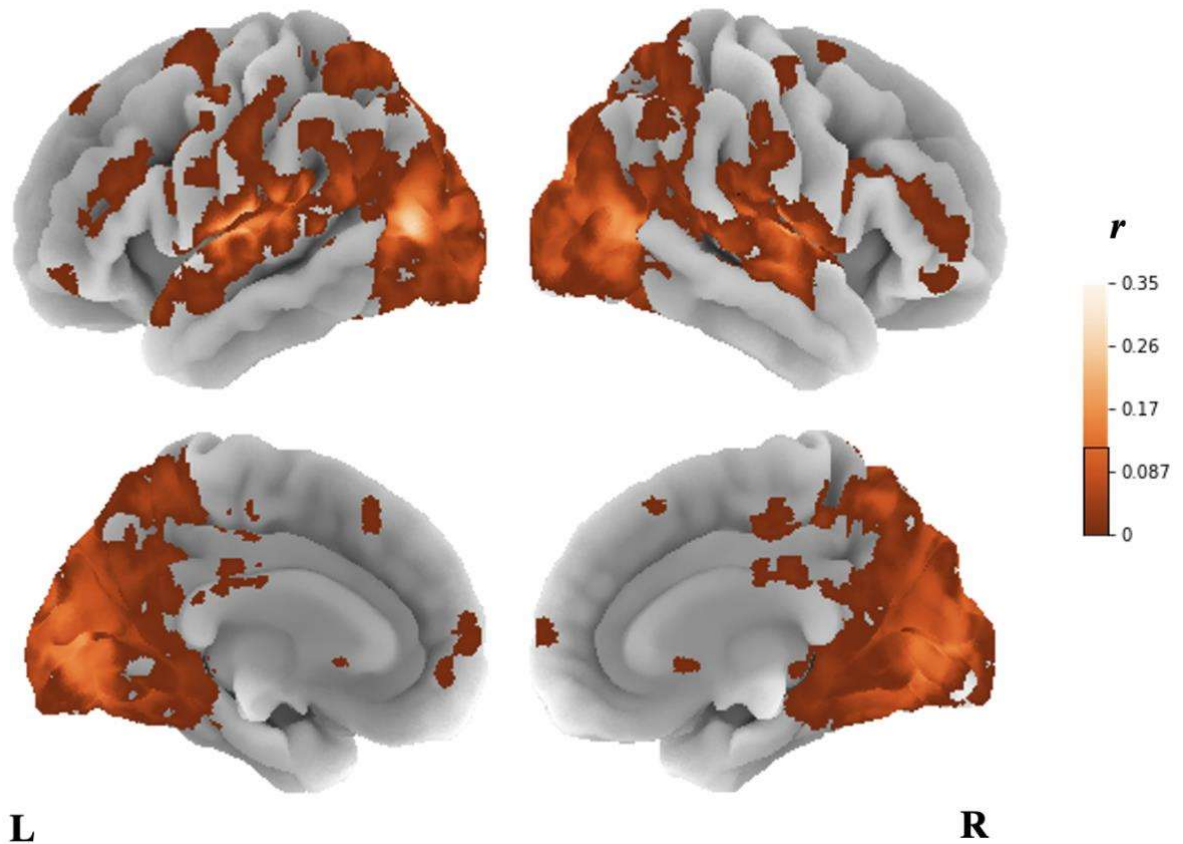
To separate participants into two distinct groups, we performed a median split analysis based on participants' Positive Affect scores (via the NIH Toolbox Positive Affect CAT Age 18+ v2.0; Gershon et al., 2013). This analysis yielded a Low Positive Affect and a High Positive Affect group consisting of ten participants each. The average Positive Affect score was 12.0 (SD = 2.11) for the Low Positive Affect group and 31.8 (SD = 19.74) for the High Positive Affect group.

Low-Low Positive Affect Group Average ISC

Results from the LME model for the Low Positive Affect group average ISC identified 29 significant clusters of neural synchrony (see Figure 2.1.1 and Table 2.1.1). This included widespread synchrony across bilateral auditory and visual cortices in the occipital and temporal lobes, frontal lobe regions including the IFG, orbitofrontal cortex (OFC), superior frontal gyrus (SFG), precentral gyri, and parietal lobe regions including the precuneus, postcentral gyri, PCC, SPL, and intraparietal sulcus (IPS). In addition to cortical regions, synchrony was also identified in subcortical regions including the thalamus and caudate, as well as the right vermis IX of the cerebellum.

Figure 2.1.1

Voxelwise ISCs showing areas of neural synchrony within the Low Positive Affect group during viewing of a positive valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.1.1

Positive Valence film: Low-Low Positive Affect group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max r	Max x	Max y	Max z
Lateral Occipital Cortex, inferior division	L	5902	0.302	-52.5	-76.5	7.5
Planum Temporale	L	535	0.401	-61.5	-16.5	7.5
Planum Temporale	R	495	0.27	58.5	-10.5	4.5
Middle Frontal Gyrus	L	94	0.0476	-43.5	19.5	25.5
Inferior Frontal Gyrus, pars opercularis	R	88	0.0483	40.5	10.5	25.5
Precentral Gyrus	L	76	0.047	-28.5	-7.5	61.5
Cingulate Gyrus, posterior division	R	24	0.0268	10.5	-22.5	40.5
Frontal Pole	L	21	0.0234	-1.5	64.5	7.5
Cingulate Gyrus, posterior division	R	20	0.0299	4.5	-28.5	28.5
Precentral Gyrus	L	17	0.0233	-61.5	-1.5	25.5
Temporal Pole	L	17	0.0576	-55.5	16.5	-19.5
Precentral Gyrus	L	15	0.0393	-37.5	4.5	28.5
Superior Temporal Gyrus, anterior division	L	12	0.0712	-58.5	1.5	-10.5
Superior Frontal Gyrus	R	11	0.0366	25.5	1.5	61.5
Vermis IX	R	10	0.0148	1.5	-58.5	-34.5
Frontal Pole	L	9	0.0193	-13.5	46.5	49.5
Supramarginal Gyrus, anterior division	R	8	0.0467	58.5	-19.5	37.5
Thalamus	R	8	0.0171	16.5	-28.5	-1.5
Precentral Gyrus	R	7	0.0202	46.5	-13.5	58.5
Frontal Pole	R	7	0.0196	49.5	46.5	-13.5
Parahippocampal Gyrus, posterior division	L	6	0.0209	-28.5	-31.5	-19.5
Precentral Gyrus	L	6	0.0991	-55.5	-7.5	49.5
Caudate	R	6	0.0141	7.5	10.5	1.5
Inferior Frontal Gyrus, pars triangularis	L	6	0.0284	-55.5	31.5	4.5
Superior Frontal Gyrus	L	5	0.0158	-1.5	25.5	52.5
Frontal Pole	L	5	0.0173	-43.5	52.5	-10.5
Supramarginal Gyrus, posterior division	L	5	0.0531	-58.5	-43.5	34.5
Precentral Gyrus	L	5	0.0353	-16.5	-31.5	40.5
Cingulate Gyrus, posterior division	R	5	0.0266	4.5	-40.5	25.5

Note. Coordinates (x, y, z) of max correlations (r) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Low-High Positive Affect Group Average ISC

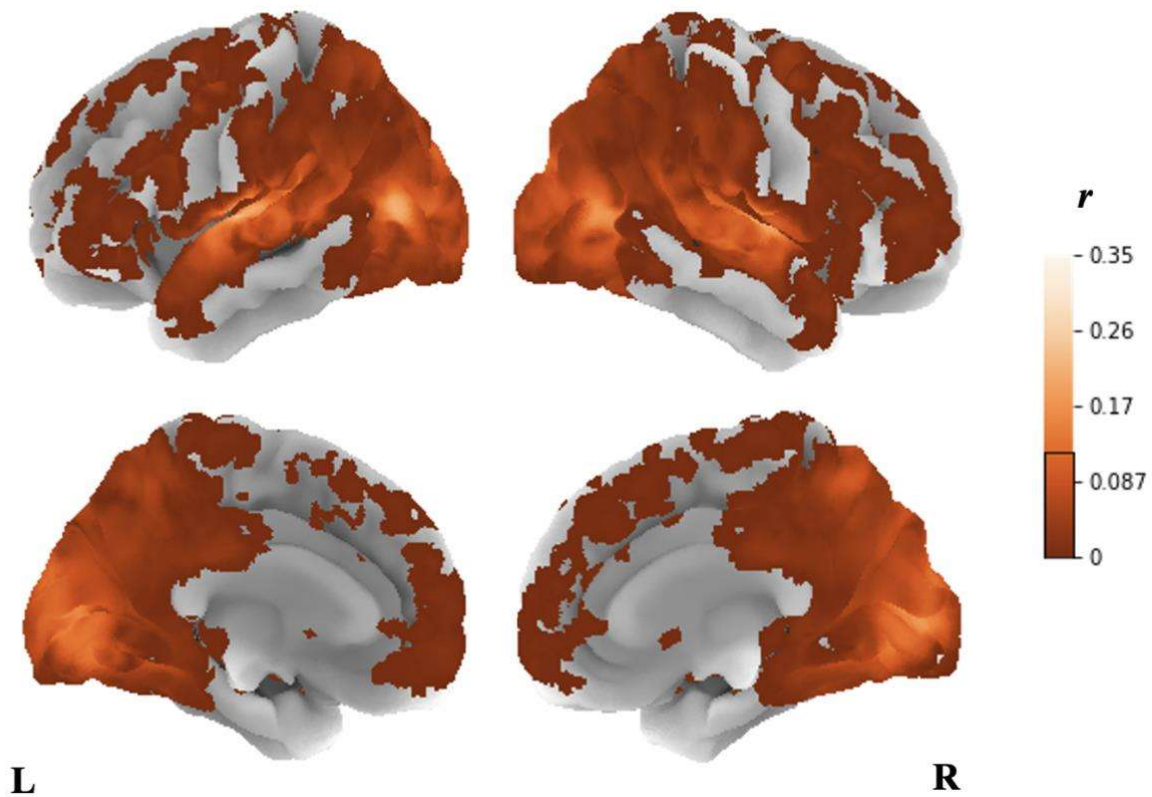
Results from the LME model for Low-High group average ISC identified 28 significant clusters of neural synchrony (see Figure 2.1.2 and Table 2.1.2). This included extensive synchrony across bilateral auditory and visual cortices in the temporal and occipital lobes, parietal lobe regions such as the PCC, precuneus, SPL, and IPS, and frontal lobe regions

including the IFG, OFC, SFG, middle frontal gyrus (MFG), medial PFC, and frontal poles.

Synchrony was also evident in subcortical regions including the putamen, caudate, and amygdala, as well as the left vermis IX, left crus I, and right IX of the cerebellum.

Figure 2.1.2

Voxelwise ISCs showing areas of neural synchrony in the between group (Low-High) average during viewing of a positive valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.1.2

Positive Valence film: Low-High group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max r	Max x	Max y	Max z
Planum Temporale	L	16080	0.329	-58.5	-16.5	7.5
Frontal Pole	R	397	0.0235	1.5	58.5	19.5
Superior Frontal Gyrus	R	239	0.048	25.5	1.5	64.5
Frontal Pole	R	149	0.024	28.5	58.5	19.5
Putamen	R	45	0.0118	22.5	4.5	-10.5
Caudate	R	37	0.0146	7.5	10.5	1.5
Frontal Pole	L	28	0.0307	-34.5	37.5	-10.5
Caudate	L	27	0.0118	-10.5	10.5	7.5
Insular Cortex	L	19	0.0163	-31.5	22.5	-4.5
Vermis IX	L	15	0.0105	-1.5	-52.5	-37.5
Frontal Pole	L	11	0.0135	-28.5	52.5	10.5
Crus I	L	10	0.0123	-43.5	-73.5	-40.5
Frontal Pole	R	10	0.0119	10.5	37.5	55.5
Central Opercular Cortex	L	9	0.014	-40.5	-4.5	16.5
Supplementary Motor Cortex	R	8	0.0127	1.5	4.5	61.5
Parahippocampal Gyrus, anterior division	L	8	0.0078	-19.5	-19.5	-19.5
Right IX	R	7	0.00963	16.5	-46.5	-49.5
Precentral Gyrus	R	7	0.0117	37.5	-16.5	40.5
Frontal Pole	L	7	0.0167	-25.5	37.5	43.5
Paracingulate Gyrus	R	7	0.0114	10.5	40.5	19.5
Postcentral Gyrus	R	6	0.00995	7.5	-43.5	76.5
Frontal Pole	R	6	0.0141	7.5	52.5	46.5
Frontal Pole	L	6	0.0124	-31.5	61.5	-4.5
Temporal Pole	R	6	0.0119	40.5	7.5	-19.5
Central Opercular Cortex	L	5	0.0102	-40.5	-13.5	19.5
Caudate	L	5	0.00726	-19.5	7.5	16.5
Amygdala	L	5	0.0109	-19.5	-4.5	-13.5
Frontal Pole	L	5	0.0106	-31.5	61.5	4.5

Note. Coordinates (x, y, z) of max correlations (r) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

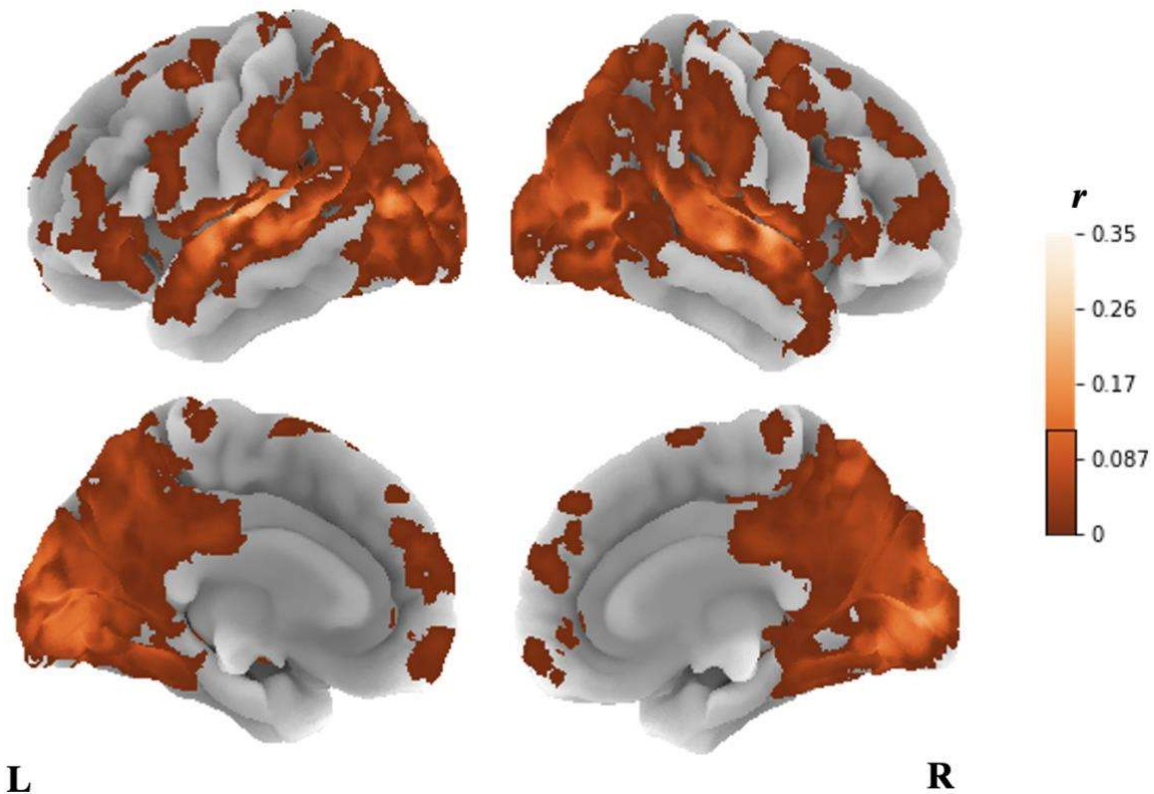
High-High Positive Affect Group Average ISC

Results from the LME model for the High Positive Affect group average ISC revealed 41 significant clusters of neural synchrony (see Figure 2.1.3 and Table 2.1.3). This included vast synchrony across bilateral audiovisual cortices of the temporal and occipital lobes, frontal lobe regions including the frontal poles, precentral gyri, IFG, OFC, medial PFC, and parietal lobe

regions such as the precuneus, PCC, SPL, and IPS. Synchrony was also identified in subcortical regions including the thalamus, caudate, and amygdala, as well as the bilateral crus I and right vermis IX of the cerebellum.

