

Mental imagery of positive and neutral memories: A fMRI study comparing field perspective  
imagery to observer perspective imagery

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## Abstract

Imagery perspective can influence what information is recalled, processing style, and emotionality; however, the understanding of possible mechanisms mediating these observed differences is still limited. We aimed to examine differences between memory recall from a field perspective and observer perspective at the neurobiological level, in order to improve our understanding of what is underlying the observed differences at the behavioral level. We conducted a fMRI study in healthy individuals, comparing imagery perspectives during recall of neutral and positive autobiographical memories. Behavioral results revealed field perspective imagery of positive memories, as compared to observer perspective, to be associated with more positive feelings afterwards. At the neurobiological level, contrasting observer perspective to field perspective imagery was associated with greater activity, or less decrease relative to the control visual search task, in the right precuneus and in the right temporoparietal junction (TPJ). Greater activity in the right TPJ during an observer perspective as compared to field perspective could reflect performing a greater shift of perspective and mental state during observer perspective imagery than field perspective imagery. Differential activity in the precuneus may reflect that during observer perspective imagery individuals are more likely to engage in (self-) evaluative processing and visuospatial processing. Our findings contribute to a growing understanding of how imagery perspective can influence the type of information that is recalled and the intensity of the emotional response. Observer perspective imagery may not automatically reduce emotional intensity but this could depend on how the imagined situation is evaluated in relation to the self-concept.

*Keywords:* mental imagery; imagery perspective; autobiographical memory; fMRI; temporoparietal junction; precuneus;

## **Mental imagery of positive and neutral memories: A fMRI study comparing field perspective imagery to observer perspective imagery**

### **1. Introduction**

When people think back of past events and experiences, they often report to have mental images related to the event. Mental imagery of autobiographical memories can have powerful emotional effects (Holmes & Mathews, 2005; 2010) and influence thoughts and behavior like present situations. Due to the strong link with emotion, mental imagery is therefore also used in psychotherapy, for example, in the form of imagery rescripting (Holmes et al., 2007). Furthermore, it has been demonstrated that the recall of positive autobiographical memories plays a role in the self-generation of positive emotions when faced with a stressful situation (Phillippe et al., 2009). In healthy participants, positive memory recall has been shown to be a successful emotional regulation strategy to improve mood after a negative mood induction (Joormann & Siemer, 2004; Joormann et al., 2007). This suggests that promoting imagery of positive emotional memories, possibly strengthening the emotional effects, may be interesting for applications of positive memory recall in emotion regulation.

A distinction is made between imagery from a field perspective and imagery from an observer perspective, with individuals being able to experience more than one perspective when recalling events (Rice & Rubin, 2009). Field perspective is about imagining a situation such that “people re-experience the event through their own eyes, as if they were looking outward, perceiving the situation now much as they did before.” Observer perspective, on the other hand, is described as when people “take the perspective of an autonomous observer or spectator, so that they see themselves as actors in the remembered scene” (McIsaac & Eich, 2002, p. 146). Imagery perspective can influence the information that is recalled about events and the intensity of the emotional response. Previous research has indicated that individuals imagining memories from a field perspective gave more statements concerning affective

reactions, physical sensations, and psychological states, whereas memories imagined from an observer perspective included more information concerning how the person looked, physical actions, or spatial relations (McIsaac & Eich, 2002). It has also been proposed that thinking about past events in terms of the experiences evoked by features of the event is related to a field perspective, as compared to thinking about the event in terms of its broader context or meaning in an individuals' life which is related to an observer perspective (Libby & Eibach, 2011).

Imagery perspective is also believed to influence the emotional response. Field perspective imagery has been related to a greater emotional response than imagery from an observer perspective and/or verbal processing (Holmes et al., 2008; Holmes et al., 2009; Holmes et al., 2006) and individuals imagining memories from a field perspective perceive their memories as more emotional than individuals imagining memories from an observer perspective (McIsaac & Eich, 2002). Alternatively, it has been proposed that imagery perspective does not directly influence emotional impact, but that the differential effects of imagery perspective on emotional impact depend on whether considering the event in terms of its broader context or meaning in an individuals' life (during observer perspective) decreases or increases the emotional power (Libby & Eibach, 2011).

Research on mental imagery thus seems to indicate that imagery perspective can influence the type of information that is recalled and the intensity of the emotional response. Given that imagery of memories is often used in psychotherapy and has interesting possibilities for application in the self-generation of positive emotions and emotion regulation, it seems important to understand the underlying mechanisms of differences between imagery perspectives. However, our understanding of possible mechanisms mediating these observed differences between imagery perspectives is still limited. A possible explanation for the differences between imagery perspectives on emotional intensity has been

proposed based on studies comparing self-distancing to self-immersion when reflecting on emotional experiences. Self-immersion has been described as focusing on concrete features of the experience leading to a reliving of the experience, which could be compared to taking a field perspective. Self-distancing on the other hand, might reflect more abstract processing and has been described as working through experiences from an ego-decentered perspective which is more in line with adopting an observer perspective (Kross et al., 2005). It has been argued that self-distancing can facilitate more adaptive forms of self-reflection (Kross & Ayduk, 2011). Taking a self-distanced perspective on negative or stressful events has shown to decrease emotional intensity (Kross et al., 2005; Kross et al., 2014), and shortens emotion duration for negative but also for positive emotional experiences (Verduyn et al., 2012). A different explanation has been suggested in studies on the role of imagery perspective in depression, proposing that adopting an observer perspective could promote evaluative thinking about the self, which could result in unfavorable self-comparisons (with an ideal self) reducing the positive affective response (Kuyken & Howell, 2006; Kuyken & Moulds, 2009). This seems also in line with the idea that an observer perspective is related to thinking about the recalled event in terms of its broader context or meaning in an individuals' life, with the meaning of such events in relation to the self-concept becoming more salient, which as a result can either decrease or increase the emotional power (Libby & Eibach, 2011).