Figure 2.1.3

Voxelwise ISCs showing areas of neural synchrony within the High Positive Affect group during viewing of a positive valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.1.3

Positive Valence film: High-High group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max r	Max x	Max y	Max z
Planum Temporale	L	10305	0.324	-61.5	-13.5	7.5
Precentral Gyrus	L	143	0.0624	-43.5	4.5	31.5
Crus I	R	134	0.0722	25.5	-85.5	-31.5
Frontal Pole	R	81	0.0329	25.5	40.5	40.5
Crus I	L	75	0.0558	-22.5	-82.5	-34.5
Precentral Gyrus	L	72	0.0504	-28.5	-10.5	61.5
Frontal Pole	R	65	0.0379	1.5	58.5	22.5
Frontal Pole	R	57	0.0291	46.5	46.5	10.5
Frontal Pole	L	54	0.0287	-43.5	40.5	10.5
Frontal Pole	R	32	0.0259	28.5	61.5	13.5
Frontal Pole	L	27	0.0302	-1.5	61.5	-10.5
Frontal Pole	L	24	0.0383	-34.5	37.5	-10.5
Temporal Pole	R	23	0.0275	49.5	13.5	-31.5
Postcentral Gyrus	L	21	0.0222	-25.5	-28.5	73.5
Frontal Pole	L	21	0.0308	-16.5	58.5	28.5
Precentral Gyrus	R	19	0.021	28.5	-25.5	73.5
Supplementary Motor Cortex	L	15	0.0424	-1.5	-1.5	67.5
Precentral Gyrus	R	14	0.0506	13.5	-19.5	43.5
Middle Frontal Gyrus	L	14	0.0826	-40.5	4.5	52.5
Precuneus Cortex	L	12	0.0607	-10.5	-46.5	55.5
Vermis IX	R	12	0.0135	4.5	-58.5	-43.5
Precentral Gyrus	R	11	0.0216	1.5	-31.5	70.5
Superior Frontal Gyrus	R	10	0.0269	28.5	22.5	58.5
Middle Frontal Gyrus	L	10	0.0285	-28.5	28.5	49.5
Parahippocampal Gyrus, anterior division	L	9	0.0141	-22.5	1.5	-16.5
Orbitofrontal Cortex	L	8	0.0234	-31.5	25.5	-4.5
Central Opercular Cortex	R	7	0.0136	37.5	4.5	13.5
Caudate	L	7	0.0152	-7.5	7.5	1.5
Frontal Medial Cortex	R	7	0.02	1.5	49.5	-7.5
Superior Frontal Gyrus	L	6	0.0309	-10.5	25.5	61.5
Superior Parietal Lobule	R	6	0.024	34.5	-55.5	43.5
Superior Parietal Lobule	R	6	0.0718	28.5	-40.5	52.5
Thalamus	R	6	0.0159	16.5	-31.5	-1.5
Frontal Pole	L	6	0.0154	-28.5	61.5	-1.5
Superior Frontal Gyrus	R	6	0.0251	1.5	46.5	43.5
Putamen	R	5	0.0122	19.5	10.5	-1.5
Precentral Gyrus	L	5	0.0183	-7.5	-34.5	73.5
Amygdala	R	5	0.0124	19.5	-1.5	-13.5
Precentral Gyrus	L	5	0.0168	-16.5	-28.5	76.5
Precentral Gyrus	R	5	0.0167	40.5	-22.5	58.5
Superior Frontal Gyrus	L	5	0.0263	-4.5	10.5	70.5

Note. Coordinates (x, y, z) of max correlations (r) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

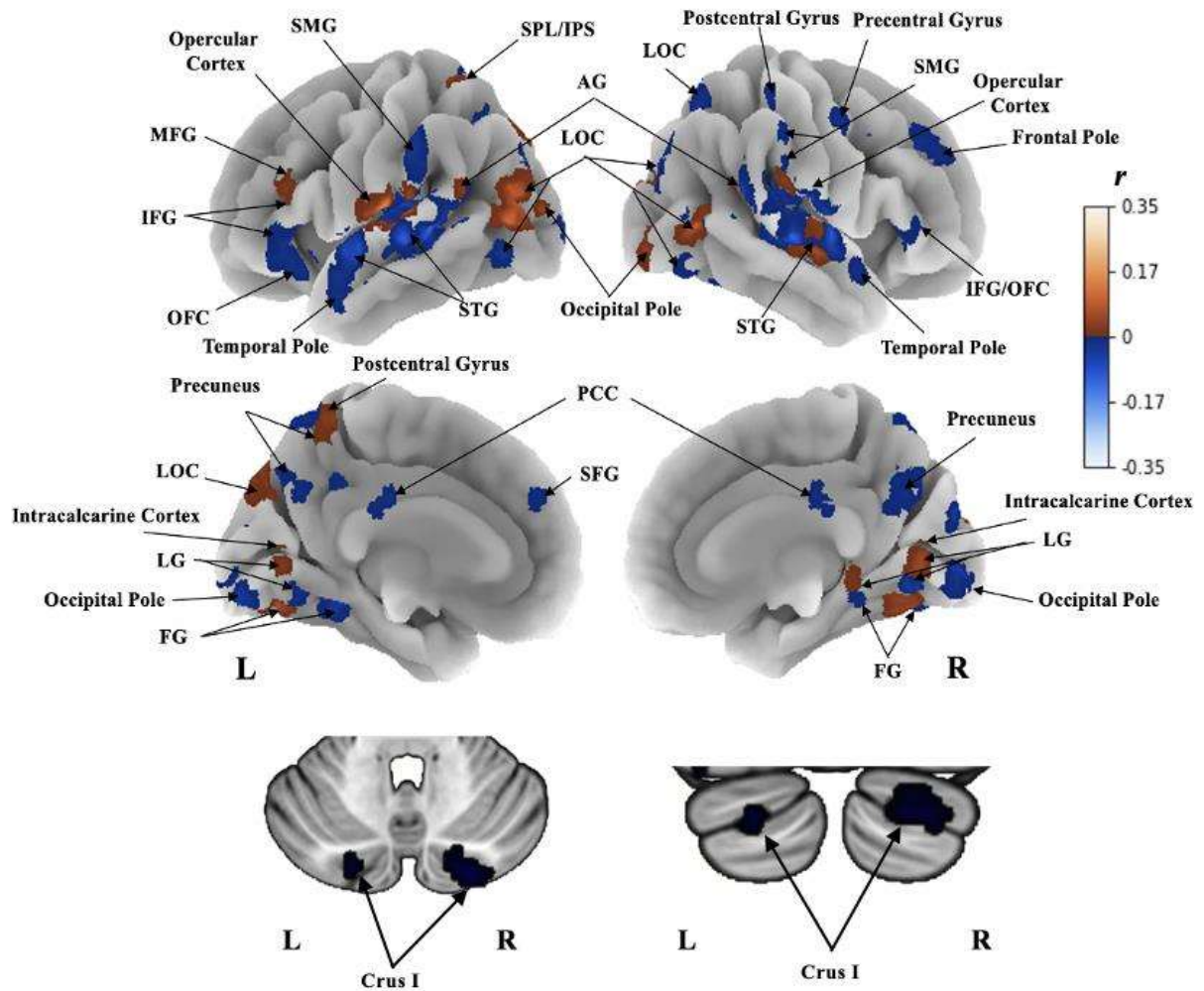
Low-Low vs. High-High Positive Affect

Results from the LME model for the Low-Low > High-High Positive Affect contrast identified 20 significant clusters of neural synchrony (see Figure 2.1.4 and Table 2.1.4). Greater neural synchrony was identified in the left SPL and IPS, left MFG, left medial postcentral gyrus, and left precuneus. Greater neural synchrony was also evident bilaterally in the opercular cortices, superior temporal gyrus (STG), planum temporale (PT), angular gyrus (AG), inferior lateral occipital cortex (LOC), occipital poles, lingual gyrus (LG), fusiform gyrus (FG), and intracalcarine cortices.

Results from the LME model for the High-High > Low-Low Positive Affect contrast identified 46 significant clusters of neural synchrony (see Figure 2.1.4 and Table 2.1.5). Greater neural synchrony was identified in the left medial SFG, left SPL, and IPS. Bilaterally, greater neural synchrony was found in the IFG, OFC, anterior and posterior STG, PT, temporal poles, supramarginal gyrus (SMG), inferior and superior LOC, precuneus cortices, PCC, occipital poles, LG, FG, and AG. Greater synchrony was also found in the right frontal pole, right precentral gyrus, and right postcentral gyrus. In addition to these cortical areas, there was also significant synchrony in the right crus I and left crus I of the cerebellum.

Figure 2.1.4

Voxelwise ISCs showing areas of neural synchrony in the Low-Low > High-High (red) and High-High > Low-Low (blue) Positive Affect contrasts during viewing of a positive valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.05$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views, and the left (L) and right (R) cerebellum in axial and posterior views.

Table 2.1.4

Positive Valence film: Low-Low > High-High Positive Affect cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Planum Temporale	L	68	0.401	-61.5	-16.5	7.5
Lateral Occipital Cortex, inferior division	L	66	0.302	-52.5	-76.5	7.5
Planum Temporale	R	43	0.212	64.5	-16.5	10.5
Occipital Fusiform Gyrus	L	38	0.155	-25.5	-76.5	-13.5
Occipital Fusiform Gyrus	R	35	0.107	28.5	-70.5	-13.5
Lateral Occipital Cortex, inferior division	R	35	0.226	43.5	-67.5	4.5
Lateral Occipital Cortex, superior division	L	20	0.114	-10.5	-85.5	40.5
Lingual Gyrus	R	18	0.157	4.5	-73.5	1.5
Occipital Pole	R	14	0.14	34.5	-91.5	-7.5
Planum Temporale	R	13	0.19	61.5	-25.5	16.5
Superior Parietal Lobule	L	13	0.0778	-34.5	-52.5	67.5
Precuneus Cortex	L	10	0.0673	-4.5	-49.5	61.5
Occipital Pole	R	9	0.164	22.5	-91.5	22.5
Heschl's Gyrus	L	9	0.0995	-40.5	-22.5	4.5
Occipital Pole	L	8	0.141	-34.5	-91.5	10.5
Inferior Frontal Gyrus, pars triangularis	L	8	0.0437	-46.5	31.5	16.5
Angular Gyrus	R	7	0.0764	46.5	-46.5	25.5
Supramarginal Gyrus, posterior division	L	5	0.117	-64.5	-52.5	19.5
Lingual Gyrus	R	5	0.057	13.5	-40.5	-4.5
Parietal Operculum Cortex	L	5	0.0503	-37.5	-28.5	22.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Table 2.1.5

Positive Valence film: High-High > Low-Low Positive Affect cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max <i>x</i>	Max <i>y</i>	Max <i>z</i>
Superior Temporal Gyrus, posterior division	L	100	0.202	-58.5	-37.5	4.5
Superior Temporal Gyrus, posterior division	R	91	0.291	64.5	-22.5	1.5
Inferior Frontal Gyrus, pars triangularis	L	72	0.0795	-52.5	25.5	-4.5
Right Crus I	R	45	0.0722	25.5	-85.5	-31.5
Superior Temporal Gyrus, anterior division	L	45	0.233	-61.5	-4.5	-4.5
Superior Temporal Gyrus, anterior division	R	42	0.282	64.5	-4.5	1.5
Frontal Pole	R	38	0.0329	25.5	40.5	40.5
Lingual Gyrus	R	38	0.202	7.5	-88.5	-1.5
Supramarginal Gyrus, anterior division	L	37	0.0581	-64.5	-31.5	34.5
Planum Temporale	L	37	0.222	-55.5	-19.5	4.5
Supramarginal Gyrus, posterior division	R	32	0.153	58.5	-43.5	16.5
Superior Parietal Lobule	L	23	0.0976	-16.5	-58.5	67.5
Precuneus Cortex	R	21	0.115	10.5	-70.5	37.5
Precentral Gyrus	R	21	0.0957	58.5	-1.5	46.5
Temporal Occipital Fusiform Cortex	L	18	0.126	-25.5	-46.5	-10.5
Heschl's Gyrus	R	17	0.137	43.5	-25.5	13.5
Lingual Gyrus	L	15	0.106	-4.5	-88.5	-10.5
Lingual Gyrus	L	14	0.103	-13.5	-70.5	-4.5
Inferior Frontal Gyrus, pars triangularis	R	14	0.0436	55.5	22.5	-1.5
Precuneus Cortex	L	12	0.0874	-7.5	-73.5	37.5
Lingual Gyrus	R	11	0.114	25.5	-40.5	-10.5
Lateral Occipital Cortex, superior division	R	10	0.0757	22.5	-70.5	52.5
Heschl's Gyrus	R	10	0.221	52.5	-16.5	10.5
Precuneus Cortex	R	8	0.0868	1.5	-61.5	37.5
Cingulate Gyrus, posterior division	L	8	0.0546	-1.5	-25.5	28.5
Lateral Occipital Cortex, inferior division	L	8	0.0941	-46.5	-70.5	-10.5
Left Crus I	L	8	0.0558	-22.5	-82.5	-34.5
Temporal Occipital Fusiform Cortex	R	8	0.0645	46.5	-49.5	-22.5
Supramarginal Gyrus, anterior division	R	7	0.0597	49.5	-34.5	55.5
Cingulate Gyrus, posterior division	L	7	0.043	-13.5	-46.5	34.5
Lingual Gyrus	R	7	0.154	10.5	-70.5	-7.5
Lateral Occipital Cortex, superior division	R	7	0.0989	10.5	-67.5	64.5
Lateral Occipital Cortex, superior division	R	7	0.0971	34.5	-82.5	34.5
Inferior Frontal Gyrus, pars triangularis	L	6	0.0374	-46.5	28.5	1.5
Lateral Occipital Cortex, superior division	L	6	0.101	-34.5	-85.5	25.5
Lateral Occipital Cortex, superior division	R	6	0.133	37.5	-85.5	19.5
Temporal Occipital Fusiform Cortex	R	6	0.126	31.5	-49.5	-7.5
Supramarginal Gyrus, anterior division	R	6	0.0543	64.5	-22.5	40.5
Lateral Occipital Cortex, inferior division	R	6	0.224	55.5	-67.5	7.5
Lateral Occipital Cortex, superior division	L	6	0.0463	-22.5	-61.5	43.5
Temporal Pole	R	5	0.0734	58.5	10.5	-16.5
Superior Frontal Gyrus	L	5	0.0243	-4.5	49.5	31.5
Cuneal Cortex	R	5	0.138	7.5	-88.5	22.5
Lateral Occipital Cortex, superior division	L	5	0.0785	-31.5	-67.5	52.5
Occipital Pole	L	5	0.121	-16.5	-100	-1.5
Lateral Occipital Cortex, inferior division	R	5	0.0852	40.5	-73.5	-16.5

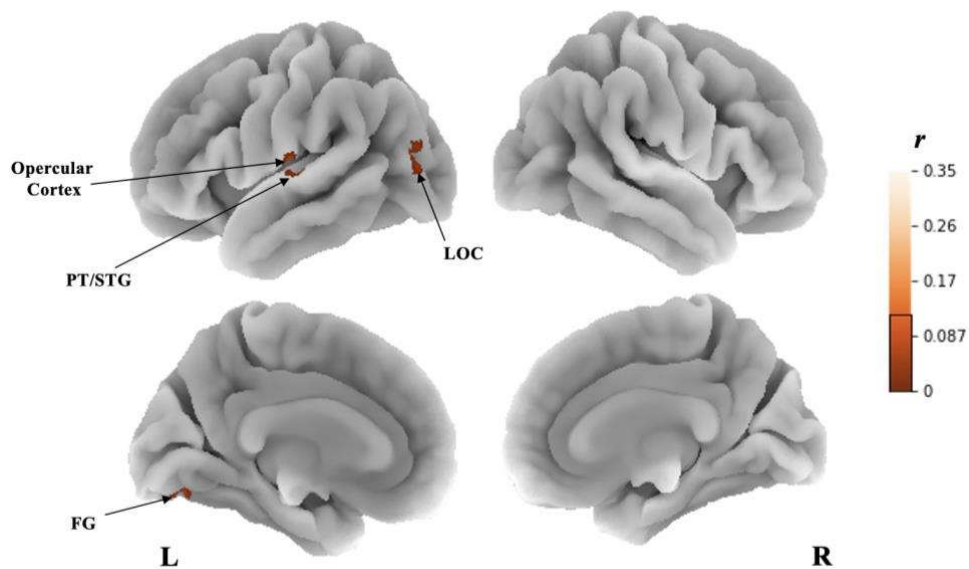
Note. Coordinates (x, y, z) of max correlations (r) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Low-Low vs. Low-High Positive Affect

Results from the LME model for the Low-Low > Low-High Positive Affect contrast revealed 3 significant clusters of neural synchrony (see Figure 2.1.5 and Table 2.1.6). This synchrony was located in the left opercular cortex, left PT, left LOC, and left FG. Results from the LME model for the Low-High > Low-Low Positive Affect contrast did not show any significant clusters of neural synchrony.

Figure 2.1.5

Voxelwise ISCs showing areas of neural synchrony in the Low-Low > Low-High Positive Affect contrast during viewing of a positive valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.05$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.1.6

Positive Valence film: Low-Low > Low-High Positive Affect cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max <i>x</i>	Max <i>y</i>	Max <i>z</i>
Occipital Fusiform Gyrus	L	13	0.148	-25.5	-76.5	-16.5
Central Opercular Cortex	L	6	0.352	-61.5	-16.5	10.5
Lateral Occipital Cortex, inferior division	L	5	0.17	-49.5	-82.5	13.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

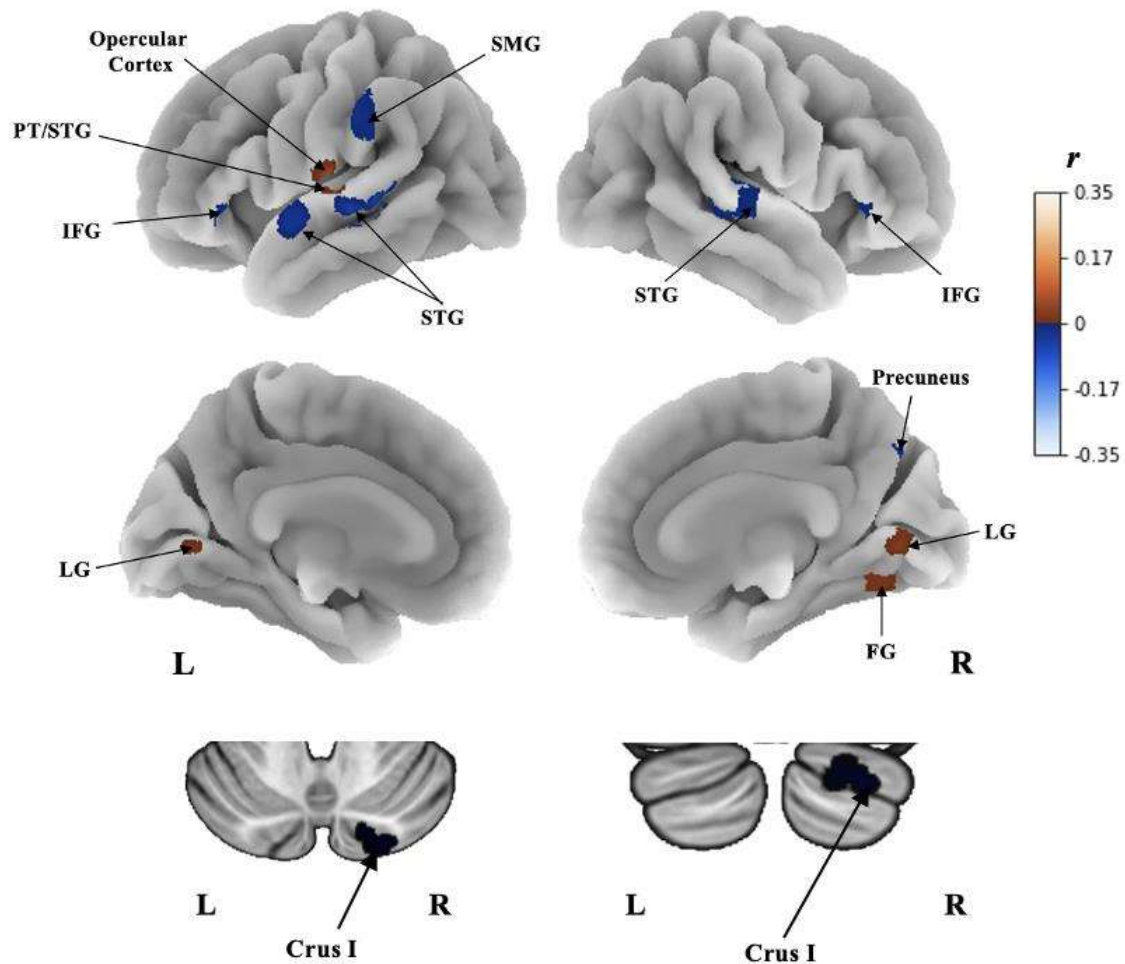
Low-High vs. High-High Positive Affect

Results from the LME model for the Low-High > High-High Positive Affect contrast revealed 3 significant clusters of neural synchrony (see Figure 2.1.6 and Table 2.1.7). The largest cluster included the left opercular cortex and left PT, the second cluster included the bilateral LG, and the last cluster was located in the right FG.

Results from the LME model for the High-High > Low-High Positive Affect contrast showed 10 significant clusters of neural synchrony (see Figure 2.1.6 and Table 2.1.8). Parietal clusters included the left SMG and right precuneus. Synchrony was also revealed in the bilateral IFG/OFC, as well as the bilateral STG. In addition to these regions, synchrony was also identified in the right crus I of the cerebellum.

Figure 2.1.6

Voxelwise ISCs showing areas of neural synchrony in the Low-High > High-High (red) and High-High > Low-High (blue) Positive Affect contrasts during viewing of a positive valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.05$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views, and the left (L) and right (R) cerebellum in axial and posterior views.

Table 2.1.7

Positive Valence film: Low-High > High-High Positive Affect cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Central Opercular Cortex	L	11	0.236	-61.5	-16.5	10.5
Occipital Fusiform Gyrus	R	5	0.0714	25.5	-64.5	-13.5
Lingual Gyrus	R	5	0.129	4.5	-73.5	4.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Table 2.1.8

Positive Valence film: High-High > Low-High Positive Affect cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Superior Temporal Gyrus, posterior division	R	33	0.291	64.5	-22.5	1.5
Supramarginal Gyrus, anterior division	L	18	0.0581	-64.5	-31.5	34.5
Right Crus I	R	16	0.0722	25.5	-85.5	-31.5
Superior Temporal Gyrus, posterior division	L	16	0.202	-58.5	-37.5	4.5
Inferior Frontal Gyrus, pars triangularis	L	13	0.0795	-52.5	25.5	-4.5
Superior Temporal Gyrus, posterior division	L	11	0.181	-64.5	-25.5	-1.5
Superior Temporal Gyrus, anterior division	L	8	0.233	-61.5	-4.5	-4.5
Inferior Frontal Gyrus, pars triangularis	R	6	0.0348	49.5	25.5	-1.5
Precunues Cortex	R	5	0.115	10.5	-70.5	37.5
Orbitofrontal Cortex	L	5	0.0354	-46.5	25.5	-16.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

2.1.4 Discussion

This experiment sought to examine ISCs during naturalistic film viewing and how neural synchrony in processing of a positive valence audiovisual film may be influenced by differences in trait levels of positive affect. We hypothesized that pairwise correlations will be higher among participants that are more similar in positive affect levels and that high positive affect individuals would show greater synchrony in regions previously associated with positive emotional

processing (the ventral PFC, dorsolateral PFC, PCC, precuneus, IFG, and cerebellum). To examine these differences, we first separated participants into two groups, low positive affect and high positive affect, based on their total scores from the NIH Toolbox Positive Affect Questionnaire (NIH Toolbox Positive Affect CAT Age 18+ v2.0; Gershon et al., 2013), followed by ISC and LME analyses both within and between positive affect groups.

Results from this experiment revealed differences in neural synchrony associated with differences in self-reported positive affect levels during viewing of a full-length audiovisual film. In the first contrast, we compared ISCs between the low positive affect group and the high positive affect group to examine where neural synchrony is greater within low positive affect individuals compared to high positive affect individuals. This contrast yielded significant clusters of neural synchrony along the ventrolateral regions of the brain, with clusters in the inferior LOC, FG, and extending ventrolaterally into the STG, primary auditory cortex, temporoparietal junction (TPJ), moving toward the parietal opercular cortex and MFG. These results suggest that low positive affect individuals have similar responses in more low-level audiovisual processing regions, as the ventral stream is involved in processing visual object recognition, colour, texture, and other stimulus-driven details (Corbetta & Shulman, 2002).

Also within this contrast, we compared ISCs between the high positive affect group and the low positive affect group to examine where neural synchrony is greater amongst the high positive affect individuals in relation to the low positive affect individuals. This contrast yielded significant clusters of neural synchrony along dorsomedial regions of the brain, with clusters in the superior LOC, SMG and AG, SPL and IPS, pre- and post-central gyri, frontal eye fields (FEF), frontal pole, medial PFC, PCC and precuneus. These results suggest that high positive affect individuals are showing more consistencies in brain areas related to the dorsal attention

stream. The dorsal attention stream has been shown to be involved in goal-directed attention (Corbetta & Shulman, 2002).

In general, synchrony in high positive affect individuals is widespread across the brain, recruiting a network of regions previously shown to be involved in narrative processing. These regions include the precuneus, IPS and FEF, TPJ, and audiovisual cortices, which are argued to be involved with narrative interpretation, engagement and arousal, engagement and suspense, and sensory processing, respectively (Jääskeläinen et al., 2020). Synchrony is also exhibited in the bilateral crus of the cerebellum, which is in line with previous research showing right crus cerebellar involvement in mentalizing the emotions of others (Van Overwalle et al., 2020), a key behaviour during movie viewing. Greater neural synchrony in the high positive affect individuals was found in regions that can also be related to positive emotional processing, including the PCC, precuneus, IFG, cerebellum, and STG (Gu et al., 2019; Habel et al., 2005; Machado & Cantilino, 2017; Saarimäki et al., 2016). This suggests that high positive affect individuals are processing a complex audiovisual narrative more similarly than low positive affect individuals across these positive emotion regions.

Engagement to the stimulus may also play a role in these results. Previous research using electroencephalography (EEG) has established a connection between attentional engagement and increased ISCs (Jääskeläinen et al., 2020; Ki et al., 2016), which may be part of the explanation for overall greater synchrony in the high positive affect individuals. It may be that these individuals are more engaged with the stimulus and thus their attentional resources are responding to the stimulus in highly similar ways, while the low positive affect individuals are less engaged and consequently their ISCs are lower. Greater neural synchrony is also exhibited in high positive affect individuals in positive affect network regions previously identified by

Rohr et al. (2013). These regions include the PCC, precuneus, medial PFC, SPL, somatosensory cortices, and audiovisual cortices. Although Rohr et al. (2013) identified a negative correlation in the functional connectivity of these regions and positive affect trait levels, the current results suggest that this network of regions is responding highly similarly across high positive affect individuals.

When examining regions where neural synchrony is greater within low positive affect individuals relative to the between group ISCs, we were able to identify areas of synchrony that are most unique to the low positive affect group. There is relatively little neural synchrony identified within this contrast, which is isolated to small clusters in the bilateral LOC, the left PT, and the left FG. These regions relate to visual object processing (Nagy et al., 2012), language processing (Binder et al., 1996), and visual face and object processing (Weiner & Zilles, 2016), respectively. The left PT is widely known as Wernicke's area, which is heavily involved in speech perception and comprehension (Shapleske et al., 1999), suggesting that low positive affect individuals may be processing speech more similarly to each other during film viewing, as opposed to other cognitive processes.

Finally, when examining areas where neural synchrony is greater amongst the high positive affect individuals relative to the between group ISCs, we were able to identify areas of synchrony that are most unique to the high positive affect group. Results showed clusters of neural synchrony in the bilateral STG, left SMG, left OFC, left precuneus, and bilateral FG. These regions relate to auditory and speech processing (Mesgarani et al., 2014), phonological language processing (Oberhuber et al., 2016), narrative interpretation (Jääskeläinen et al., 2020), and visual face and object processing (Weiner & Zilles, 2016), respectively. Synchrony in these

areas suggests that high positive affect individuals are processing the stimulus most similarly across auditory, language, narrative, and visual processing areas.

In conclusion, this experiment examined differences in neural synchrony during viewing of a positive valence film as modulated by low vs. high levels of positive affect. Results from this experiment showed greater synchrony across all four lobes of the brain for individuals with high trait levels of positive affect, including more higher-order cognitive regions such as the precuneus and PCC, as well as lower-level processing areas among the auditory and visual cortices. Individuals with high positive affect also exhibit greater synchrony in regions previously associated with positive affect by Rohr et al. (2013), including the PCC, precuneus, and SPL. Additionally, high positive affect individuals exhibit greater synchrony in regions previously associated with narrative processing by Jääskeläinen et al. (2020), including the precuneus, SMG, SPL/IPS, and audiovisual cortices. Contrastingly, far less synchrony is exhibited for individuals with low trait levels of positive affect, and is more refined to basic auditory and visual processing areas. Overall, this experiment identifies a differential effect of positive affect trait levels on the neural processing of naturalistic film viewing of a positive valence stimulus, whereby high positive affect individuals respond more similarly across higher-order brain regions, and low positive affect individuals respond more similarly across lower-order brain regions.

Experiment 2

2.2.1 Introduction

While Experiment 1 examined differences in neural synchrony as modulated by positive affect trait levels during viewing of a positive valence film, it did not examine the potential results with a negative valence film stimulus. Experiment 2 seeks to understand how trait levels of positive affect influence neural processing of a negative valence film. More specifically, it will investigate the similarities in neural processing within low and high positive affect groups during a negative valence movie viewing condition, as well as differences in processing between the groups.

Previous research has examined low positive affect through the induction of negative moods. For example, Habel et al. (2005) used fMRI to examine whether there were significant differences in activation dependent on valence levels of mood induction. Specifically, participants were directed to mimic feelings of sadness while viewing photos of sad facial expressions during fMRI. Results from this experiment showed that negative emotions in the sad condition were associated with higher activation in the ventromedial PFC, the anterior cingulate cortex (ACC), and the STG when compared to positive emotions. Saarimäki et al. (2016) found that neural networks associated with processing negative emotions included the ventromedial PFC, the amygdala, the insula, and the ACC. Gu et al. (2019) performed a meta-analysis on fMRI data of basic emotions and found that sadness was associated with activity in the ACC, fear was associated with activity in the amygdala, anger was associated with activity in the OFC and amygdala, and disgust was associated with activity in the insula. Finally, Nummenmaa et al. (2012) used fMRI to image brain activity during movie viewing of negative, neutral, and positive valence films. Results showed neural synchrony in the insula, STG, and TPJ during negative

valence film viewing. Although there is variability across previous studies focusing on fMRI and negative emotional processing, the similarities that seem to remain consistent include increased neural activity in the ventromedial PFC, amygdala, insula, ACC, and STG.

The current experiment seeks to identify neural synchrony as modulated by positive affect trait levels during viewing of a negative valence feature-length film. First, participants will be separated into low and high positive affect groups based on their scores via the NIH Toolbox Positive Affect questionnaire (Gershon et al., 2013). Using ISC analysis and LME modelling, synchrony will be compared between the positive affect groups in several ways. First, neural synchrony will be compared between low positive affect individuals vs. high positive affect individuals. More specifically, the first contrast will exhibit where in the brain the low positive affect individuals are responding more similarly to each other than the high-positive affect individuals are, and vice-versa, where the high positive affect individuals are responding more similarly to each other than the low positive affect individuals. Next, neural synchrony will be compared between low positive affect individuals vs. the between-group ISCs. This contrast will determine where in the brain the low positive affect individuals are exhibiting more synchrony than the between-group pairings, and vice-versa, where the between-group pairings may be exhibiting greater neural synchrony than the low positive affect individuals. Lastly, neural synchrony will be compared between high positive affect individuals vs. the between-group ISCs. This contrast will determine where in the brain the high positive affect individuals are responding more similarly than the between-group pairings, and vice-versa, where the between-group pairings may be exhibiting greater neural synchrony than the high positive affect individuals.

Our specific hypotheses are as follows: First, we hypothesize that synchronized neural networks will differ between the low positive affect and high positive affect groups. Based on the previous research discussed, we anticipate regions associated with negative emotional processing such as the ventromedial PFC, amygdala, insula, ACC, and STG (Gu et al., 2019; Habel et al., 2005; Saarimäki et al., 2016) will show greater neural synchrony in the low positive affect group, as these individuals experience positive moods less frequently than the high positive affect group (Lyubomirsky et al., 2005; Qi et al., 2021). As this paradigm using neural synchrony to measure consistencies in brain activity has been relatively unexplored in the context of positive affect, we may uncover regions not previously associated with positive affect studies that employed resting state functional connectivity, task-based fMRI, or less naturalistic stimuli.

2.2.2 Methods

The methods for Experiment 2 were the same as Experiment 1, with the following exceptions.

Participants

We used preprocessed fMRI data from the NNdB (Aliko et al., 2021, version 2.0.0) from 18 participants who viewed a feature length audiovisual movie. This experiment specifically looked at a negative valence film titled *Citizenfour* (Poitras, 2014). This included 9 females and 9 males, with an average age of 27.0 (Aliko et al., 2020). These 18 participants are unique to the negative valence film condition, meaning the participant pools are separate between Experiments 1 and 2.

Materials and Stimuli

Prior to imaging, participants filled out the NIH Toolbox Positive Affect CAT Age 18+ v2.0 (Gershon et al., 2013) to assess their positive affect scores. This questionnaire is an

assessment within the NIH Toolbox Emotion battery. In this experiment, participants viewed the film *Citizenfour* (Poitras, 2014) during fMRI. This film is categorized in the thriller genre, with a subcategorization of political thriller. The narrative follows a main character involved in illegal practices within the USA National Security Agency, totaling 1 hour and 53 minutes in length.

Data Acquisition and Preprocessing

Data acquisition and preprocessing techniques for this experiment remain identical to Experiment 1, via the NNdB (Aliko et al., 2021, version 2.0). The one exception being, 6804 volumes were acquired for this film condition.

Data Analysis

To examine whether there were significant differences in pairwise ISCs between low positive affect and high positive affect individuals, we first performed a median split analysis to split participants into two groups based on their Positive Affect scores (via the NIH Toolbox Positive Affect CAT Age 18+ v2.0; Gershon et al., 2013). This analysis yielded a Low Positive Affect and a High Positive Affect group.

We then performed ISC analysis for each pair of participants both within (i.e., Low-Low, High-High) and between (i.e., Low-High) positive affect groups. AFNI's *3dTcorrelate* was used to create these unique ISC pairings across the negative film condition, resulting in 153 unique pairwise combinations.

LME modeling, thresholding, and formation of anatomical figures was completed identically to Experiment 1.

2.2.3 Results

Median Split Analysis

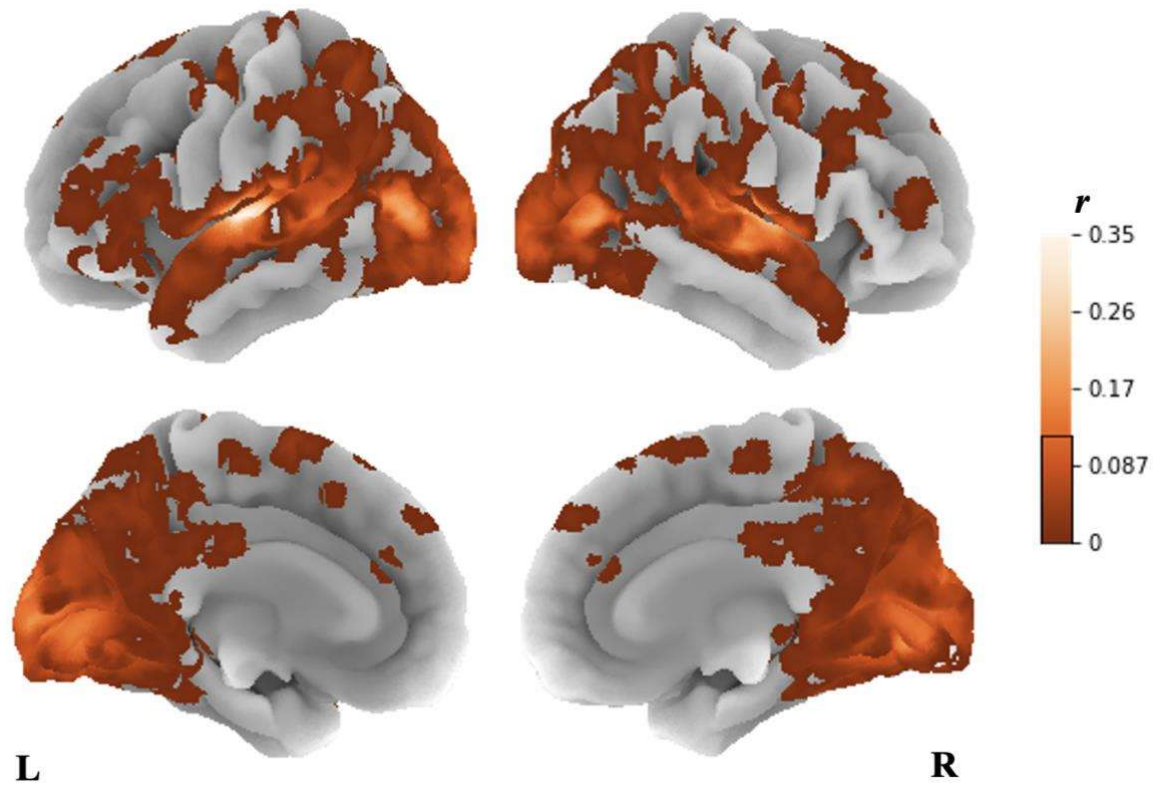
To separate participants into low and high positive affect groups, we performed a median split analysis based on participants' Positive Affect scores (via the NIH Toolbox Positive Affect CAT Age 18+ v2.0; Gershon et al., 2013). This analysis yielded a Low Positive Affect and a High Positive Affect group consisting of ten participants and eight participants, respectively. The unequal distribution between the two groups is the result of multiple participants with the median score of 15, yielding each of those participants to remain in the same group (the Low Positive Affect group). The average Positive Affect score was 12.6 (SD = 2.32) for the Low Positive Affect group and 21.5 (SD = 15.16) for the High Positive Affect group.

Low-Low Positive Affect Group Average ISC

Results from the LME model for the Low Positive Affect group average ISC identified 46 significant clusters of neural synchrony (see Figure 2.2.1 and Table 2.2.1). These clusters spanned the bilateral auditory and visual cortices of the temporal and occipital lobes, frontal lobe regions including the IFG, precentral gyri, SFG, ACC, and medial PFC, as well as parietal lobe regions including the PCC, precuneus, and opercular cortices. Synchrony was also found subcortically in the bilateral thalamus and in the bilateral crus II and left vermis IX of the cerebellum.