Although behavioral research provides some suggestions on what might be underlying the observed differences depending on imagery perspectives, little is known about neurobiological differences between imagery perspectives in memory recall while this could complement knowledge from behavioral research. There are some functional Magnetic Resonance Imaging (fMRI) studies comparing visual perspectives, investigating whether a first-person perspective (i.e. field perspective) is related to a greater sense of 'reliving' a situation than a third-person perspective (i.e. observer perspective), but these studies mostly

used externally generated images (e.g. Jackson et al., 2006). When participants were shown video clips of hand and foot actions, either from a first-person- or a third-person perspective, more activity was shown in the left sensory-motor cortex when viewing the video clips from a first-person perspective compared to a third-person perspective, which is in line with the idea of a greater sense of ‘reliving’ in field perspective imagery (Jackson et al., 2006). However, such studies investigating the difference between visual perspectives (Jackson et al., 2006; Ruby & Decety, 2001) often use externally generated pictures or video fragments of physical actions and tend to confound imagery perspective with the identity of the actor of the physical action (i.e. imagining the self versus another person doing an action). During a study in which participants mentally imagined doing actions with objects, greater activity was observed in the posterior cingulate cortex, right precuneus, inferior parietal lobule, and frontopolar gyrus during a third-person perspective when contrasted to a first-person perspective (Ruby & Decety, 2001). Although this study differs from our design on some important aspects (e.g. confounding third person perspective with the identity of the actor), it can still be indicative of brain areas involved when one is taking a more distanced perspective (third person) as compared to imagining being more actively engaged in a situation (first person), which is an important difference between the visual perspectives.

To our knowledge there is only one study so far that directly investigated the neural systems mediating field and observer perspective when imagining memories (Eich et al., 2009). In this study participants performed four tasks, which during a second-session a week later were to be recalled in the scanner (Eich et al., 2009). Three regions were found to show greater activity during field perspective imagery when directly compared to observer perspective imagery. During field memories increased activity was observed in the right posterior amygdala, bilateral insula, and in left motor and somatosensory areas (Eich et al., 2009). These results, combined with behavioral results of this study showing that field

memories were related to greater subjective emotionality, are consistent with studies associating subjective emotionality of autobiographical memories to the amygdala (Cabeza & St. Jacques, 2007). Furthermore, both the insula and somatosensory areas have been previously linked to interoceptive awareness of one's feelings (e.g. Critchley et al., 2004; Pollatos et al., 2006) corresponding to the idea that adopting a field perspective as compared to an observer perspective is related to increased affective monitoring (Eich et al. 2009).

In the current study we aimed to extend our knowledge on differences in neural areas mediating field and observer memories, using fMRI, in order to improve our understanding of what might explain the observed differences between imagery perspectives on subjective emotionality. Eich et al. (2009) used memory recall of tasks that were performed as part of the experiment and aimed to represent everyday life situations. However, our goal was to compare a field and observer perspective when imagining self-generated memories for both neutral and positive emotional events, reflecting better how mental imagery could be applied to memory recall in the context of self-generation of positive emotions and emotion regulation.

We first aimed to identify the brain areas showing increases in the blood-oxygenation level dependent (BOLD) signal during recall of both positive and neutral memories from a field and observer perspective relative to the same control task, a visual search task, as Eich et al. (2009). We hypothesized that for both perspectives in neutral and positive memories, we would observe activity in prefrontal and medial temporal cortices, temporal-parietal areas, and the precuneus, in line with Eich et al. (2009) and previous research on autobiographical memory recall (for reviews, see Cabeza & St. Jacques, 2007; Svoboda et al., 2006). Secondly, we directly contrasted field perspective imagery to observer perspective imagery regardless of type of memory (i.e. neutral and positive collapsed). We expected greater activity in the amygdala, insula, and motor and somatosensory areas during field perspective imagery when

directly contrasted to observer perspective imagery, which would fit the idea that field perspective imagery is related to a greater sense of ‘reliving’ and subjective emotionality (see also Eich et al., 2009). Additionally we hypothesized that the posterior cingulate cortex/precuneus would show greater activity during observer perspective imagery as compared to field perspective imagery. Previous studies have shown activity in these areas when taking a third-person perspective, as compared to a first-person perspective, during imagery of actions with objects (Ruby & Decety, 2001) and when describing reactions to both neutral and social emotional situations (Ruby & Decety, 2004). The precuneus has also shown to be active when comparing being an observer of social interaction as contrasted to being personally involved in the social interaction (Schilbach et al., 2006). Interestingly, activity in the posterior cingulate cortex and precuneus has been implicated in the self-distancing from neutral and negative pictures of social situations (i.e. as they were viewing the scene objectively) to down-regulate emotions (Koenigsberg et al., 2010). This was explained by the posterior cingulate cortex and precuneus being implicated in processes important for assuming a distanced perspective, such as being unengaged in witnessed social interactions and assessing the self-relevance of stimuli (Koenigsberg et al., 2010). Indeed, studies have associated the posterior cingulate cortex and precuneus with self-referential/-evaluative processing (for review, see Northoff et al., 2006). However, a recent review proposes the posterior cingulate cortex and precuneus to be part of a network involved in evaluative processes enabling identification, attribution, and reflection upon a subject, but not specifically for self or others (Legrand & Ruby, 2009). It is proposed that the posterior cingulate cortex and precuneus are crucial areas in this evaluation network in providing information from memory for evaluative processes (Legrand & Ruby, 2009). These findings fit the idea that observer perspective imagery is related to thinking about the recalled event in terms of its broader meaning in an individuals’ life, with the meaning of such events in relation to the self-concept becoming



more salient (Libby & Eibach, 2011), or evaluative thinking about the self (Kuyken & Howell, 2006; Kuyken & Moulds, 2009).

Finally, as behavioral research relates field perspective imagery to a greater emotional response than observer perspective imagery (e.g. Holmes et al., 2008; McIsaac & Eich, 2002), differences between imagery perspectives could be larger for emotional memories because more variance in the emotional response is possible. As neutral memories are expected to evoke no, or just a small emotional response, differences between imagery perspectives with regard to the emotional response might be smaller, also at the neurobiological level. Therefore, we examined whether differences in neural activity between imagery perspectives was different for neutral and positive emotional memories, by investigating the interaction with adopted imagery perspective and memory valence. We hypothesized that differential activity between field- versus observer perspective imagery in areas related to subjective emotionality and interoceptive awareness of one's feelings (i.e. amygdala, insula, and somatosensory areas) would be larger for emotional, positive memories than for neutral memories.

## **2. Method**

### **2.1 Participants**

Thirty-four healthy, right-handed females, aged between 18 and 31 ( $M = 22.71$ ,  $SD = 2.71$ ), participated in this study and received €40 for their participation. A 'uniform' group of right-handed female subjects was selected because of sex-related influences on neural mechanisms underlying emotion processing (e.g. Cahill, 2003; Van Strien & Van Beek, 2000). This study was approved by the medical ethical committee of the University Hospital at Ghent University.