Figure 2.2.1

Voxelwise ISCs showing areas of neural synchrony in the Low Positive Affect group during viewing of a negative valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.2.1

Negative Valence film: Low-Low group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max <i>x</i>	Max <i>y</i>	Max <i>z</i>
Planum Temporale	L	8736	0.431	-58.5	-16.5	4.5
Crus II	R	92	0.0506	28.5	-85.5	-34.5
Middle Frontal Gyrus	R	68	0.0447	49.5	16.5	31.5
Superior Frontal Gyrus	R	64	0.0278	25.5	25.5	58.5
Precentral Gyrus	L	40	0.0749	-46.5	-4.5	52.5
Crus II	L	35	0.0284	-25.5	-85.5	-34.5
Precentral Gyrus	R	33	0.0677	43.5	-1.5	52.5
Postcentral Gyrus	R	30	0.0176	31.5	-28.5	64.5
Supplementary Motor Cortex	L	29	0.0459	-4.5	1.5	67.5
Cingulate Gyrus, posterior division	L	27	0.0239	-1.5	-22.5	28.5
Frontal Pole	L	27	0.0194	-34.5	37.5	-10.5
Frontal Pole	R	26	0.0253	46.5	46.5	13.5
Precentral Gyrus	R	22	0.101	55.5	-1.5	46.5
Precentral Gyrus	L	22	0.0163	-22.5	-28.5	67.5
Precentral Gyrus	L	20	0.0149	-1.5	-16.5	58.5
Frontal Pole	L	18	0.0205	-43.5	40.5	31.5
Superior Frontal Gyrus	L	18	0.0236	-13.5	16.5	67.5
Superior Frontal Gyrus	R	17	0.0259	7.5	16.5	67.5
Superior Frontal Gyrus	R	13	0.0218	1.5	49.5	40.5
Orbitofrontal Cortex	R	12	0.021	46.5	25.5	-4.5
Temporal Pole	L	11	0.0176	-49.5	4.5	-40.5
Orbitofrontal Cortex	R	10	0.0201	31.5	28.5	1.5
Cingulate Gyrus, anterior division	L	9	0.0159	-1.5	34.5	22.5
Superior Frontal Gyrus	R	8	0.0175	28.5	1.5	61.5
Thalamus	R	7	0.0155	16.5	-31.5	-1.5
Vermis IX	L	7	0.0135	-1.5	-58.5	-37.5
Precentral Gyrus	L	6	0.0226	-46.5	7.5	28.5
Precentral Gyrus	R	6	0.0273	28.5	-10.5	58.5
Superior Frontal Gyrus	R	6	0.017	10.5	28.5	61.5
Thalamus	L	6	0.0133	-16.5	-31.5	-1.5
Superior Parietal Lobule	R	6	0.036	34.5	-43.5	64.5
Inferior Temporal Gyrus, temporoccipital part	L	5	0.0181	-58.5	-49.5	-13.5
Precuneus Cortex	L	5	0.0176	-7.5	-58.5	61.5
Superior Frontal Gyrus	L	5	0.018	-7.5	31.5	61.5
Paracingulate Gyrus	L	5	0.0139	-1.5	16.5	46.5
Precentral Gyrus	L	5	0.0275	-37.5	7.5	25.5
Precentral Gyrus	L	5	0.0573	-52.5	4.5	46.5
Temporal Pole	R	5	0.0135	49.5	4.5	-37.5
Inferior Frontal Gyrus, pars opercularis	R	5	0.0191	49.5	10.5	19.5

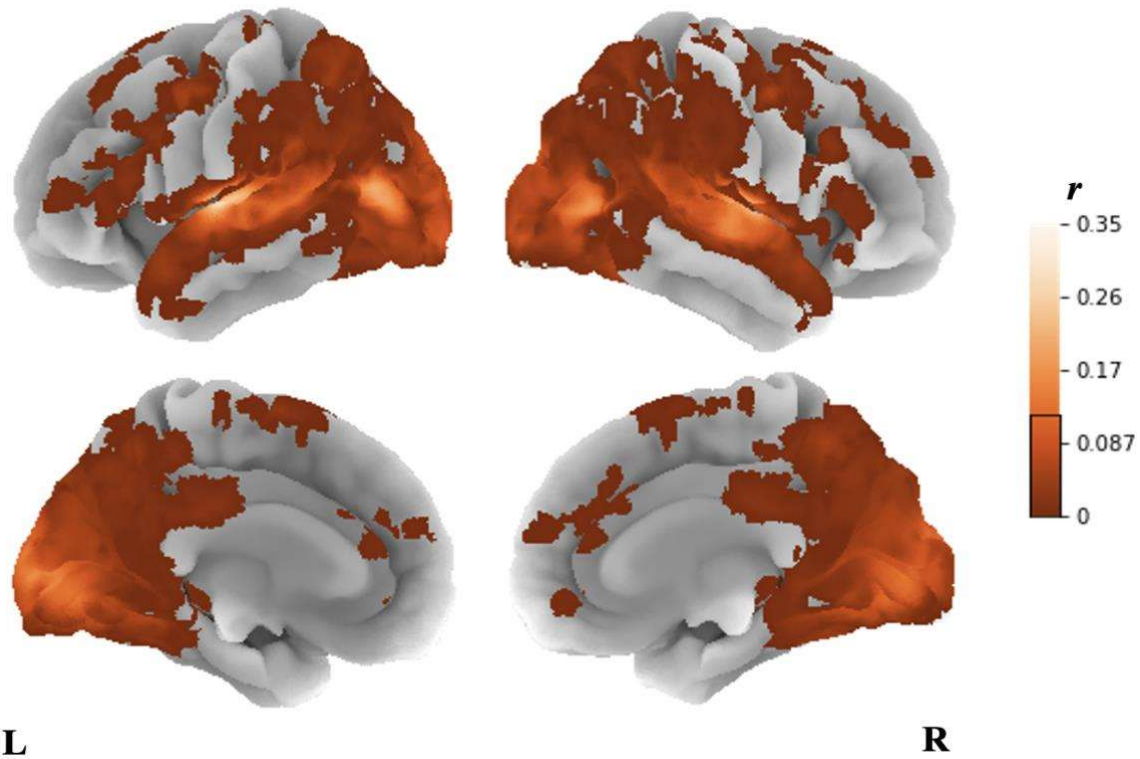
Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Low-High Positive Affect Group Average ISC

Results from the LME model for the Low-High Positive Affect group average ISC showed 23 significant clusters of neural synchrony (see Figure 2.2.2 and Table 2.2.2). Synchrony was greatest in bilateral auditory and visual cortices of the temporal and occipital lobes, but still widespread across frontal regions such as the IFG, MFG, precentral gyri, medial PFC, and parietal regions such as the PCC, precuneus, SPL, and SMG. Synchrony was also evident subcortically in the thalamus, as well as the left crus II and left vermis IX of the cerebellum.

Figure 2.2.2

Voxelwise ISCs showing areas of neural synchrony in the Low-High Positive Affect group during viewing of a negative valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.2.2

Negative Valence film: Low-High group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Planum Temporale	L	11495	0.358	-64.5	-10.5	4.5
Precentral Gyrus	L	310	0.0695	-55.5	1.5	43.5
Precentral Gyrus	R	184	0.0847	55.5	-4.5	46.5
Middle Frontal Gyrus	R	99	0.0405	46.5	19.5	28.5
Supplementary Motor Cortex	L	89	0.0437	-1.5	-1.5	67.5
Middle Frontal Gyrus	L	52	0.0197	28.5	31.5	52.5
Paracingulate Gyrus	R	35	0.0125	1.5	31.5	28.5
Middle Frontal Gyrus	L	30	0.0141	-28.5	31.5	52.5
Precentral Gyrus	R	20	0.0122	19.5	-28.5	64.5
Thalamus	L	18	0.013	-16.5	-31.5	-1.5
Vermis IX	L	14	0.0132	-1.5	-58.5	-34.5
Postcentral Gyrus	R	14	0.0127	37.5	-25.5	64.5
Precentral Gyrus	L	13	0.0115	-22.5	-28.5	67.5
Precentral Gyrus	L	13	0.0234	-28.5	-13.5	58.5
Frontal Pole	R	12	0.0157	1.5	55.5	16.5
Orbitofrontal Cortex	L	12	0.0152	-31.5	28.5	1.5
Frontal Medial Cortex	R	6	0.00919	4.5	49.5	-10.5
Orbitofrontal Cortex	R	6	0.0131	31.5	28.5	4.5
Inferior Frontal Gyrus, pars opercularis	L	6	0.0128	-55.5	13.5	-1.5
Precentral Gyrus	L	5	0.00979	-1.5	-22.5	64.5
Superior Frontal Gyrus	L	5	0.0156	-25.5	22.5	58.5
Crus II	L	5	0.0128	-7.5	-82.5	-40.5
Paracingulate Gyrus	R	5	0.00891	10.5	22.5	34.5

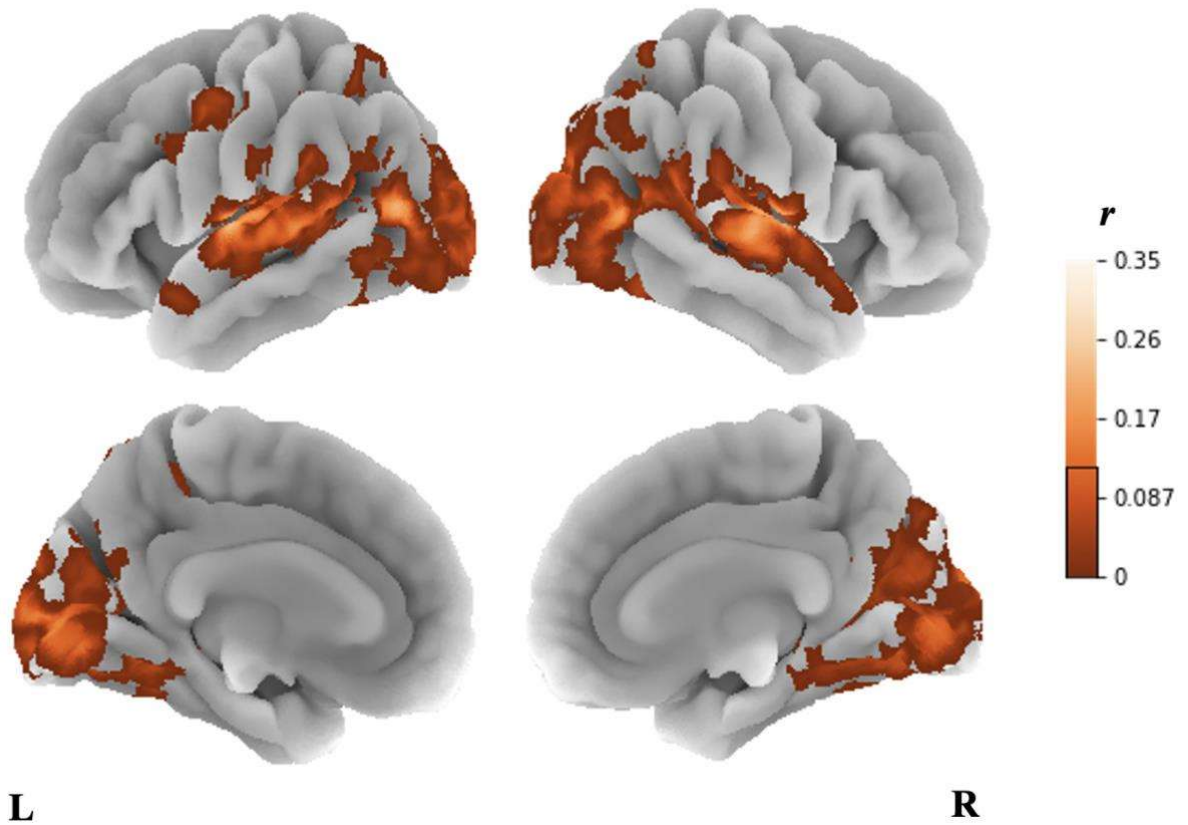
Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

High-High Positive Affect Group Average ISC

Results from the LME model for the High Positive Affect Group average ISC showed 20 significant clusters of neural synchrony (see Figure 2.2.3 and Table 2.2.3). Synchrony was greatest in the auditory and visual cortices of the temporal and occipital lobes, namely in the bilateral STG, PT, LOC, and FG. In the frontal lobe, synchrony was identified in the left precentral gyrus, and in the parietal lobe, synchrony was found in the bilateral SPL, left SMG, postcentral gyrus, and precuneus.

Figure 2.2.3

Voxelwise ISCs showing areas of neural synchrony within the High Positive Affect group during viewing of a negative valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.2.3

Negative Valence film: High-High group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max <i>x</i>	Max <i>y</i>	Max <i>z</i>
Occipital Pole	L	1481	0.207	-7.5	-91.5	1.5
Planum Temporale	R	397	0.302	61.5	-7.5	4.5
Planum Temporale	L	358	0.378	-64.5	-10.5	4.5
Occipital Fusiform Gyrus	R	231	0.127	28.5	-76.5	-7.5
Occipital Fusiform Gyrus	L	223	0.133	-25.5	-73.5	-4.5
Lateral Occipital Cortex, inferior division	L	90	0.247	-49.5	-73.5	10.5
Precentral Gyrus	L	71	0.0963	-55.5	1.5	43.5
Lateral Occipital Cortex, superior division	R	53	0.0925	31.5	-67.5	52.5
Occipital Fusiform Gyrus	R	31	0.0828	40.5	-61.5	-19.5
Lateral Occipital Cortex, superior division	L	17	0.0509	-55.5	-64.5	25.5
Superior Parietal Lobule	L	13	0.0532	-28.5	-58.5	55.5
Lateral Occipital Cortex, superior division	R	11	0.0538	28.5	-61.5	61.5
Temporal Pole	L	10	0.0522	-52.5	7.5	-22.5
Lateral Occipital Cortex, superior division	L	9	0.0507	-16.5	-70.5	61.5
Lateral Occipital Cortex, superior division	R	8	0.0369	46.5	-70.5	37.5
Precuneus Cortex	L	6	0.0366	-16.5	-67.5	28.5
Inferior Temporal Gyrus, temporoccipital part	R	5	0.0349	46.5	-43.5	-16.5
Supramarginal Gyrus, posterior division	L	5	0.0307	-43.5	-43.5	43.5
Postcentral Gyrus	L	5	0.0385	-64.5	-19.5	22.5
Precuneus Cortex	L	5	0.0344	-13.5	-46.5	52.5

Note. Coordinates (*x*, *y*, *z*) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Low-Low vs. High-High Positive Affect

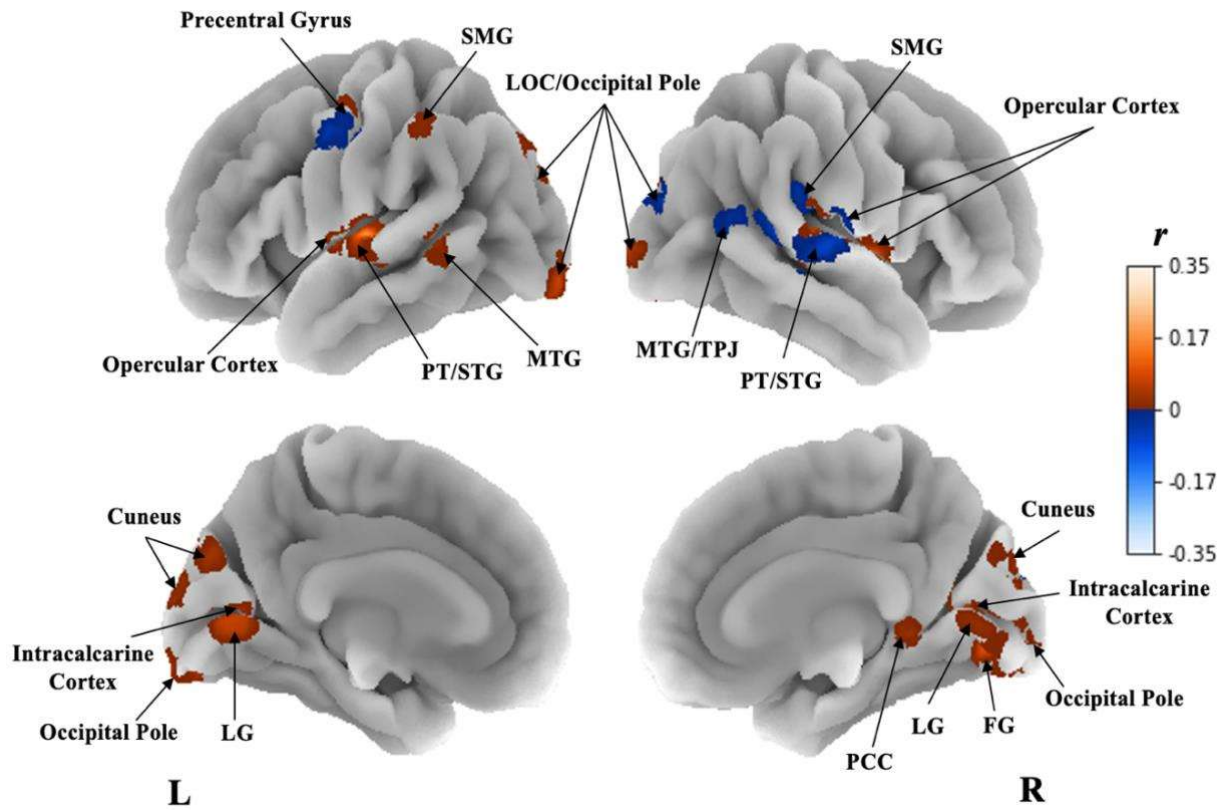
Results from the LME model for the Low-Low > High-High Positive Affect contrast identified 19 significant clusters of neural synchrony (see Figure 2.2.4 and Table 2.2.4).

Synchrony was found in auditory regions of the temporal lobe, specifically the bilateral PT and STG, and the left posterior MTG. In the occipital lobe, synchrony was found in the bilateral LG, occipital poles, intracalcarine cortices, cuneus, and LOC. Synchrony was also found in the parietal and frontal lobes, namely in the left posterior SMG, right inferior PCC, left precentral gyrus, and bilateral opercular cortices.

Results from the LME model for the High-High > Low-Low Positive Affect contrast identified 8 significant clusters of neural synchrony (see Figure 2.2.4 and Table 2.2.5). Synchrony was revealed in the right temporal lobe, specifically the STG, PT, and posterior MTG, as well as the right parietal lobe including the opercular cortex and SMG. Additionally, synchrony was found in the right LOC and occipital pole of the occipital lobe and the left precentral gyrus of the frontal lobe.

Figure 2.2.4

Voxelwise ISCs showing areas of neural synchrony in the Low-Low > High-High (red) and High-High > Low-Low (blue) Positive Affect contrasts during viewing of a negative valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.05$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.2.4

Negative Valence film: Low-Low > High-High Positive Affect cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max <i>x</i>	Max <i>y</i>	Max <i>z</i>
Lingual Gyrus	R	72	0.203	10.5	-76.5	-4.5
Planum Temporale	L	40	0.431	-58.5	-16.5	4.5
Occipital Pole	L	25	0.177	-25.5	-97.5	-10.5
Planum Polare	R	24	0.177	55.5	-1.5	1.5
Lingual Gyrus	L	24	0.171	-4.5	-79.5	1.5
Lateral Occipital Cortex, superior division	L	21	0.0589	-25.5	-82.5	37.5
Occipital Pole	R	20	0.17	10.5	-91.5	16.5
Planum Temporale	R	19	0.144	55.5	-25.5	13.5
Occipital Pole	R	11	0.132	22.5	-100	-1.5
Middle Temporal Gyrus, temporooccipital part	L	10	0.11	-58.5	-46.5	4.5
Cuneal Cortex	L	9	0.0727	-4.5	-82.5	28.5
Occipital Pole	L	8	0.224	-7.5	-97.5	16.5
Supramarginal Gyrus, posterior division	L	7	0.0369	-58.5	-43.5	49.5
Cingulate Gyrus, posterior division	R	7	0.0647	10.5	-46.5	1.5
Occipital Pole	L	6	0.105	-16.5	-104	-10.5
Precentral Gyrus	L	5	0.0749	-46.5	-4.5	52.5
Occipital Pole	L	5	0.122	-16.5	-94.5	28.5
Occipital Pole	R	5	0.127	7.5	-91.5	25.5
Superior Temporal Gyrus, posterior division	R	5	0.115	49.5	-28.5	4.5

Note. Coordinates (x, y, z) of max correlations (r) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Table 2.2.5

Negative Valence film: High-High > Low-Low Positive Affect cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max <i>x</i>	Max <i>y</i>	Max <i>z</i>
Superior Temporal Gyrus, posterior division	R	31	0.278	67.5	-13.5	7.5
Precentral Gyrus	L	31	0.0944	-55.5	-1.5	43.5
Occipital Pole	R	22	0.172	22.5	-91.5	25.5
Lateral Occipital Cortex, superior division	R	15	0.0925	31.5	-67.5	52.5
Parietal Operculum Cortex	R	12	0.0969	37.5	-28.5	19.5
Supramarginal Gyrus, posterior division	R	11	0.13	49.5	-40.5	10.5
Middle Temporal Gyrus, temporooccipital part	R	10	0.162	46.5	-58.5	10.5
Occipital Fusiform Gyrus	R	5	0.127	28.5	-76.5	-7.5

Note. Coordinates (x, y, z) of max correlations (r) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

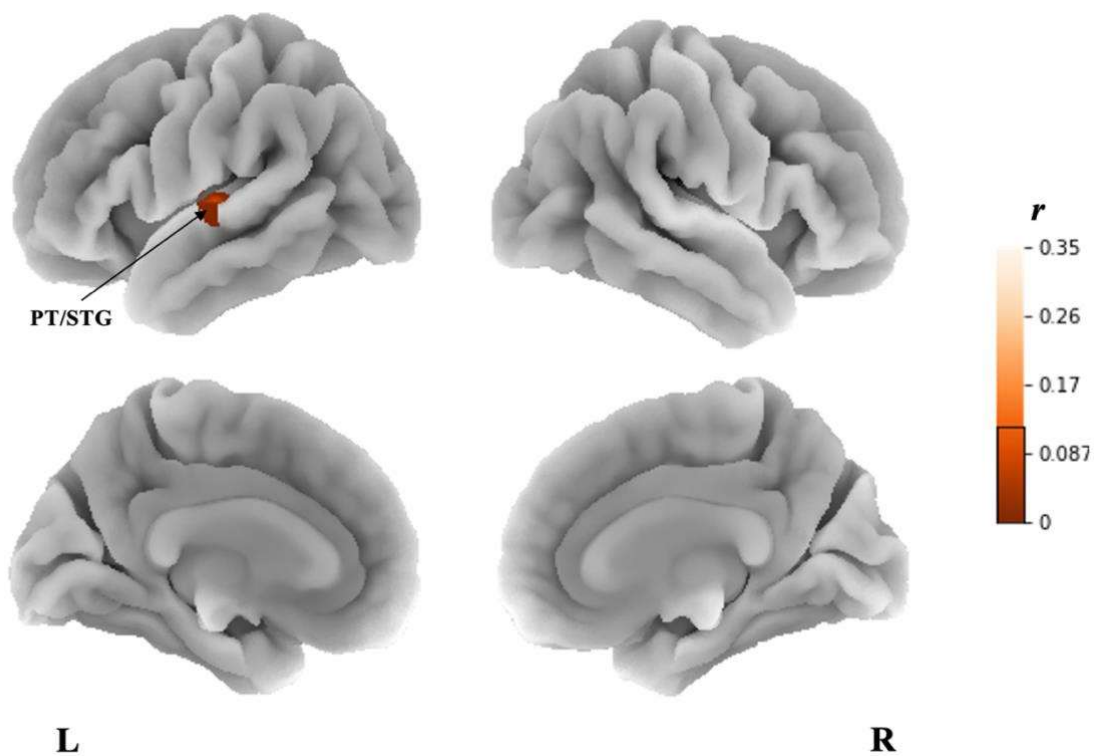
Low-Low vs. Low-High Positive Affect

Results from the LME model for the Low-Low > Low-High Positive Affect contrast showed one cluster of significant neural synchrony (see Figure 2.2.5 and Table 2.2.6). This cluster was located in the left PT and STG.

Results from the LME model for the Low-High > Low-Low Positive Affect contrast did not show any significant clusters of neural synchrony.

Figure 2.2.5

Voxelwise ISCs showing areas of neural synchrony in the Low-Low > Low-High Positive Affect contrast during viewing of a negative valence film.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.05$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 2.2.6

Negative Valence film: Low-Low > Low-High Positive Affect cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max <i>x</i>	Max <i>y</i>	Max <i>z</i>
Planum Temporale	L	8	0.431	-58.5	-16.5	4.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Low-High vs. High-High Positive Affect

Results from the LME model for the High-High > Low-High Positive Affect contrast did not show any significant clusters of neural synchrony. Results from the LME model for the High-High > Low-High contrast did not show any significant clusters of neural synchrony.

2.2.4 Discussion

This experiment sought to examine ISCs during naturalistic film viewing and how neural synchrony in processing of a negative valence audiovisual film may be influenced by differences in trait levels of positive affect. To examine these differences, we first separated participants into two groups, low positive affect and high positive affect, based on their scores from the NIH Toolbox Positive Affect Questionnaire (NIH Toolbox Positive Affect CAT Age 18+ v2.0; Gershon et al., 2013), followed by ISC and LME analyses both within and between positive affect groups. We hypothesized that pairwise correlations will be higher among participants that are more similar in positive affect levels and that low positive affect individuals would show greater synchrony in regions previously associated with negative emotional processing (the ventromedial PFC, amygdala, insula, ACC, and STG).

Results from this experiment revealed differences in neural synchrony based on positive affect levels during viewing of a full-length audiovisual film. When examining regions with greater synchrony for the low positive affect individuals compared to high positive affect individuals, we found significant clusters of neural synchrony in the bilateral PT, STG, LG, occipital poles, intracalcarine cortices, cunei, LOC, and left posterior MTG. These regions are heavily involved in auditory and visual processing (Binder et al., 1996; Gao et al., 2023; Jones & Callan, 2003). Synchrony was also found in the parietal and frontal lobes, namely in the left posterior SMG, right inferior PCC, left precentral gyrus, and bilateral opercular cortices. The left SMG contributes to phonological language processing (Hartwigsen et al., 2010). The majority of synchrony in this condition was observed in primary, secondary, and associative audiovisual processing areas, suggesting that low positive affect individuals are processing basic auditory and visual details of the stimulus in highly similar patterns across the brain.

We also identified areas of neural synchrony that were greater for the high positive affect individuals than the low positive affect group. This contrast yielded significant clusters of neural synchrony in the right temporal lobe, specifically the STG, PT, and posterior MTG, as well as the right parietal lobe, including the opercular cortex and SMG. Additionally, synchrony was found in the right LOC and occipital pole, and the left precentral gyrus. These temporal, parietal, and occipital regions are primarily involved in audiovisual processing (Binder et al., 1996; Gao et al., 2023; Jones & Callan, 2003). Additionally, the left precentral gyrus is shown to be related to speech production and fine motor movement of the mouth (Graff-Radford et al., 2014; Itabashi et al., 2016). Interestingly, both the low and high positive affect individuals exhibit synchrony in this area, though present in more superior and inferior sections of the left precentral

gyrus, respectively. Taken together, synchrony in these areas suggests that high positive affect individuals are processing basic auditory and speech input primarily in the right hemisphere.

We also examined where neural synchrony was greater within low positive affect individuals relative to the between-group ISCs, in order to identify regions of synchrony most unique to the low positive affect individuals. This contrast revealed only one cluster in the left PT and STG (i.e., Wernicke's area), which is responsible for speech perception and comprehension (Shapleske et al., 1999). This suggests that low positive affect individuals may process speech more similarly during the negative valence film.

When comparing neural synchrony between high positive affect individuals relative to the between-group ISCs, no significant results were found. This suggests that the high positive affect individuals do not share unique neural processing during viewing of a negative valence film relative to the between-group ISCs.

In conclusion, this experiment examined differences in neural synchrony during viewing of a negative valence film between low positive affect and high positive affect individuals. Results from this experiment showed greater synchrony across all four lobes of the brain for individuals with low trait levels of positive affect, most notably in the auditory and visual cortices in the temporal and occipital lobes. Areas outside of these audiovisual cortices showing greater synchrony for individuals with low positive affect are the left SMG and left precentral gyrus. Thus, low positive affect individuals exhibit greater synchrony in regions previously associated with narrative processing by Jääskeläinen et al. (2020), namely the left SMG and audiovisual cortices. Contrastingly, individuals with high positive affect exhibit less synchrony during viewing of a negative valence film, with all but one cluster lateralized in the right audiovisual cortices. Overall, there is little synchrony in higher-order cognitive regions or

regions previously associated with positive affect and negative emotional processing, suggesting that, in contrast to Experiment 1, positive affect may not modulate neural synchrony in these regions during a negative valence stimulus. Overall, this experiment identifies a differential effect of positive affect trait levels on the neural processing of naturalistic film viewing of a negative valence stimulus in lower-level auditory and visual processing areas.

CHAPTER 3: Neural Synchrony of Positive Affect as Modulated by Emotional Valence during Audiovisual Film Viewing

Experiment 3

3.1.1 Introduction

Experiments 1 and 2 investigated how low and high trait levels of positive affect influence neural synchrony related to positive and negative naturalistic stimuli, respectively, however, they did not directly compare the differing emotional valences of the films. Therefore, the current experiment seeks to compare differences in how low positive affect individuals process positive and negative valence stimuli. More specifically, neural synchrony will be compared across the low positive affect individuals to examine which areas of the brain exhibit greater synchrony during the positive valence film relative to the negative valence film, and which areas exhibit greater synchrony during the negative valence film relative to the positive valence film. These contrasts will give insight into how low positive affect impacts the neural processing of naturalistic audiovisual stimuli with different emotional valence.

First, we hypothesize that neural synchrony will differ between the positive and negative valence film conditions, specifically that low positive affect individuals will show heightened neural synchrony in the negative valence film condition, as they experience negative moods more often in everyday life (Lyubomirsky et al., 2005; Qi et al., 2021). Based on previous research, the low positive affect individuals are hypothesized to show greater neural synchrony during the negative valence film in regions previously associated with negative valence emotional processing, such as the ventromedial PFC, amygdala, insula, ACC, and STG (Gu et al., 2019; Habel et al., 2005; Saarimäki et al., 2016). Additionally, as low positive affect individuals experience positive emotions less often (Lyubomirsky et al., 2005; Qi et al., 2021),

we hypothesize that there will be less overall synchrony during the positive valence film, and that synchrony during the positive valence film will be located in basic audiovisual processing areas not related to emotion. As this paradigm using neural synchrony to measure consistencies in brain activity has been relatively unexplored in the context of positive affect, we may uncover regions not previously associated with positive affect studies that employed resting state functional connectivity, task-based fMRI, or less naturalistic stimuli.

3.1.2 Methods

The methods for Experiment 3 were the same as Experiments 1 and 2, with the following exceptions.

Participants

For this experiment, we used the same fMRI data as Experiments 1 and 2, taken from the NNdB (Aliko et al., 2020), however, only participants from the Low Positive Affect groups of each film condition were included. Based on the median split analyses from Experiments 1 and 2, this consisted of 10 participants for both the Positive Valence and Negative Valence film conditions. The Positive Valence group had an average Positive Affect score of 12.0 (SD = 2.11), average age of 27.2, with 6 males and 4 females, while the Negative Valence group had an average Positive Affect score of 12.6 (SD = 2.32), average age of 28.6, with 5 males and 5 females.

Data Analysis

To compute ISCs between the positive valence film condition and the negative valence film condition, we first had to ensure films were the same length. To do so, we used *fslroi* (Jenkinson et al., 2012) to remove volumes from the Negative Valence film (*Citizenfour*) to match the length of the Positive Valence film (*500 Days of Summer*; i.e., 5470 volumes). As the

Negative Valence film was originally 6804 volumes, this resulted in 1334 volumes being removed from the end of each dataset. We then performed ISC analysis for each pair of participants both within the Valence groups (i.e., Positive Valence-Positive Valence, Negative Valence-Negative Valence) and between the Valence groups (i.e., Positive Valence-Negative Valence). AFNI's *3dTcorrelate* was used to create these unique ISC pairings across the 20 participants, resulting in 190 unique pairwise combinations. In the current research, a linear mixed effects (LME) model is used to further analyze the ISC data. A single LME analysis was performed and modeled the data with the following outputs: average ISC in the positive valence film (Positive Valence-Positive Valence); average ISC in the negative valence film (Negative Valence-Negative Valence); and the contrast between the positive and negative valence films (Positive Valence-Positive Valence vs. Negative Valence-Negative Valence). It is important to note that this LME model differs from Experiments 1 and 2 as we are not interested in the between group comparison (i.e., Positive Valence-Negative Valence), and thus the corresponding weight of these groups and contrasts was set to 0. Otherwise, the film condition would be the main driving force behind the ISCs and corresponding contrasts, rather than ISCs unique to the Low Positive Affect groups. The within-group ISC average *t*-statistics were thresholded at a voxelwise FDR of $q < 0.001$, while the between-group contrast was thresholded at a voxelwise FDR of $q < 0.05$. A cluster threshold of 5 voxels was also applied to each *t*-statistic (via AFNI's *clusterize*) to eliminate any clusters of < 5 voxels. The thresholded and clusterized *t*-statistics were then masked onto the corresponding group average ISC (via *fslmaths -mas* function) and in-house python code was then used to visually represent these masked images as anatomical figures. Cluster tables for each condition were created using FSL's *cluster* function.

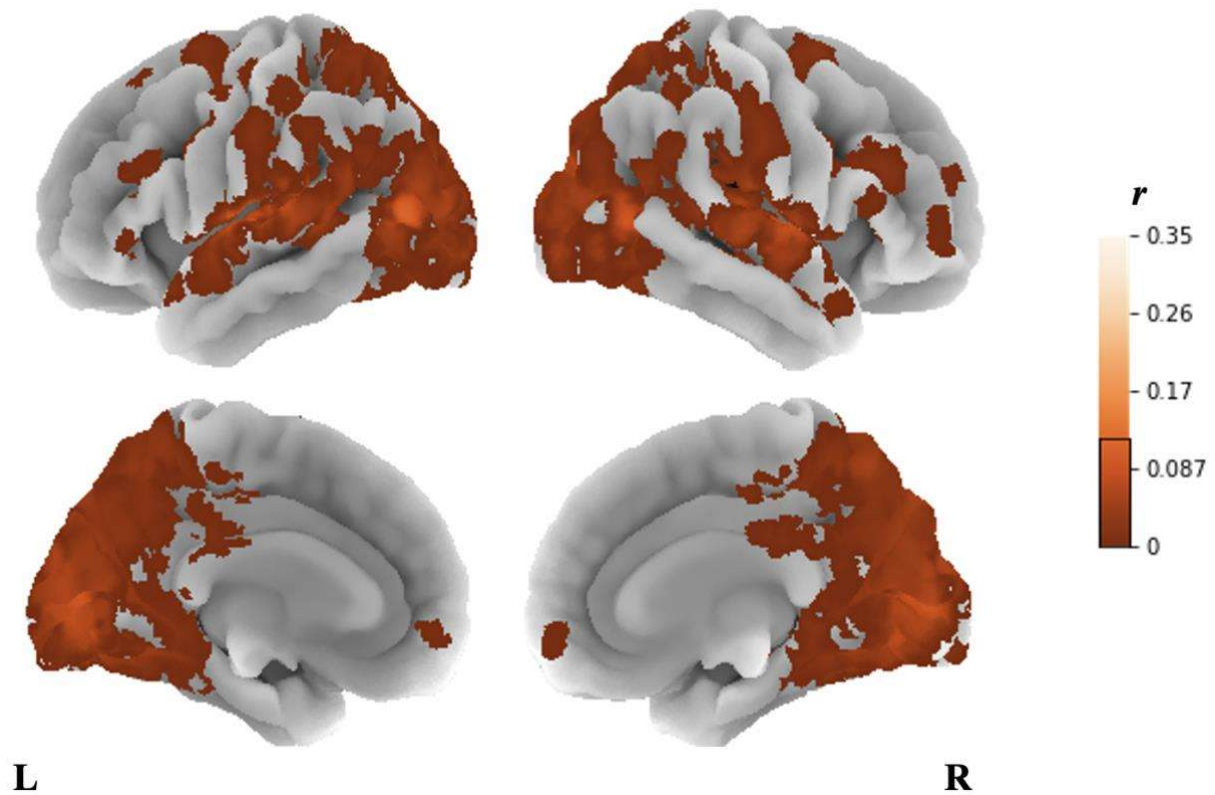
3.1.3 Results

Low Positive Affect: Positive Valence-Positive Valence Film Group Average ISC

Results from the LME model for the Positive Valence-Positive Valence Film group average ISC found 32 significant clusters of neural synchrony (see Figure 3.1.1 and Table 3.1.1). Synchrony was identified in the bilateral STG, PT, LOC, FG, and LG. Synchrony was also found in frontal and parietal regions, including the bilateral precuneus, IFG, medial PFC, SPL, and postcentral gyri.