### **2.2 Material**

**2.2.1 Screening.** Current and lifetime history of psychiatric disorders based on DSM-IV and ICD-10 criteria was assessed using the Dutch version of the structured Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998).

Safety criteria for participation in an experiment using an MR-scanner were checked through a pre-scanning safety checklist developed by the Ghent Institute for Functional and Metabolic Imaging. This checklist is based on guidelines from the Institute for Magnetic Resonance Safety, Education and Research and the International Commission on Non-Ionizing Radiation Protection.

**2.2.2 Questionnaires.** Throughout the fMRI paradigm in the scanner we measured mood state and adopted imagery perspective using 9-point Likert scales. We measured how happy and sad participants were feeling “*at the moment*” on a 9-point scale from 1 “neutral” to 5 “moderate” to “as happy/sad as I can imagine.” Furthermore, participants were asked to rate to what extent they “...saw the event through your own eyes, like you were actively involved?” (i.e. field perspective) and “to what extent did you experience the event looking at yourself from outside, as if you see yourself taking part in the situation?” (i.e. observer perspective) on a 9-point scale ranging from 1 “not at all” to 5 “somewhat” to 9 “very much.”

A post-scanning checklist was administered at the end of the scanning session assessing whether the participant had experienced any symptoms as a result of time-varying magnetic fields. This checklist is based on guidelines from the Institute for Magnetic Resonance Safety, Education and Research and the International Commission on Non-Ionizing Radiation Protection.

**2.2.3 fMRI paradigm.** For the task in the scanner, participants were asked to provide four memories of specific events that happened more than one week ago. Participants were asked to recall two situations that did not elicit strong negative or positive emotions at that time (i.e. two neutral memories) and two situations which made them feel very happy at that

time (i.e. two positive memories). Cue words were connected to each of the four situations, so that these could be used for instructions during the task in the scanner to indicate which of the situations had to be recalled and imagined. Participants then received an explanation of the differences between field perspective imagery (“as if you are there, seeing the situation through your own eyes”) and observer perspective imagery (“as if you are there, seeing what is happening looking at yourself from the outside, watching yourself taking part in the situation”). Furthermore, participants completed two similar imagery practice tasks of cutting a lemon, once receiving instructions on adopting a field perspective and once receiving instructions on adopting an observer perspective (based on Holmes, Coughtrey, & Connor, 2008).

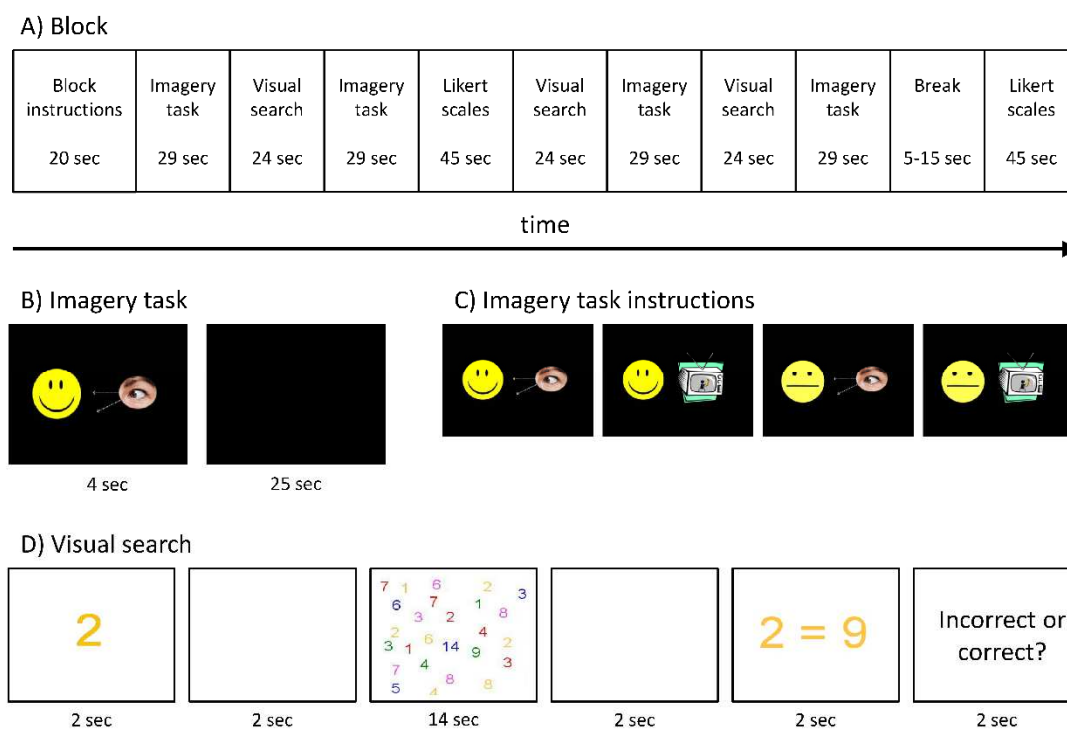


Figure 1. Each block (A) consisted of an alternation of the mental imagery task (B) and visual search task (D). The imagery task started with instructions on memory type and imagery perspective, depicted by icons (C). All participants were familiarized with these icons and

*how they related to the different conditions prior to entering the scanner. The memory being recalled and the imagery perspective remained constant during the entire block.*

The actual fMRI paradigm consisted of eight blocks (see Figure 1A) and was designed in such a way that hemodynamic activity during imagery of autobiographical memories was contrasted to hemodynamic activity during a control task, that is, a visual search task (based on the design of Eich et al., 2009). Different experimental conditions in the paradigm were based on valence of memory (positive vs. neutral memory) and imagery perspective (field vs. observer perspective), resulting in four experimental conditions: positive-field, neutral-field, positive-observer, and neutral-observer. The memory being recalled and the imagery perspective remained constant during an entire block. Participants were asked to recall two different positive and neutral situations, which were each recalled from both a field- and observer perspective. Thus, each experimental condition/block occurred twice, resulting in eight blocks divided over two functional runs consisting of four blocks each. There were two versions of the fMRI paradigm, counterbalancing the starting imagery perspective across participants, while each participant started with imagery of a positive memory which was then followed by a block imagining a neutral memory. That is, the order of blocks (i.e. experimental conditions) in one functional run was either: positive-field, neutral-field, positive-observer, and neutral-observer, or positive-observer, neutral-observer, positive-field, and neutral-field. Block order in the two functional runs was identical within one participant, but a different positive and neutral situation was recalled across the two functional runs.

Each block (see Figure 1A) consisted of an alternation of the mental imagery task and a visual search task. The visual search task was used as an active control task in order to avoid that increases in BOLD-signal during the mental imagery task could be attributed to a general increase in cognitive activity rather than memory retrieval itself (Eich et al., 2009). The block

began with auditory instructions given by the experimenter on which specific memory was to be imagined and from which imagery perspective. Halfway and at the end of each block participants were asked to rate verbally, using the four Likert scales, how happy and sad they were feeling at the time and to what extent they had imagined the memory from a field perspective and observer perspective. Before the second administration of the Likert scales at the end of the block, there was a short break with a duration randomized between 5000 and 15000msec in steps of 500msec.

**2.2.3.1 Imagery task.** The imagery task (see Figure 1B) started with a screen presented for 4sec repeating the block instructions depicted by icons (see Figure 1C). These icons indicated whether a positive or neutral memory was to be recalled (the specific situation had been described in the auditory instructions at the beginning of the block) and from which imagery perspective. This screen was followed by a black screen presented for 25sec during which participants closed their eyes and silently imagined the recalled situation. At the end of the 25sec a beep sound was played to indicate the end of the imagery task and participants had to open their eyes.

**2.2.3.2 Visual search task.** The visual search task (see Figure 1D) was identical to that used by Eich and colleagues (2009). The task started with the 2-sec presentation of a single letter or number of a particular color, which was the target for the visual search (both letter and color need to match). This was followed by a 2-sec blank screen after which the search display was presented for 14sec. After the search display again a 2-sec blank screen was presented followed by a suggestion of the number of displayed targets for 2sec. Participants then indicated whether this was the number of targets they had found in the search display by saying “correct” or “incorrect” for which they had 2sec. Across all visual search displays in the paradigm, the actual number of targets matched the suggested number of targets in only 50% of the time.

### 2.3 Procedure

Participants were recruited through an experiment website where people can voluntarily sign up for participation in psychology experiments. The first inclusion criteria such as gender and right-handedness were checked through questions on the website before people could actually register for the experiment. Information about the study on the website informed participants that only after additional screening, registration could be confirmed. After registration, participants were contacted by email and invited for a screening appointment. During this first screening appointment, inclusion criteria (no history of psychiatric disorders and meeting the safety criteria for participating in an MRI experiment) were further checked with the Dutch version of the MINI to explore a history of axis-I disorders and a pre-scanning safety checklist to make sure participants met the safety criteria for using the MRI system. When the inclusion criteria were met, participation in the fMRI experiment was confirmed. Further detailed information on the study was provided on paper. Participants were asked to read the information and were given the opportunity to ask further questions to the experimenter before signing the informed consent form.

During the actual testing appointment participants were first asked to provide two neutral and two positive memories of specific events that happened more than one week ago. After completing two practice tasks, one to practice field perspective imagery and one to practice observer perspective imagery, participants were explained how the fMRI paradigm would look like in the scanner. They received instructions on how to rate the Likert scales and were explained the procedure of the mental imagery task and visual search task. Participants were then prepared to enter the MRI scanner. Each scanning session started with an anatomical scan which lasted about 5 minutes, followed by the fMRI paradigm divided in two functional runs with a short break in between. After finishing the task in the scanner, the

participant was asked to fill out the post-scan checklist. Finally, participants were fully debriefed about the experiment.

## **2.4 fMRI Data Acquisition**

Scanning was performed with a Siemens Trio Tim 3T MRI scanner (Siemens Medical Systems, Erlangen, Germany), using a 32-channel head coil. After automatic shimming of the magnetic field on each participant, T1-weighted 3D high resolution MPRAGE images were acquired of the whole brain in the sagittal plane (176 slices, TR = 2550 ms, TE = 4.18 msec, TI = 900 msec, acquisition matrix =  $256 \times 256$ , FoV = 256 mm, flip angle =  $9^\circ$ , voxel size =  $1 \times 1 \times 1$  mm). These anatomical images were used for coregistration with the functional images and normalization. During the fMRI paradigm, functional echo-planar images (EPIs) in the axial plane were acquired (34 interleaved slices, TR = 2000msec, TE = 28msec, acquisition matrix =  $64 \times 64$ , FoV = 224 mm, flip angle =  $80^\circ$ , voxel size =  $3.5 \times 3.5 \times 3$  mm, slice thickness = 3mm, inter-slice gap = 0.5mm).

## **2.5 Image Analysis**

Data analysis was performed using BrainVoyager QX (Goebel et al., 2006). Each participants' 3D anatomical data was normalized into Talairach standard space in two steps. The first step consisted of translating and rotating the cerebrum into the AC-PC plane (AC = anterior commissure, PC = posterior commissure). In the second step, the borders of the cerebrum were identified and in addition with the AC and PC point, the size of the brain was fitted into Talairach standard space using sinc interpolation. For the functional data of each participant, a standard sequence of preprocessing steps was performed. Slice scan time correction was performed by means of sinc interpolation, 3D motion correction by spatial alignment to the first volume was performed by means of sinc interpolation, and temporal filtering was performed using linear trend removal and high pass filtering for low-frequency drifts of two or fewer cycles. Spatial smoothing using a Gaussian filter (FWHM = 6mm) was

applied for the volume-based analysis. The functional data for each participant was then coregistered with the participants' 3D anatomical data and transformed into Talairach standard space.

For each subject, a protocol file was created representing the onset and duration of each 25sec imagery period of the mental imagery task for the four different experimental conditions and the onset and duration of each 14sec search display of the visual search task for the control condition. Factorial designs were automatically defined from the created stimulus protocols. Additionally, 6 motion predictors (3 translation, 3 rotation parameters) were added as confounds to the single-subject General Linear Model. The blood-oxygen-level dependent (BOLD) response in each condition was then modeled by convolving the neural functions with a canonical hemodynamic response function (two gamma HRF) to form covariates in a General Linear Model.