Figure 3.1.1

Voxelwise ISCs showing areas of neural synchrony in Low Positive Affect individuals in the positive valence film condition.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 3.1.1

Low Positive Affect both films: Positive Valence-Positive Valence group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Planum Temporale	L	7230	0.194	-61.5	-16.5	7.5
Precentral Gyrus	L	116	0.0244	-28.5	-7.5	61.5
Superior Frontal Gyrus	R	84	0.025	25.5	4.5	64.5
Middle Frontal Gyrus	R	66	0.023	46.5	28.5	22.5
Cingulate Gyrus, posterior division	L	30	0.0151	-1.5	-31.5	28.5
Precentral Gyrus	R	26	0.0157	49.5	7.5	22.5
Middle Frontal Gyrus	L	25	0.0184	-43.5	19.5	25.5
Supramarginal Gyrus, posterior division	R	24	0.0183	46.5	-40.5	49.5
Inferior Temporal Gyrus, temporoccipital part	L	21	0.0204	-49.5	-58.5	-19.5
Frontal Pole	R	16	0.0126	46.5	49.5	7.5
Temporal Pole	L	16	0.0288	-55.5	16.5	-19.5
Precentral Gyrus	L	13	0.017	-52.5	10.5	31.5
Frontal Pole	R	13	0.0136	34.5	37.5	-10.5
Precentral Gyrus	R	12	0.0182	13.5	-19.5	43.5
Precentral Gyrus	L	12	0.0243	-40.5	4.5	28.5
Precentral Gyrus	L	8	0.0145	-13.5	-22.5	43.5
Inferior Frontal Gyrus, pars triangularis	R	8	0.0138	55.5	25.5	10.5
Cingulate Gyrus, posterior division	R	8	0.0157	4.5	-37.5	25.5
Cingulate Gyrus, posterior division	R	8	0.00985	1.5	-28.5	46.5
Frontal Pole	R	7	0.0103	22.5	58.5	19.5
Temporal Pole	R	6	0.0201	52.5	16.5	-25.5
Supramarginal Gyrus, posterior division	L	6	0.0147	-37.5	-46.5	40.5
Crus I	R	6	0.00934	25.5	-76.5	-34.5
Frontal Pole	L	6	0.0092	-7.5	55.5	-7.5
Frontal Pole	R	6	0.0112	1.5	58.5	-7.5
Middle Frontal Gyrus	L	6	0.0125	-28.5	31.5	55.5
Crus I	L	6	0.0118	-28.5	-82.5	-34.5
Precentral Gyrus	L	5	0.0398	-55.5	-4.5	52.5
Superior Temporal Gyrus, anterior division	R	5	0.0125	49.5	1.5	-22.5
Precentral Gyrus	L	5	0.00976	-43.5	-16.5	55.5
Supramarginal Gyrus, anterior division	R	5	0.0209	64.5	-31.5	37.5
Inferior Frontal Gyrus, pars triangularis	L	5	0.0175	-49.5	31.5	-4.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

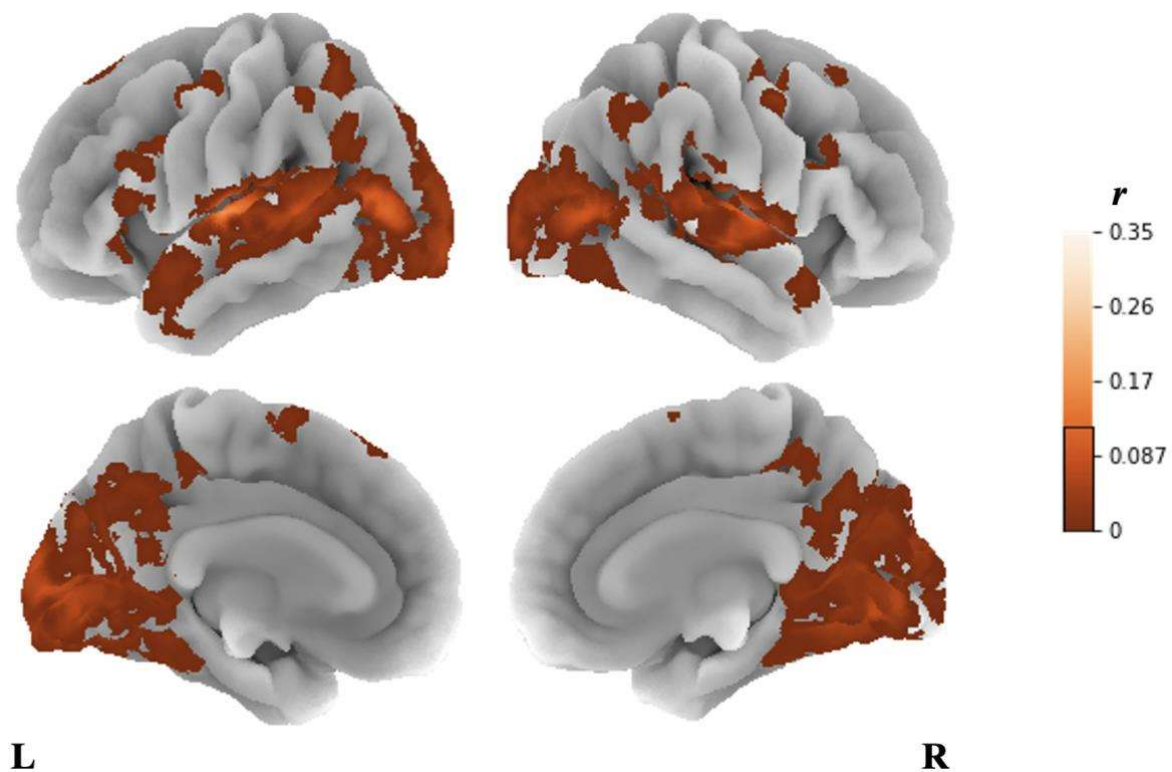
Low Positive Affect: Negative Valence-Negative Valence Group Average ISC

Results from the LME model for the Negative Valence-Negative Valence film group average ISC found 33 significant clusters of neural synchrony (see Figure 3.1.2 and Table 3.1.2).

Synchrony was identified in the bilateral LOC, FG, LG, temporal poles, and STG. In the frontal and parietal lobes, synchrony is evident in the bilateral precuneus, precentral gyri, SFG, and left IFG/OFC.

Figure 3.1.2

Voxelwise ISCs showing areas of neural synchrony in Low Positive Affect individuals in the negative valence film condition.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 3.1.2

Low Positive Affect both films: Negative Valence-Negative Valence group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Occipital Pole	L	2724	0.108	-7.5	-97.5	16.5
Planum Temporale	L	623	0.211	-64.5	-13.5	4.5
Planum Temporale	R	407	0.154	58.5	-10.5	4.5
Temporal Pole	L	65	0.0412	-58.5	7.5	-13.5
Crus II	R	36	0.0275	28.5	-85.5	-34.5
Superior Parietal Lobule	L	35	0.03	-31.5	-58.5	52.5
Precentral Gyrus	R	34	0.031	43.5	-1.5	52.5
Angular Gyrus	L	27	0.0279	-43.5	-58.5	28.5
Middle Frontal Gyrus	R	26	0.0261	49.5	16.5	31.5
Precuneus Cortex	R	21	0.0195	13.5	-43.5	52.5
Precentral Gyrus	L	19	0.0212	-37.5	7.5	28.5
Inferior Frontal Gyrus, pars triangularis	L	19	0.0165	-46.5	31.5	-4.5
Precuneus Cortex	L	18	0.0157	-10.5	-40.5	49.5
Temporal Pole	R	15	0.0277	55.5	10.5	-16.5
Superior Frontal Gyrus	L	13	0.0131	-7.5	31.5	61.5
Angular Gyrus	R	12	0.0156	52.5	-58.5	37.5
Inferior Frontal Gyrus, pars opercularis	L	11	0.0221	-58.5	16.5	7.5
Parietal Opercular Cortex	L	11	0.0653	-40.5	-37.5	16.5
Occipital Pole	R	10	0.0482	25.5	-91.5	28.5
Occipital Fusiform Gyrus	R	10	0.0117	7.5	-79.5	-22.5
Precentral Gyrus	L	10	0.0327	-46.5	-4.5	52.5
Lateral Occipital Cortex, superior division	L	9	0.0233	-25.5	-73.5	34.5
Occipital Fusiform Gyrus	R	9	0.0112	19.5	-76.5	-22.5
Supramarginal Gyrus, posterior division	L	8	0.0148	-58.5	-43.5	49.5
Supplementary Motor Cortex	L	8	0.0237	-4.5	1.5	64.5
Temporal Pole	L	8	0.00954	-49.5	4.5	-40.5
Precentral Gyrus	R	8	0.0493	55.5	-1.5	46.5
Inferior Frontal Gyrus, pars opercularis	L	7	0.0177	-58.5	19.5	22.5
Postcentral Gyrus	R	7	0.0156	34.5	-34.5	46.5
Crus II	L	7	0.0148	-28.5	-88.5	-31.5
Superior Frontal Gyrus	R	5	0.0152	25.5	25.5	58.5
Precentral Gyrus	L	5	0.0141	-40.5	-1.5	55.5
Heschl's Gyrus	L	5	0.043	-34.5	-28.5	13.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Low Positive Affect: Positive Valence-Positive Valence > Negative Valence-Negative Valence

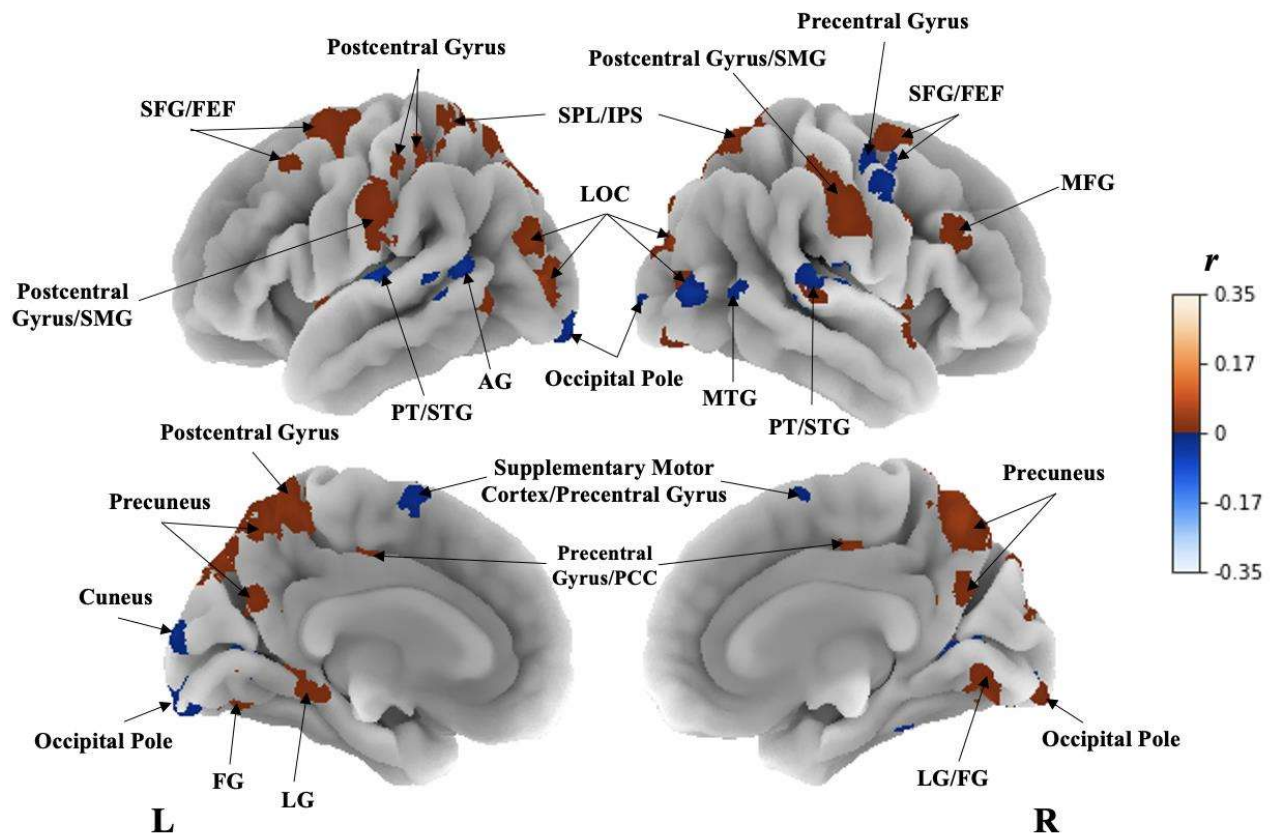
Results from the LME model for the Positive Valence-Positive Valence > Negative Valence-Negative Valence film contrast found 38 significant clusters of neural synchrony (see Figure 3.1.3 and Table 3.1.3). In the frontal lobe, significant synchrony was found in bilateral SFG and FEF, as well as the right MFG. Parietal regions exhibiting synchrony include the bilateral SPL/IPS, postcentral gyri, SMG, and precuneus. In the temporal and occipital lobes, synchrony was found in the bilateral LOC, LG, FG, and right PT/STG.

Low Positive Affect: Negative Valence-Negative Valence > Positive Valence-Positive Valence

Results from the LME model for the Negative Valence-Negative Valence > Positive Valence-Positive Valence film contrast identified 17 significant clusters of neural synchrony (see Figure 3.1.3 and Table 3.1.4). Frontal lobe regions exhibiting synchrony included the bilateral supplementary motor cortices and precentral gyri, as well as the right SFG and FEF. Synchrony is also identified in the temporal and occipital lobes, namely the bilateral PT/STG and occipital poles, the left cuneus and AG, and the right MTG and LOC.

Figure 3.1.3

Voxelwise ISCs showing areas of neural synchrony in the Low Positive Affect groups for the Positive Valence-Positive Valence > Negative Valence-Negative Valence (red) and Negative Valence-Negative Valence > Positive Valence-Positive Valence (blue) contrasts.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.05$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 3.1.3

Low Positive Affect both films: Positive Valence-Positive Valence > Negative Valence-Negative Valence cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Precuneus Cortex	R	441	0.0578	1.5	-61.5	55.5
Precentral Gyrus	L	105	0.0244	-28.5	-7.5	61.5
Postcentral Gyrus	R	62	0.024	58.5	-19.5	40.5
Superior Temporal Gyrus, posterior division	L	56	0.0821	-70.5	-25.5	13.5
Supracalcarine Cortex	L	53	0.0452	-22.5	-64.5	19.5
Lingual Gyrus	R	40	0.0718	16.5	-70.5	-10.5
Occipital Pole	L	37	0.0649	-34.5	-91.5	4.5
Superior Frontal Gyrus	R	32	0.025	25.5	4.5	64.5
Precuneus Cortex	R	32	0.0521	22.5	-58.5	22.5
Lateral Occipital Cortex, superior division	R	26	0.0861	22.5	-88.5	22.5
Superior Parietal Lobule	L	20	0.0226	-43.5	-43.5	61.5
Lateral Occipital Cortex, inferior division	R	20	0.0433	34.5	-82.5	10.5
Planum Polare	R	16	0.0417	49.5	-1.5	-4.5
Lateral Occipital Cortex, superior division	L	15	0.0517	-43.5	-79.5	19.5
Heschl's Gyrus	L	13	0.0439	-40.5	-22.5	1.5
Lateral Occipital Cortex, superior division	L	13	0.0485	-16.5	-82.5	40.5
Middle Frontal Gyrus	R	12	0.023	46.5	28.5	22.5
Parietal Operculum Cortex	L	12	0.0631	-37.5	-31.5	19.5
Occipital Fusiform Gyrus	L	11	0.0656	-25.5	-76.5	-16.5
Supramarginal Gyrus, anterior division	R	10	0.0182	49.5	-31.5	49.5
Lateral Occipital Cortex, inferior division	L	10	0.0302	-49.5	-64.5	-1.5
Planum Polare	R	10	0.0534	46.5	-13.5	-1.5
Supramarginal Gyrus, anterior division	L	9	0.0209	-58.5	-28.5	46.5
Precentral Gyrus	R	9	0.0182	13.5	-19.5	43.5
Occipital Pole	L	9	0.0546	-7.5	-88.5	37.5
Occipital Pole	R	8	0.0535	16.5	-88.5	40.5
Right VI	R	7	0.017	40.5	-52.5	-25.5
Occipital Pole	R	7	0.0339	34.5	-91.5	-13.5
Superior Temporal Gyrus, posterior division	R	7	0.0563	70.5	-22.5	4.5
Occipital Pole	R	6	0.0258	13.5	-94.5	-10.5
Lingual Gyrus	L	6	0.0225	-13.5	-43.5	-7.5
Precuneus Cortex	R	6	0.0328	1.5	-67.5	28.5
Temporal Pole	R	5	0.0525	58.5	13.5	-10.5
Precentral Gyrus	L	5	0.0117	-13.5	-16.5	43.5
Precentral Gyrus	R	5	0.013	55.5	13.5	34.5
Middle Frontal Gyrus	L	5	0.0122	-43.5	19.5	49.5
Planum Polare	L	5	0.0259	-49.5	-1.5	-4.5
Lingual Gyrus	L	5	0.0272	-13.5	-46.5	-1.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Table 3.1.4

Low Positive Affect both films: Negative Valence-Negative Valence > Positive Valence-Positive Valence cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Intracalcarine Cortex	R	29	0.0447	22.5	-61.5	4.5
Precentral Gyrus	R	26	0.031	43.5	-1.5	52.5
Central Opercular Cortex	R	24	0.106	55.5	-16.5	10.5
Occipital Pole	L	22	0.0826	-25.5	-97.5	-13.5
Angular Gyrus	L	15	0.0392	-52.5	-52.5	13.5
Occipital Pole	R	11	0.0603	22.5	-97.5	-1.5
Precentral Gyrus	R	11	0.0493	55.5	-1.5	46.5
Intracalcarine Cortex	R	10	0.0566	16.5	-67.5	7.5
Lateral Occipital Cortex, inferior division	R	9	0.0949	49.5	-76.5	4.5
Planum Temporale	L	8	0.154	-55.5	-16.5	4.5
Supplementary Motor Cortex	L	7	0.0266	-1.5	1.5	64.5
Lateral Occipital Cortex, inferior division	R	7	0.102	55.5	-67.5	4.5
Intracalcarine Cortex	L	7	0.0385	-13.5	-70.5	4.5
Temporal Occipital Fusiform Cortex	R	6	0.0245	37.5	-40.5	-22.5
Occipital Pole	L	5	0.1	-7.5	-97.5	13.5
Middle Temporal Gyrus, posterior division	L	5	0.091	-67.5	-40.5	4.5
Superior Temporal Gyrus, posterior division	R	5	0.078	67.5	-28.5	10.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

3.1.4 Discussion

This experiment sought to examine ISCs during naturalistic film viewing for individuals with low positive affect during viewing of both a positive valence and negative valence film. To examine these differences, we separated participants into two groups: low positive affect individuals that viewed a positive valence audiovisual film, and low positive affect individuals that viewed a negative valence audiovisual film. Next, we performed ISC and LME analyses to compare neural synchrony patterns between low positive affect groups for the differing film conditions. Results from this experiment revealed differences in neural synchrony within the low positive affect individuals associated either a positive or negative emotional valence film,

suggesting that individuals with low positive affect influences the neural processing of positive and negative experiences differently.

When examining where ISCs were higher for the positive valence film relative than the negative valence film in individuals with low positive affect, we found a more extensive pattern of synchrony across the brain. This pattern included significant clusters of neural synchrony in audiovisual processing areas including the bilateral LOC, LG, FG, and right STG. These areas are related to low-level processing of an audiovisual stimulus (Binder et al., 1996; Gao et al., 2023; Jones & Callan, 2003). Additionally, synchrony is evident across higher-level cognitive processing areas of the parietal and frontal lobes, including the bilateral FEF, postcentral gyri, precuneus, SMG, as well as the left SPL and IPS. Of these regions, the FEF, IPS/SPL, TPJ (this includes the SMG), and precuneus are argued to be heavily involved in both the processing of, and attentional engagement to, a narrative (Jääskeläinen et al., 2020). Synchrony in the SPL/IPS, precuneus, and PCC is in line with previous research associating low levels of positive affect with greater functional connectivity in these regions (Rohr et al., 2013).

Next, we compared ISCs between the low positive affect groups to examine where neural synchrony was greater during the negative valence film in relation to the positive valence film, which revealed a less extensive pattern of synchrony. This pattern included significant clusters of neural synchrony in the bilateral STG, posterior MTG, LOC, medial precentral gyri, and right lateral precentral gyrus. In line with Jaaskelainen et al. (2020), the STG, MTG, LOC, and cuneus are involved in narrative processing, as well as basic auditory and visual processing of the stimulus (Binder et al., 1996; Gao et al., 2023; Jones & Callan, 2003). Synchrony in these areas suggests that low positive affect individuals are processing the lower-level aspects of the positive valence film more similarly to each other, rather than the emotional valence of the film.

In conclusion, this experiment reveals a greater and more extensive pattern of synchrony across the brain during the positive valence film. This suggests that positive valence stimuli may synchronize neural processing across individuals more than negative valence stimuli in individuals with low positive affect. Synchrony during a positive valence film stimulus exhibits a pattern including basic auditory and visual processing areas, but extends to higher-order cognitive areas such as the precuneus and PCC and lateral regions of the frontal lobe as well. In contrast, the negative valence film stimulus exhibits a less extensive pattern of synchrony across the brain, refined to rudimentary auditory and visual cortices, the supplementary motor cortex, and the right SFG. Overall, this experiment suggests that the valence of a stimulus may influence patterns of neural synchrony across individuals with similar, low trait levels of positive affect.

Experiment 4

3.2.1 Introduction

Experiment 3 examined the influence of emotional valence on individuals with low positive affect, but did not examine individuals with high positive affect. Therefore, the current experiment seeks to compare the high positive affect individuals across the two film conditions. More specifically, neural synchrony will be compared across the high positive affect individuals to examine which areas of the brain exhibit greater synchrony during the positive valence film relative to the negative valence film, and, which areas exhibit greater synchrony during the negative valence film relative to the positive valence film. These contrasts will give insight into how high positive affect impacts the neural processing of naturalistic audiovisual stimuli with different emotional valence.

We hypothesize that synchronized neural networks will differ between the positive and negative valence film conditions, specifically that high positive affect individuals will show heightened neural synchrony in the positive valence film condition, as they experience positive emotions more often in everyday life (Lyubomirsky et al., 2005; Qi et al., 2021). Based on previous research, the high positive affect individuals are hypothesized to show greater neural synchrony during the positive valence film condition in regions previously associated with positive valence emotional processing: the ventral PFC, dorsolateral PFC, PCC, precuneus, IFG, and cerebellum (Gu et al., 2019; Habel et al., 2005; Saarimäki et al., 2016). Additionally, as high positive affect individuals experience negative emotions less often (Lyubomirsky et al., 2005; Qi et al., 2021), we hypothesize that there will be less overall synchrony during the negative valence film, and that synchrony during the negative valence film will be located in basic audiovisual processing areas not related to positive emotions.

3.2.2 Methods

The methods for Experiment 4 are the same as Experiment 3, with the following exceptions.

Participants

For this experiment, we used the same fMRI data as Experiments 1 and 2 (taken from the NNdB (Aliko et al., 2020)). However, only participants from the High Positive Affect groups of each film were included. Based on the median split analyses from Experiments 1 and 2, this consisted of 10 participants from the Positive Valence film condition and 8 participants from the Negative Valence film condition. The Positive Valence group had an average Positive Affect score of 31.8 (SD = 19.74), average age of 26.8, with 5 males and 5 females, while the Negative Valence group had an average Positive Affect score of 21.5 (SD = 15.16), average age of 26.75, with 3 males and 5 females. Although the two groups do not have the same number of participants, LME has been shown to accurately account for unequal sample sizes (Chen et al., 2016; Chen et al., 2020).

Data Analysis

To compute ISCs between the positive valence film condition and the negative valence film condition, we first had to ensure films were the same length. To do so, we used *fslroi* (Jenkinson et al., 2012) to remove volumes from the Negative Valence film (*Citizenfour*) to match the length of the Positive Valence film (*500 Days of Summer*; i.e., 5470 volumes). As the Negative Valence film was originally 6804 volumes, this resulted in 1334 volumes being removed from the end of each dataset. We then performed ISC analysis for each pair of participants both within the Valence groups (i.e., Positive Valence-Positive Valence, Negative Valence-Negative Valence) and between the Valence groups (i.e., Positive Valence-Negative

Valence). AFNI's *3dTcorrelate* was used to create these unique ISC pairings across the 18 participants, resulting in 153 unique pairwise combinations. Next, a single LME analysis was performed. The LME analysis modeled the data with the following outputs: average ISC in the positive valence film (Positive Valence-Positive Valence); average ISC in the negative valence film (Negative Valence-Negative Valence); and the contrast between the positive and negative valence films (Positive Valence-Positive Valence vs. Negative Valence-Negative Valence). This LME model was identical to that of Experiment 3, in which we are not interested in the between group comparison (i.e., Positive Valence-Negative Valence), and thus the corresponding weight of these groups and contrasts was set to 0. Thresholding and creation of anatomical figures was identical to that of Experiment 3.

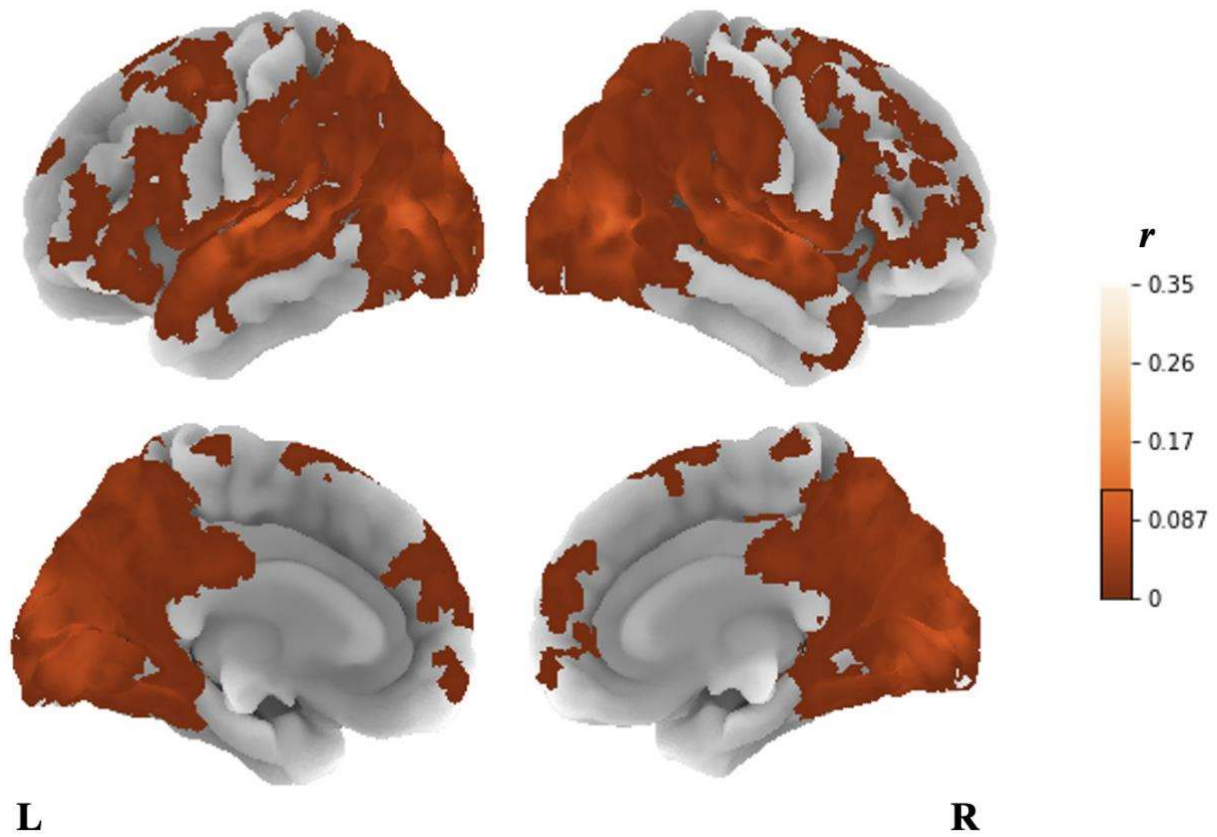
3.2.3 Results

High Positive Affect: Positive Valence-Positive Valence Group Average ISC

Results from the LME model for the Positive Valence-Positive Valence film group average ISC showed 19 significant clusters of neural synchrony (see Figure 3.2.1 and Table 3.2.1). These clusters showed extensive neural synchrony across audiovisual areas including the bilateral STG, PT, MTG, TPJ, LOC, FG, LG, cuneus, and occipital and temporal poles. Synchrony is also revealed in frontal and parietal regions, including the bilateral precuneus, IFG, medial PFC, SFG, SPL, SMG, FEF, frontal poles, and postcentral gyri.

Figure 3.2.1

Voxelwise ISCs showing areas of neural synchrony in High Positive Affect individuals in the positive valence film condition.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 3.2.1

High Positive Affect both films: Positive Valence-Positive Valence group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Planum Temporale	L	13139	0.151	-61.5	-13.5	7.5
Frontal Pole	R	96	0.0199	1.5	58.5	22.5
Supplementary Motor Cortex	L	84	0.0243	-1.5	1.5	67.5
Crus II	L	73	0.0305	-22.5	-82.5	-34.5
Frontal Pole	R	71	0.018	46.5	43.5	1.5
Frontal Pole	L	66	0.0175	-43.5	40.5	10.5
Temporal Pole	R	32	0.0232	49.5	13.5	-25.5
Frontal Pole	L	22	0.0145	-1.5	61.5	-10.5
Frontal Pole	R	21	0.0149	28.5	58.5	19.5
Precentral Gyrus	R	16	0.0135	40.5	-22.5	67.5
Middle Frontal Gyrus	L	14	0.0157	-28.5	28.5	49.5
Postcentral Gyrus	L	13	0.0126	-31.5	-25.5	67.5
Frontal Pole	L	13	0.0204	-34.5	37.5	-10.5
Middle Frontal Gyrus	R	12	0.0122	40.5	34.5	43.5
Precentral Gyrus	R	10	0.0137	1.5	-31.5	70.5
Frontal Pole	L	9	0.0164	-16.5	58.5	28.5
Frontal Pole	R	6	0.00966	31.5	55.5	-1.5
Precentral Gyrus	R	6	0.0118	43.5	-13.5	55.5
Temporal Pole	R	6	0.0194	49.5	25.5	-22.5

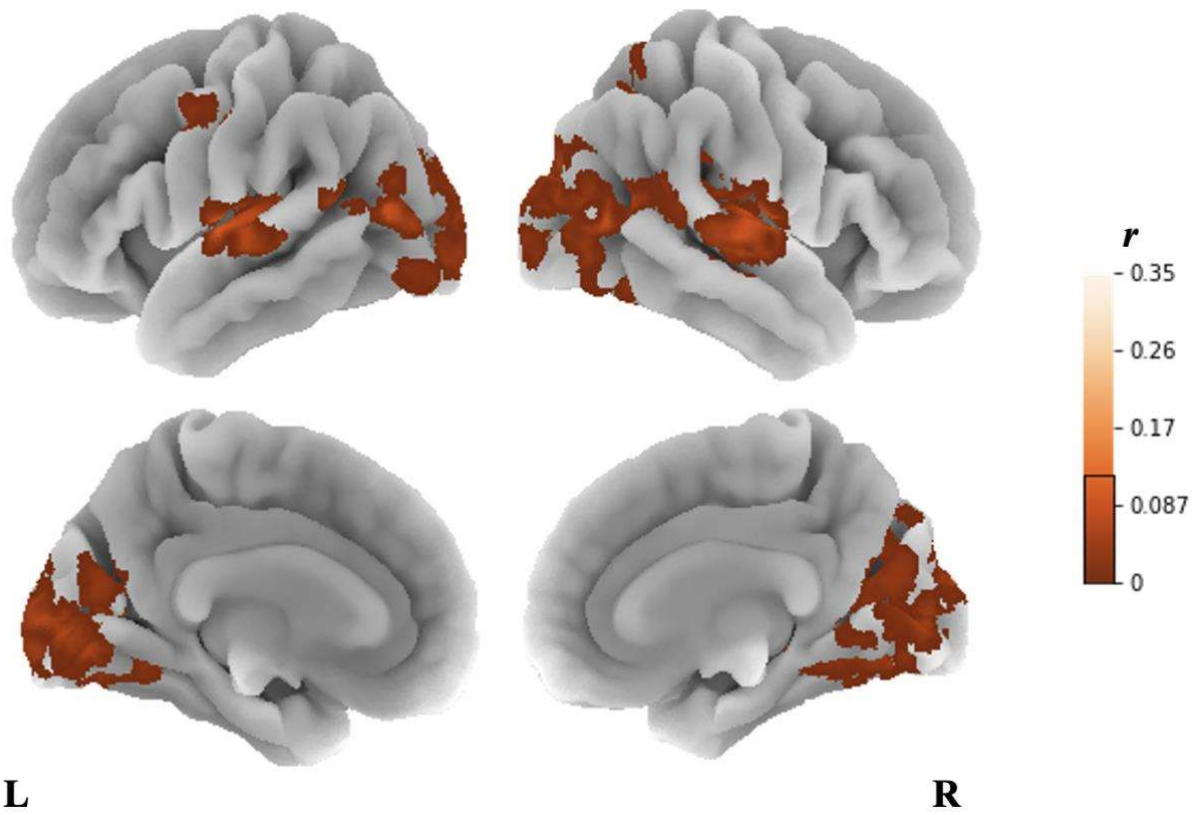
Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

High Positive Affect: Negative Valence-Negative Valence Group Average ISC

Results from the LME model for the Negative Valence-Negative Valence film group average ISC showed 16 significant clusters of neural synchrony (see Figure 3.2.2 and Table 3.2.2). These clusters revealed synchrony across auditory and visual cortices including the bilateral LOC, FG, LG, TPJ, PT and STG. In the frontal and parietal lobes, synchrony is evident in the bilateral opercular cortices, left precentral gyrus, and right SPL/IPS.

Figure 3.2.2

Voxelwise ISCs showing areas of neural synchrony in High Positive Affect individuals in the negative valence film condition.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.001$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views.

Table 3.2.2

High Positive Affect both films: Negative Valence-Negative Valence group average ISC cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Occipital Pole	L	477	0.0735	-7.5	-100	4.5
Lateral Occipital Cortex, inferior division	R	314	0.0887	49.5	-70.5	4.5
Planum Temporale	R	256	0.116	61.5	-7.5	4.5
Temporal Occipital Fusiform Cortex	R	187	0.0559	28.5	-55.5	-7.5
Planum Temporale	L	158	0.158	-64.5	-10.5	4.5
Occipital Fusiform Gyrus	L	102	0.0575	-25.5	-73.5	-7.5
Lateral Occipital Cortex, inferior division	L	33	0.108	-52.5	-70.5	10.5
Postcentral Gyrus	L	21	0.0333	-58.5	-10.5	46.5
Angular Gyrus	L	17	0.0565	-61.5	-49.5	13.5
Lateral Occipital Cortex, inferior division	L	15	0.0323	-40.5	-85.5	-13.5
Planum Temporale	R	13	0.0444	37.5	-28.5	16.5
Cuneal Cortex	R	11	0.0351	10.5	-82.5	43.5
Lateral Occipital Cortex, superior division	R	10	0.0288	31.5	-67.5	52.5
Temporal Occipital Fusiform Cortex	R	9	0.031	43.5	-58.5	-16.5
Lingual Gyrus	R	7	0.0227	10.5	-61.5	-4.5
Lateral Occipital Cortex, superior division	R	6	0.0237	28.5	-61.5	64.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

High Positive Affect: Positive Valence-Positive Valence > Negative Valence-Negative Valence

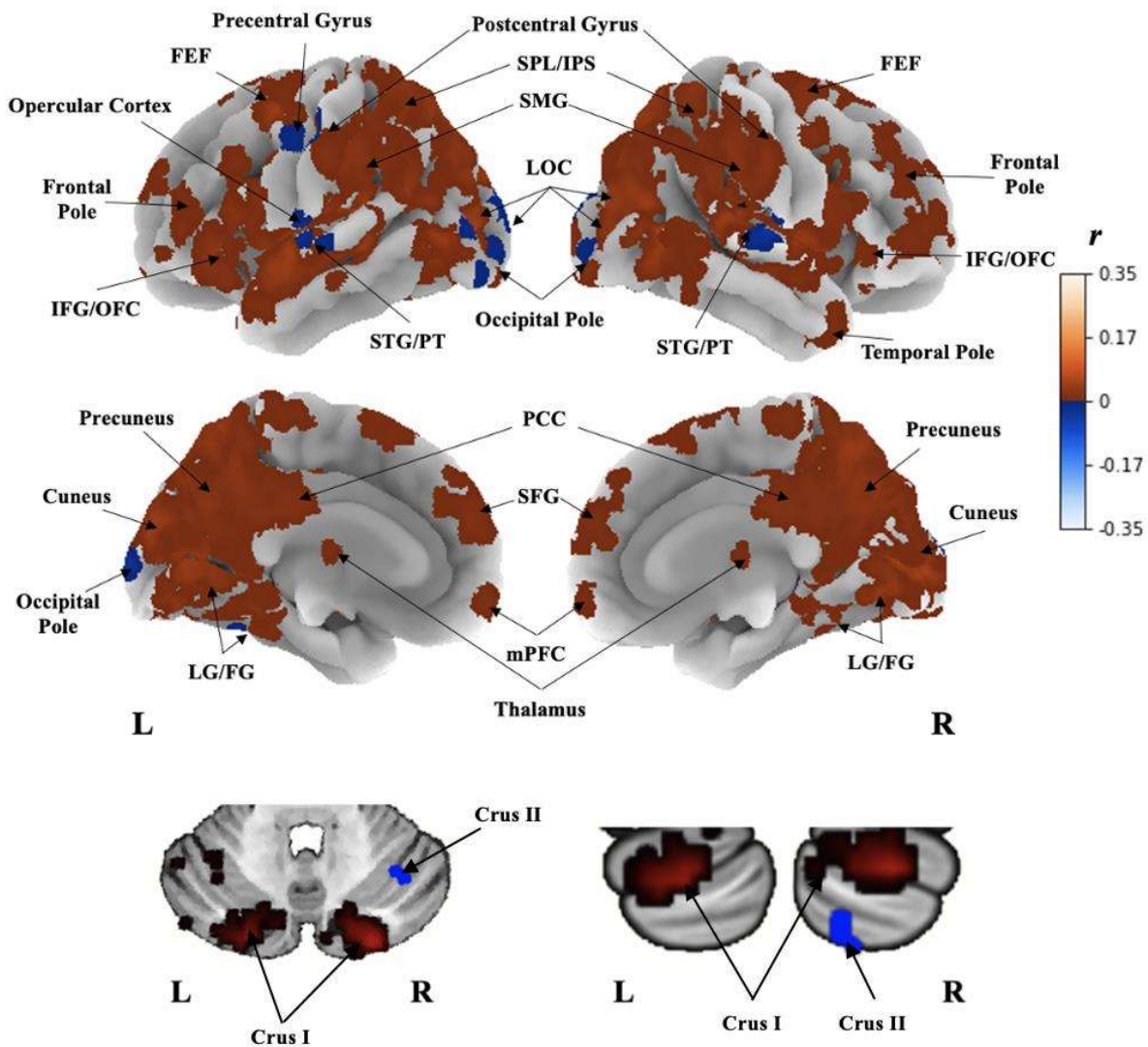
Results from the LME model for the Positive Valence-Positive Valence > Negative Valence-Negative Valence film contrast found 33 significant clusters of neural synchrony (see Figure 3.3.3 and Table 3.3.3). These clusters were extensive across all four lobes of the brain. Frontal regions included the bilateral FEF, frontal poles, IFG, OFC, SFG, and mPFC. Parietal regions included the bilateral postcentral gyri, SPL/IPS, SMG, and precuneus, and PCC. Synchrony was also evident across the auditory and visual areas of the temporal and occipital lobes, including the bilateral STG, PT, temporal poles, LOC, cunei, LG, and FG. In addition to cortical areas, synchrony was found in the bilateral crus I of the cerebellum.

High Positive Affect: Negative Valence-Negative Valence > Positive Valence-Positive Valence

Results from the LME model for the Negative Valence-Negative Valence > Positive Valence-Positive Valence film contrast found 13 significant clusters of neural synchrony (see Figure 3.3.3 and Table 3.3.4). Synchrony was identified in the bilateral occipital poles, LOC, STG, PT, and left FG of the occipital and temporal lobes. In the frontal lobe, synchrony was found in the left precentral gyrus. In addition to cortical areas, synchrony was also found in the right crus II of the cerebellum.