After the General Linear Models (GLM) had been fitted, group (random effects procedure) *t*-maps were generated to evaluate the effects of imagining memories from different perspectives, for which a brain tissue mask was applied. First, we determined voxel clusters showing significant increases in the BOLD response for each of the four experimental conditions separately, contrasting the effects of imagery of autobiographical memories from a certain perspective to the control condition (visual search): positive-field>visual search, neutral-field>visual search, positive-observer>visual search, and neutral-observer>visual search. In a second step, we directly contrasted adopting a field perspective versus an observer perspective collapsed over positive and neutral autobiographical memories: positive-field + neutral-field>positive-observer + neutral-observer and positive-observer + neutral-observer>positive-field + neutral-field. Finally we tested the interaction between Perspective (field vs. observer) and memory Valence (neutral vs. positive) with a factorial ANOVA, to investigate whether differential activity between imagery perspectives was different



depending on the valence of the memory. The basic contrasts comparing experimental conditions to the control task were adequately described with a threshold of  $p < .05$  corrected for multiple comparisons using False Discovery Rate (FDR) correction (Genovese et al., 2002). However, for the contrasts directly comparing field perspective to observer perspective this threshold required adjustment to describe subtle differences, but this is explicitly mentioned in the text and figure. Areas that showed significant activation were identified using the brain atlases of Mai, Paxinos, and Voss (2008), and Talairach and Tournoux (1988). Areas in the cerebellum that showed significant activation were identified using the Talairach daemon (Lancaster, et al., 1997; Lancaster et al., 2000).

For our main research question of interest (i.e. directly contrasting the visual perspectives) we calculated time courses for the clusters that survived threshold, by means of event-related averaging. The mean time course for conditions was obtained by averaging all peri-stimulus time course segments belonging to the same condition (i.e. the 25 sec. imagery block, separately per condition). The baseline to calculate the percent signal change was set to 24 seconds before the 25 sec. imagery block, thus including the visual search control task, and was computed in a file-based manner. That is, the baseline values of each epoch were first averaged and then used to calculate the percent signal change.

### **3. Results**

#### **3.1 Preliminary analyses**

Seven participants were excluded from further analyses, based on results from 3D motion correction during preprocessing ( $n = 6$ ), and due to technical issues during data acquisition ( $n = 1$ ). The remaining sample consisted of 27 right-handed women, aged between 18 and 31 years ( $M = 22.41$ ,  $SD = 2.81$ ).

#### **3.2 Behavioral data**

**3.2.1 Imagery perspective manipulation check.** To investigate differences between the four experimental conditions in the extent to which participants adopted a field and observer perspective, a repeated measures ANOVA with within-subject factors Valence (positive memory, neutral memory) and Perspective (field, observer) was performed on the data from the Likert scales.

The repeated measures ANOVA on ratings of adopting a field perspective yielded a significant main effect of Valence,  $F(1,26) = 7.43, p = .011, \eta_p^2 = .22$ , and a main effect of Perspective,  $F(1,26) = 331.93, p < .001, \eta_p^2 = .93$ . These results indicated that participants generally reported to adopt a field perspective more when imagining positive memories ( $M = 5.19, SD = 0.53$ ) than when imagining neutral memories ( $M = 4.93, SD = 0.68$ ), regardless of instructions on imagery perspective. Furthermore, across both positive and neutral memories participants reported to adopt a field perspective more when instructions were to imagine the situation from a field perspective ( $M = 7.43, SD = 0.74$ ) as compared to an observer perspective ( $M = 2.69, SD = 1.00$ ).

The repeated measures ANOVA on ratings of adopting an observer perspective yielded a significant main effect of Perspective,  $F(1,26) = 427.95, p < .001, \eta_p^2 = .94$ . This indicated that as expected, across both positive and neutral memories participants reported to adopt an observer perspective more when instructions were to imagine the situation from an observer perspective ( $M = 7.20, SD = 0.90$ ) as compared to a field perspective ( $M = 2.10, SD = 0.67$ )<sup>1</sup>.

**3.2.2 Memory remoteness and imagery perspective.** Previous research has shown that memory remoteness can influence imagery perspective (Rice & Rubin, 2009). Recent memories are more likely viewed from a field perspective while more remote memories are more likely viewed from an observer perspective. Although we manipulated imagery

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<sup>1</sup> Adding block order (i.e. starting with field perspective imagery or observer perspective imagery) as a between-subjects factor did not change the results of the manipulation check on imagery perspective.

perspective in the current experiment, we tested whether memory remoteness influenced the extent to which participants adopted a field and observer perspective when imagining each specific memory. We analyzed the effect of memory remoteness with non-parametric Kruskal-Wallis tests (due to non-normality of the data). Memory remoteness was entered as independent variable (coded as 1 = 1-2 weeks; 2 = 2 weeks - 6 months; 3 = > 6 months) and data from the Likert scales as dependent variable (4 separate tests: Likert field when block instructions are field; Likert observer when block instructions are field; Likert field when block instructions are observer; Likert observer when block instructions are observer) for each memory (4 separate tests per Likert scale (positive memory 1; positive memory 2; neutral memory 1; neutral memory 2)). This results in sixteen separate tests. These analyses showed that Memory remoteness had a significant effect on ratings of field perspective during blocks in which the instructions were to adopt a field perspective for positive memory 1,  $H(2) = 6.10, p = .047$ . Additionally, for positive memory 2, remoteness had a significant effect on ratings of observer perspective imagery during blocks in which the instructions were to adopt a field perspective,  $H(2) = 4.70, p = .027$ , and ratings of field perspective imagery during blocks in which the instructions were to adopt an observer perspective,  $H(2) = 4.16, p = .041$ . However, when correcting for multiple testing to avoid type-I error inflation (i.e.  $\alpha / 16 = 0.0031$ ), no significant effects were observed of memory remoteness on the extent to which participants adopted a field and observer perspective during imagery.

**3.2.3 Effects of perspective manipulation on mood.** Throughout the task in the scanner, participants were also asked to rate how happy and sad they were feeling at that moment. Due to non-normality of the data, we performed non-parametric Wilcoxon Signed Rank tests. We tested our main predictions on the differences in happy and sad mood between the field perspective condition and observer perspective condition when participants imagined either positive or neutral memories. There were no significant differences in ratings of

sadness between field perspective imagery and observer perspective imagery when imagining positive,  $T = 23.00$ ,  $p = .730$ ,  $r = -.06$ , or neutral memories,  $T = 13.00$ ,  $p = .079$ ,  $r = -.25$ .

Neither was there a difference in ratings of happiness between field perspective imagery and observer perspective imagery when imagining neutral memories,  $T = 129.00$ ,  $p = .565$ ,  $r = -.08$ . However, there was a significant difference in ratings of happiness between field perspective imagery and observer perspective imagery when imagining positive memories,  $T = 70.00$ ,  $p = .020$ ,  $r = -.31$ , indicating that feelings of happiness were higher when imagining positive memories from a field perspective ( $M = 6.70$ ,  $SD = 0.92$ ), than from an observer perspective ( $M = 6.40$ ,  $SD = 1.05$ ).

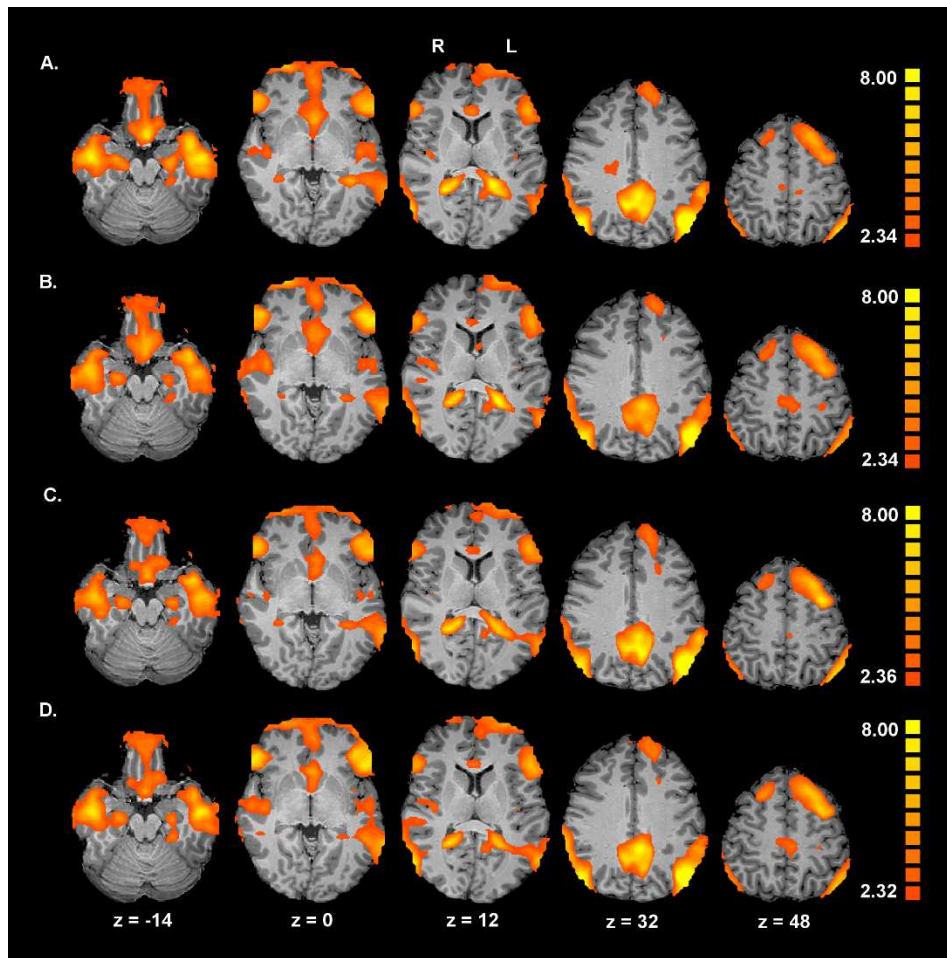


Figure 2. A. Contrast for positive memories imagined from a field perspective versus the control visual search task. B. Contrast for neutral memories imagined from a field

*perspective versus the control visual search task. C. Contrast for positive memories imagined from an observer perspective versus the control visual search task. D. Contrast for neutral memories imagined from an observer perspective versus the control visual search task.*

*Activation maps are at (FDR)  $p < .05$ . L = left hemisphere, R = right hemisphere.*

### 3.3 Imaging data

**3.3.1 Experimental conditions versus control task.** In a first step we identified the regions that showed significant increases in BOLD-signal during recall of positive and neutral memories from a field and observer perspective (see Figure 2A-D). Across the four experimental conditions compared to the control task we observed significant activity in mostly similar areas. Across experimental conditions, when contrasted to the control task, areas of increased BOLD activity included dorsolateral, dorsomedial, ventrolateral, ventromedial and orbital parts of the prefrontal cortex (PFC) bilaterally although more extensive in the left hemisphere, middle/superior temporal gyrus extending to the angular gyrus bilaterally, hippocampus bilaterally, and precuneus (extending to cingulate cortex). A full overview of the clusters that showed significant activity can be found in Supplemental Material (Supplemental table 1-4 in S1) available online.

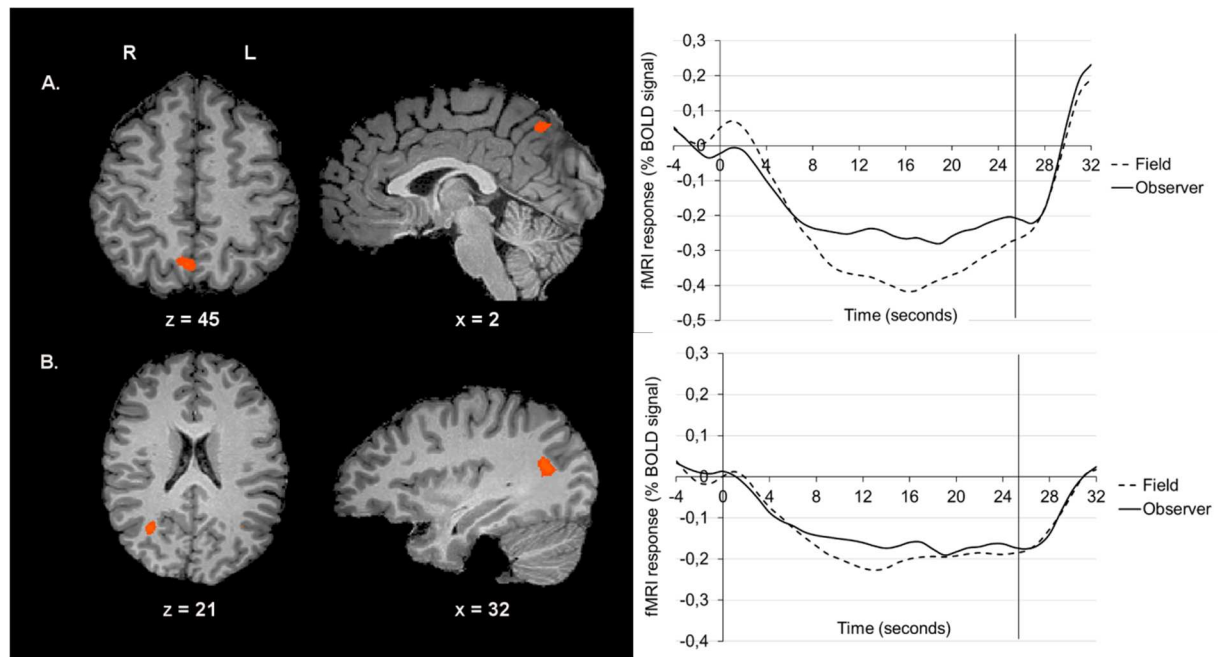


Figure 3. *Observer perspective, when contrasted to field perspective, was associated with greater activation in A. the right precuneus (peak activation at  $x = 5$ ,  $y = -62$ ,  $z = 45$ ) and in B. an area at the junction of the right angular gyrus and superior/middle temporal gyrus (peak activation at  $x = 32$ ,  $y = -62$ ,  $z = 21$ ). Statistics were based on a threshold of  $p < .001$  uncorrected with a minimum cluster size of  $k \geq 300$  contiguous voxels (voxel size  $1 \times 1 \times 1 \text{ mm}$ ). Time courses for these clusters are depicted.*