Figure 3.3.3

Voxelwise ISCs showing areas of neural synchrony in the High Positive Affect groups for the Positive Valence-Positive Valence > Negative Valence-Negative Valence (red) and Negative Valence-Negative Valence > Positive Valence-Positive Valence (blue) contrasts.



Note. Correlation value r is indicated by colour. Results are displayed at an FDR of $q < 0.05$.

Only clusters greater than or equal to 5 voxels are reported. Maps of synchrony are shown for the left (L) and right (R) hemispheres in lateral and medial views, and the left (L) and right (R) cerebellum in axial and posterior views.

Table 3.3.3

High Positive Affect both films: Positive Valence-Positive Valence > Negative Valence-Negative Valence cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max <i>x</i>	Max <i>y</i>	Max <i>z</i>
Lateral Occipital Cortex, inferior division	R	7694	0.149	52.5	-67.5	7.5
Frontal Pole	R	135	0.018	46.5	43.5	1.5
Superior Frontal Gyrus	R	129	0.0316	28.5	-7.5	58.5
Frontal Pole	R	120	0.0199	1.5	58.5	22.5
Frontal Pole	R	106	0.02	28.5	43.5	40.5
Precentral Gyrus	L	103	0.0236	-28.5	-10.5	61.5
Superior Frontal Gyrus	L	91	0.0162	-10.5	25.5	61.5
Precentral Gyrus	R	69	0.0137	1.5	-31.5	70.5
Crus I	L	68	0.0305	-22.5	-82.5	-34.5
Middle Frontal Gyrus	L	67	0.0557	-43.5	4.5	55.5
Temporal Occipital Fusiform Cortex	R	64	0.0801	28.5	-52.5	-7.5
Middle Frontal Gyrus	L	46	0.0332	-52.5	19.5	28.5
Postcentral Gyrus	L	43	0.0126	-31.5	-25.5	67.5
Frontal Pole	L	36	0.0175	-43.5	40.5	10.5
Frontal Pole	R	28	0.0164	-16.5	58.5	28.5
Temporal Pole	R	22	0.0232	49.5	13.5	-25.5
Frontal Pole	L	21	0.0145	-1.5	61.5	-10.5
Temporal Occipital Fusiform Cortex	R	16	0.0297	31.5	-46.5	-19.5
Precentral Gyrus	R	14	0.011	28.5	-25.5	73.5
Occipital Pole	L	11	0.041	-25.5	-94.5	-13.5
Inferior Temporal Gyrus, temporooccipital part	L	8	0.0365	-43.5	-49.5	-19.5
Frontal Pole	L	8	0.0126	-13.5	64.5	22.5
Frontal Pole	L	6	0.0139	-43.5	55.5	-4.5
Putamen	R	6	0.00764	19.5	10.5	-1.5
Frontal Orbital Cortex	R	6	0.0103	25.5	31.5	-13.5
Temporal Pole	R	6	0.0194	49.5	25.5	-22.5
Supplementary Motor Cortex	R	6	0.0202	1.5	4.5	67.5
Thalamus	R	6	0.00774	1.5	-7.5	10.5
VI	L	5	0.00574	-28.5	-40.5	-40.5
Crus I	L	5	0.00684	-49.5	-67.5	-37.5
Middle Temporal Gyrus, posterior division	L	5	0.00689	-70.5	-22.5	-16.5
Amygdala	R	5	0.0055	19.5	-7.5	-13.5
Amygdala	L	5	0.00621	-16.5	-10.5	-13.5

Note. Coordinates (x, y, z) of max correlations (r) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

Table 3.3.4

High Positive Affect both films: Negative Valence-Negative Valence > Positive Valence-Positive Valence cluster table.

Anatomical Location	Hemisphere	# of Voxels	Max <i>r</i>	Max x	Max y	Max z
Superior Temporal Gyrus, posterior division	R	34	0.113	67.5	-13.5	7.5
Planum Temporale	L	24	0.158	-64.5	-10.5	4.5
Postcentral Gyrus	L	24	0.0333	-58.5	-10.5	46.5
Occipital Pole	L	15	0.0735	-7.5	-100	4.5
Occipital Pole	L	10	0.0477	-22.5	-97.5	13.5
Temporal Occipital Fusiform Cortex	L	8	0.0238	-37.5	-52.5	-22.5
Occipital Pole	L	7	0.0633	-25.5	-97.5	-4.5
Occipital Pole	R	7	0.0513	16.5	-100	13.5
Occipital Pole	R	6	0.0596	22.5	-94.5	25.5
Crus II	R	5	0.0131	13.5	-82.5	-46.5
Occipital Pole	R	5	0.0503	25.5	-94.5	-4.5
Lateral Occipital Cortex, inferior division	L	5	0.0719	-49.5	-82.5	4.5
Lateral Occipital Cortex, inferior division	L	5	0.0297	-40.5	-88.5	-13.5

Note. Coordinates (x, y, z) of max correlations (*r*) are in MNI space. Only clusters greater than or equal to 5 voxels are reported. Locations are listed by left (L) or right (R) hemisphere.

3.2.4 Discussion

This experiment sought to examine ISCs during naturalistic film viewing for individuals with high positive affect during viewing of both a positive valence and negative valence film. To examine these differences, we separated participants into two groups: high positive affect individuals that viewed a positive valence audiovisual film, and high positive affect individuals viewed a negative valence audiovisual film. Next, we performed ISC and LME analyses to compare neural synchrony patterns between high positive affect groups for the differing film conditions. Results from this experiment revealed differences in neural synchrony within the high positive affect individuals associated either a positive or negative emotional valence film, suggesting that high positive affect differentially influences the neural processing of positive and negative experiences.

First, we compared ISCs between the high positive affect groups to examine where neural synchrony is greater during a positive valence film relative to a negative valence film. This contrast yielded significant clusters of neural synchrony across the brain, spanning cortical regions in all four lobes, as well as subcortical and cerebellar regions. These regions include the precuneus, SPL, IPS, FEF, TPJ, and audiovisual cortices, which are previously known for their role in narrative interpretation, engagement and arousal, engagement and suspense, and sensory processing, respectively (Jääskeläinen et al., 2020). Synchrony is also exhibited in the bilateral crus of the cerebellum, which is involved in mentalizing and analyzing the emotions of others (Van Overwalle et al., 2020). Synchrony in these areas suggests that high positive affect individuals are interpreting and analyzing the narrative of a positive valence film more similarly than a negative valence film. Greater neural synchrony was also revealed in regions previously related to positive emotional processing, including the precuneus, PCC, IFG, cerebellum, and STG (Gu et al., 2019; Habel et al., 2005; Machado & Cantilino, 2017; Saarimäki et al., 2016), suggesting that individuals with high positive affect process the emotional content of a positive valence film highly similarly to each other.

We then compared ISCs between the high positive affect groups to examine where neural synchrony was greater during a negative valence film relative to a positive valence film. This contrast yielded significant clusters of neural synchrony in the bilateral LOC, occipital poles, STG, PT, and left precentral gyrus. Synchrony is confined to these regions primarily involved in audiovisual processing (Binder et al., 1996; Gao et al., 2023; Jones & Callan, 2003), as well as the left precentral gyrus, which is involved in speech production and fine motor movement of the mouth (Graff-Radford et al., 2014; Itabashi et al., 2016). Synchrony in these areas suggests that a

negative valence stimulus synchronizes neural processing of basic, low-level audiovisual information in individuals with high positive affect levels.

In conclusion, this experiment reveals a greater and more extensive pattern of synchrony across the brain during the positive valence film. This suggests that positive valence synchronizes neural processing across individuals more impactfully than negative valence, despite individuals reporting similar, high trait levels of positive affect. These results suggest that a positive valence film greatly impacts the brain and synchronizes neural activity across individuals with high trait levels of positive affect in regions previously associated with narrative processing and positive affect (Jääskeläinen et al., 2020; Rohr et al., 2013), while a negative valence film has much less of a synchronizing effect and mainly impacts basic audiovisual processing areas. Taken together, these results show that high positive affect individuals are processing a positive valence stimulus much more similarly to each other than a negative valence stimulus. Overall, this experiment suggests that the valence of a stimulus can influence patterns of neural synchrony across individuals with high trait levels of positive affect.

CHAPTER 4: GENERAL DISCUSSION

This thesis sought to examine ISCs during naturalistic film viewing and how neural synchrony is modulated by differences in trait levels of positive affect. Specifically, we hypothesized that pairwise correlations will be higher among participants that are more similar in positive affect levels, with high positive affect individuals exhibiting greater synchrony in regions previously associated with positive emotional processing (i.e., the ventral PFC, dorsolateral PFC, PCC, precuneus, IFG, and cerebellum), and low positive affect individuals exhibiting synchrony in regions previously associated with negative emotional processing (i.e., the ventromedial PFC, amygdala, insula, ACC, and STG). To examine these differences, we first separated participants into two groups, a low positive affect group and a high positive affect group. We then compared ISC results across multiple positive affect and film conditions. The first experiment examined differences in neural synchrony, as modulated by positive affect trait levels, during viewing of a positive valence film, while the second experiment examined these differences during viewing of a negative valence film. The third experiment sought to examine neural synchrony between individuals with low positive affect levels across both positive and negative film conditions, while the fourth experiment examined neural synchrony between individuals with high positive affect levels across both positive and negative film conditions. Our main findings are summarized below.

4.1 Neural Correlates of Low Positive Affect during Viewing of a Positive Valence Film

Experiments 1 and 3 investigated the neural correlates of positive valence audiovisual film processing in individuals with low trait levels of positive affect. In both of these experiments, there were several neural areas that showed consistent synchrony: the bilateral LOC, LG, and FG, left SPL/IPS and medial postcentral gyrus, and right STG. The LOC, LG, and

FG are heavily involved in visual processing (Gao et al., 2023), specifically in the processing of faces and objects (Nagy et al., 2012; Nomi et al., 2008). The SPL/IPS are argued to be involved in the comprehension of, and engagement to, a narrative (Jääskeläinen et al., 2020). The STG is involved in primary and associative auditory processing (Reale et al., 2007). Synchrony in these areas suggests that individuals with low positive affect process audiovisual information in a positive valence film more similarly to each other, likely attending to more low-level details of the stimulus, such as character's faces and voices, objects, colour, and music. Expanding on these results, this finding suggests that individuals with low positive affect may process positive emotional experiences in the "real-world" similarly to each other in lower-level cognitive areas, but differ in higher-order cognitive areas.

4.2 Neural Correlates of Low Positive Affect during Viewing of a Negative Valence Film

Experiments 2 and 3 examined the neural correlates of negative valence audiovisual film processing in individuals with low trait levels of positive affect. Areas of the brain showing consistent synchrony across these two experiments include the bilateral PT/STG and occipital poles, and left cuneus and MTG. The STG and MTG are involved in auditory processing, as is the PT, with the left PT having a large role in speech comprehension (also known as Wernicke's area) (Gao et al., 2023; Reale et al., 2007; Shapleske et al., 1999). The occipital poles and cuneus are part of the visual processing cortex (Tyler et al., 2005). Synchrony across these regions suggests that individuals with low positive affect process basic visual and auditory information similarly during a negative valence film stimulus. Synchrony was hypothesized to be located in regions previously associated with negative emotional processing (i.e., the ventromedial PFC, amygdala, insula, ACC, and STG in the STG), though the STG was the only region showing consistent synchrony across Experiments 2 and 3 in support of this hypothesis. The other regions

included in the hypothesis (i.e., the ventromedial PFC, amygdala, insula, ACC) did not show consistent synchrony across Experiments 2 and 3.

4.3 Neural Correlates of High Positive Affect during Viewing of a Positive Valence Film

Experiments 1 and 4 explored the neural correlates of positive valence audiovisual film processing in individuals with high trait levels of positive affect. Consistencies in neural synchrony across both of these experiments were evident in the following regions bilaterally: IFG/OFC, SMG, STG, temporal poles, PCC, precuneus, LG, and FG. Consistencies in left-lateralized neural synchrony were found in the SPL/IPS and medial SFG, while consistencies in right-lateralized neural synchrony were found in the frontal pole, precentral gyrus, and postcentral gyrus. The precuneus is heavily involved in narrative interpretation (Jääskeläinen et al., 2020). This suggests that high positive affect individuals are analyzing and interpreting events of the narrative in highly similar ways, and also suggests that the precuneus may be especially selective to a narrative with positive valence. The LG is known to be involved in visual processing (Palejwala et al., 2021), suggesting that individuals are processing visual cues of a positive valence film highly similarly in this region. The PCC is argued to be involved in emotional processing, attention, and focusing thoughts (Buckner et al., 2008; Leech et al., 2011; Leech & Sharp, 2014). This suggests that during the positive valence film, high positive affect individuals may be feeling similar emotions and/or sympathizing similarly with characters in the narrative, focusing their attention to the narrative in similar ways, and focusing thoughts related to the narrative in similar ways. More generally, this result suggests that the PCC is consistently recruited across individuals with high positive affect in order to process a complex audiovisual film narrative with positive valence. As previously mentioned, the precuneus and TPJ (including the SMG) are heavily involved in narrative interpretation and engagement (Jääskeläinen et al.,

2020). Taken together, these regions are consistently recruited in high positive affect individuals during a positive valence film, suggesting that these individuals are interpreting a complex narrative in highly similar ways.

4.4 Neural Correlates of High Positive Affect during Viewing of a Negative Valence Film

Experiments 2 and 4 investigated the neural correlates of negative valence audiovisual film processing in individuals with high trait levels of positive affect. Across these two experiments, consistent neural synchrony was located in the left precentral gyrus and right PT/STG. These regions are involved in speech production/fine motor movement of the mouth (Graff-Radford et al., 2014; Itabashi et al., 2016) and auditory processing (Gao et al., 2023; Reale et al., 2007), respectively. These results suggest that high positive affect individuals process basic auditory speech similarly during a negative valence film. While the left precentral gyrus and right PT/STG exhibit synchrony, the absence of widespread synchrony in other regions indicates that high levels of positive affect may not greatly influence the emotional processing of negative valence stimuli. High positive affect therefore seems to have a less modulatory effect on emotional processing when the valence is negative, in contrast to the modulatory effect identified when the valence of the stimulus is positive.

4.5 Current Study Findings and Previous Positive Affect Research

Across all experiments, an overall pattern of more extensive neural synchrony was evident during the positive valence film. While this synchronization is most significant for high positive affect individuals, the pattern remains for low positive affect individuals and between low and high positive affect individuals as well. More specifically, the positive valence film is most influential on neural synchrony in individuals with high levels of trait positive affect, in which higher order cognitive areas are synchronized in addition to audiovisual processing areas.

This finding is evident in the results of Experiments 1 and 4. Contrastingly, there is less consistency in findings across low positive affect individuals and the negative valence film conditions, in which synchrony is generally more confined to audiovisual cortices.

This thesis contributes to tackling the ambiguity of previous research on positive affect by identifying regions associated with low and high levels of the trait during both positive valence and negative valence audiovisual film processing. Previous studies commonly relied on the viewing or inducing of positive emotions, rather than assessing trait levels directly, and use simplistic stimuli in their experimental paradigms (Gu et al., 2019; Habel et al., 2005; Saarimäki et al., 2016). To address this limitation, this thesis utilizes a more contemporary approach to neuroimaging work by using naturalistic stimuli in conjunction with a behavioural trait assessment. It also helps to understand the activity of regions found to be functionally connected in relation to positive affect trait levels by Rohr et al. (2013), including the precuneus, PCC, SPL, and PFC, as well as regions previously associated with emotional processing, including the ventral PFC, dorsolateral PFC, PCC, precuneus, IFG, and cerebellum. As positive affect has been previously associated with better quality of life and health outcomes, particularly healthy daily habits including higher amounts of exercise, balanced diets, and better sleep patterns (Cohen & Pressman, 2006), lower levels of stress (including lower levels of stress hormones such as cortisol; Cohen & Pressman, 2006) and lower mortality risk (Okely et al., 2017), this thesis contributes to the foundation of future research investigating the connection between positive affect and general health.

4.6 Future Directions and Limitations

There are several limitations within this study upon which future directions may be applied. As we employed the online NNdB, the data acquisition, materials, and stimuli used were

not able to be controlled. Although the two films used were chosen to elicit positive valence and negative valence processing in participants, there were no emotional ratings recorded from participants after viewing. A future direction will include a direct measure of participants' emotions during the films, to ensure and support the assumptions made about the valence levels and their subsequent effects on neural synchrony. Additionally, the sample size was not able to be controlled. Although the NNdB consisted of 86 participants, each participant only watched one film, and there was not an equal distribution of participants across each film. To attain the largest sample sizes possible, we used the two films with the largest number of participants (20 and 18 for the positive valence and negative valence film, respectively), and elected not to use data from the other films as they consisted of 6 or fewer participants. This also meant that the participants between our two film conditions differed.

To address these limitations, future work should aim to increase the sample size and ideally, all participants would watch all film conditions. While we were able to investigate the differences in neural synchrony between a positive valence and negative valence film, it would be beneficial to introduce a third film condition utilizing a neutral valence stimulus. This would allow for comparisons between positive and neutral valence, as well as negative and neutral valence. Further, multiple film stimuli for each valence condition (i.e., positive, negative, and neutral) could strengthen valence-specific results by removing film-specific synchrony. In terms of data acquisition, the NNdB utilized a 1.5T MRI scanner. To improve data quality in a future study, data acquisition should utilize a scanner with a magnetic field strength of 3T or stronger.

4.7 Conclusion

In conclusion, this thesis investigated the neural correlates of audiovisual film viewing as modulated by trait levels of positive affect. Over the course of four experiments, results from this

thesis uncovered different patterns of neural synchrony between low positive affect and high positive affect individuals across both positive and negative valence audiovisual film stimuli. During the positive valence film, key neural findings included synchrony in the bilateral LOC, LG, and FG, left SPL/IPS and medial postcentral gyrus, and right STG for the low positive affect individuals, and the bilateral IFG/OFC, SMG, STG, temporal poles, PCC, precuneus, LG, and FG, left SPL/IPS and medial SFG, and right frontal pole, precentral gyrus, and postcentral gyrus for the high positive affect individuals. During the negative valence film, key neural findings included synchrony in the bilateral PT/STG and occipital poles, and left cuneus and MTG for the low positive affect individuals, and the left precentral gyrus and right PT/STG for the high positive affect individuals. These results suggest that differing trait levels of positive affect manifest as differences in neural synchrony during naturalistic film viewing and influence the way in which individuals perceive the world around them. Specifically, individuals with higher levels of positive affect show different patterns of neural synchrony than those with low positive affect, generally recruiting more higher-order cognitive areas and positive emotional processing regions, especially during processing of stimuli with positive valence. In contrast, individuals with lower levels of positive affect show different patterns of neural synchrony than those with high positive affect, generally recruiting more lower-level audiovisual processing areas. Overall, this thesis provides valuable insight into neural synchrony associated with positive affect, the importance of naturalistic stimuli in neuroscience research, and the potential effects of personality traits on an individual's perception of the "real-world."

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