**3.3.2 Field versus observer perspective.** In a next step we directly compared adopting a field perspective versus an observer perspective collapsed over positive and neutral autobiographical memories. As we anticipated this to reflect subtle differences we adjusted the threshold to  $t > 3.771$ ,  $p < .001$  (uncorrected), and used a minimum cluster size of ( $k \geq 300$  contiguous voxels with voxel size  $1 \times 1 \times 1 \text{ mm}$ ).

No regions showed a significant greater BOLD-response during a field perspective as contrasted to adopting an observer perspective ((positive-field + neutral-field) > (positive-observer + neutral-observer)). For explorative purposes we calculated the time courses for the four imagery conditions for the amygdala, insula, precentral gyrus (motor cortex), and

postcentral gyrus (sensory cortex), using anatomical ROIs (masks) based on the Talairach coordinates (Talairach & Tournoux, 1988). These can be found in Supplemental Material (Supplemental figures 1-4 in S1) available online. On the other hand, during an observer perspective, when directly contrasted to a field perspective ((positive-observer + neutral-observer) > (positive-field + neutral-field); see Figure 3), we observed a greater response in the right precuneus ( $x = 5, y = -62, z = 45$ ;  $t$ -value: 4.30;  $p < 0.001$  uncorr.) and in an area at the junction of the right angular gyrus and superior/middle temporal gyrus ( $x = 32, y = -62, z = 21$ ;  $t$ -value: 4.65;  $p < 0.001$  uncorr.). These clusters had BOLD responses that were significantly more negative during field perspective as compared to observer perspective, relative to the baseline visual search control task (see Figure 3).<sup>2</sup>

**3.3.3 Interaction imagery perspective with memory valence.** A two-factor ANOVA was specified in order to test the interaction between imagery perspective and memory valence. The model consisted of two within-subject factors, Perspective (field vs. observer) and memory Valence (neutral vs. positive). We performed an  $F$  test for the Perspective x Valence interaction, using a threshold of (FDR)  $F(1,26) > 17.12, p < .05$ . However, no significant activity was observed, neither when adjusting the threshold to  $F(1,26) > 13.74, p < .001$  uncorrected with a minimum cluster size of ( $k \geq 300$  contiguous voxels with voxel size 1x1x1mm), to allow for investigation of more subtle differences.

## 4. Discussion

The present study was designed to examine differences in neural areas mediating autobiographical memory recall from a field perspective and observer perspective. Imagery perspective has shown to influence what is recalled (McIsaac & Eich, 2002), processing style (Libby & Eibach, 2011), and emotionality (Holmes et al., 2008). However, our understanding

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<sup>2</sup> We also hypothesized differential activity for field and observer perspective in the amygdala. As activation in these structures are commonly in a small voxel range, we performed a ROI-analysis using a mask of the left and right amygdala according to the Talairach coordinates (Talairach & Tournoux, 1988). However, no significant activation was observed during the field > observer and observer > field contrasts, neither when testing the interaction between imagery perspective and memory valence in a factorial ANOVA.

of possible mechanisms mediating these observed differences is still limited. By investigating what is underlying differences between field- and observer perspective imagery at the neurobiological level, we aimed to complement behavioral research and thereby improve our understanding of how imagery perspective can influence what is recalled, processing style, and emotionality. Therefore, we conducted a fMRI study comparing field perspective imagery to observer perspective imagery when imagining neutral and positive autobiographical memories.

First, behavioral data confirmed that our manipulation of imagery perspective had worked. Across both neutral and positive memories, participants adopted a field perspective more when instructions were to imagine the event from a field perspective, while participants adopted an observer perspective more when instructions were to imagine the event from an observer perspective. Furthermore, participants reported to adopt a field perspective more when they were imagining positive emotional memories as compared to neutral memories, regardless of perspective instructions. This could be explained by previous research suggesting that a field perspective is (automatically) adopted when a memory is more congruent with the current self-concept, while observer perspective is more adopted in the case of inconsistency with currently activated self-views (Libby & Eibach, 2002; Wilson & Ross, 2003). Healthy individuals often consider positive memories more in line with a current self, so positive memories are often recalled from a field perspective (Libby & Eibach, 2002; Wilson & Ross, 2003), while (sub-clinical) depressed individuals have a tendency to recall positive memories from an observer perspective (Lemogne et al., 2006; Nelis et al., 2013).

The behavioral results on the emotional response to imagery showed that there were no differences between imagery perspectives in the positive emotional response for neutral memories, probably due to the non-emotional nature of the memories. However, when imagining positive autobiographical memories, feelings of happiness were slightly, but



significantly higher when adopting a field perspective, than when adopting an observer perspective. This is consistent with previous research showing a reduced emotional response during observer perspective imagery (Holmes et al., 2008). No differences were found for feelings of sadness between the two imagery perspectives, likely due to our focus on memories evoking neutral or more positive feelings.

Results from our imaging data showed that across all experimental conditions, when contrasted to the control task, areas of increased activity included dorsolateral, dorsomedial, ventrolateral, ventromedial and orbital parts of the prefrontal cortex (PFC) bilaterally although more extensive in the left hemisphere. Additionally we observed activity in the middle and superior temporal gyrus extending to the angular gyrus bilaterally, the hippocampus bilaterally, and the precuneus. This is in line with previous findings on autobiographical memory recall (Cabeza & St. Jacques, 2007; Eich et al., 2009; Svoboda et al., 2006) and shows this network is engaged regardless of imagery perspective. Interestingly, most of these areas are also part of the emotion regulation circuitry (Davidson et al., 2002), suggesting that in healthy individuals similar brain networks are implicated in the re-activation of neutral and positive autobiographical memories and the regulation of emotions by prefrontal areas.

When directly contrasting field perspective imagery to observer perspective imagery, no regions showed increased activity during field perspective imagery and this did not interact with memory valence (neutral, positive). This is inconsistent with our predictions and previous research showing a field perspective, when directly compared to an observer perspective, to be associated with more activity in the amygdala, insula and somato-motor areas (Eich et al., 2009). Although it remains unclear exactly why our results did not confirm previous findings, one possible explanation could be related to the age of the memory. Previous research has indicated that remote memories, as compared to recent memories, were

associated with more observer perspective and less field perspective, and this effect was explained by a loss of visual and sensory details for more remote memories (Rice & Rubin, 2009). Whereas Eich et al. (2009) used memories of physically engaging tasks performed the week before, the autobiographical events in the current study had occurred *at least* one week before, with the result that participants recalled memories with more spread in memory remoteness as compared to the study of Eich et al. (2009). Thus, even though we manipulated imagery perspective, and analyses on the influence of memory remoteness on the extent to which participants adopted a field and observer perspective during imagery revealed no significant influence of memory remoteness, this may have had an influence on the visual and sensory details available in memory. This may thereby have attenuated differences between field perspective and observer perspective in the degree of (physically) reliving the situation or interoceptive awareness of feelings and affective monitoring (related to the insula, somato-motor areas, and amygdala). A second possible explanation is that less sensory details were available for the memories because such sensory aspects might have been less central for the autobiographical events recalled in the current study, as compared to the recalled (physical) tasks in the study of Eich et al. (2009). Similarly, previous studies on perspective taking when viewing externally generated images involved physical actions in which sensory aspects play a central role (e.g. Jackson et al., 2006). As the meaning of the self-generated autobiographical memories in the current study might have been more inclined towards broader implications in one's life, sensory details may have not been maintained as well in memory, even if memory age was similar.

During observer perspective imagery, when contrasted to field perspective imagery, we observed differences between visual perspectives. Greater activity was observed, or less decreased activity relative to the control task, in the right precuneus and an area at the junction of the right angular gyrus and superior/middle temporal gyrus, often described as the

right temporoparietal junction (TPJ). No regions showed significant activity for the interaction between perspective and memory valence (neutral, positive), suggesting that the underlying neurobiological differences between observer perspective and field perspective are not different for neutral and (positive) emotional memories.

Based on previous literature examining differences between visual perspectives, we did not hypothesize to observe greater right TPJ activity during observer as compared to field perspective imagery. The right TPJ has been linked to both attention processes and social cognition (Krall et al., 2015). It is believed that the underlying commonality between these seemingly different cognitive processes is attentional shifting, given that right TPJ involvement is often found in attention reorienting tasks and theory of mind related paradigms that require performing a shift in mental state (Krall et al., 2015). One explanation for that observer perspective as compared to field perspective imagery involved greater right TPJ activity, or less decreased activity relative to the visual search control task, is that imagining yourself in a situation from a distance (observer) requires a greater shift of perspective in mental state than imagining a situation through your own eyes (field). Interestingly, the right TPJ has also been involved in coding embodiment and out-of-body experiences (e.g. Arzy, Thut, Mohr, Michel, & Blanke, 2006; Blanke et al., 2005). Experimental studies have used an own-body-transformation (OBT) task in which participants are asked to imagine themselves in the body position of a human figure on a screen and then make left-right judgments adopting the figure's visuospatial perspective (Arzy et al., 2006; Blanke et al., 2005). Such an OBT task requires participants to perform own-body imagery with a disembodied self-location, and thus also involves a shift to a more self-distanced perspective. The observed differential activity in the right TPJ area during observer versus field perspective imagery may thus reflect differences in the extent to which a shift in perspective or mental state is performed while adopting the specific imagery perspective.

Our results on differential activity in the precuneus are in line with research comparing third-person perspective to first-person perspective when imagining motor action (Ruby & Decety, 2001), observing social interaction as compared to being personally involved in the social interaction (Schilbach et al., 2006), and during self-distancing from neutral and negative pictures of social situations (Koeningsberg et al. 2010). Previous research has explained these findings with the role of the precuneus in processes important for assuming a distanced perspective (Koeningsberg et al., 2010) and self-representation (Ruby & Decety, 2001), also with regard to the spatial reference of oneself relative to others (Schilbach et al., 2006). This reflects that during observer perspective imagery, people adopt a more self-distanced perspective than during field perspective imagery. Many studies have also linked the precuneus to self-referential/self-evaluative processes (for review, see Northoff et al., 2006) or as part of a network involved in evaluative processing more generally (Legrand & Ruby, 2009). This is interesting as it has previously been suggested that self-evaluative processing is more likely to occur during observer perspective imagery than during field perspective imagery, which could mediate differences in the emotional response (Kuyken & Howell, 2006; Kuyken & Moulds, 2009). Our finding that relative to the control task, activity in the precuneus decreased more during field perspective imagery than during observer perspective imagery, could therefore support this idea that field perspective imagery is less likely to evoke (self-) evaluative processing. Imagery perspective might thus not directly influence the emotional response, but this may depend on whether evaluative consideration of the event in relation to the self-concept – more likely occurring during an observer perspective - decreases or increases emotional power (Libby & Eibach, 2011). Our findings of both differential activity in the precuneus depending on imagery perspective and the absence (i.e. not ‘surviving’ the threshold) of differential activity in areas like the amygdala, seem to correspond with this latter idea.

In light of this idea, a possible explanation for why previous research on the neurobiological differences between imagery perspectives during memory recall (Eich et al., 2009) did not find any differential activation in the precuneus during observer as compared to field perspective might be related to characteristics of the memories that were recalled. Imagery of real autobiographical events might be necessary to capture the process of evaluative consideration of specific events, and the likelihood of such evaluative processing occurring may thus differ depending on imagery perspective. However, memories of performed (physical) tasks (see Eich et al., 2009) may have only limited potential for broader meaning and thus may not provide material to sustain such evaluative thinking. If emotional intensity in response to memory recall depends on how the event is evaluated, with such (self-) evaluative processing more likely occurring during observer perspective imagery, individual differences in general/current self-beliefs can lead to different meanings of events and thereby influence the evoked emotional response (Libby & Eibach, 2011). Provided that depression is associated with more negative self-evaluation and self-schema (Clark et al., 1999), this increases the likelihood that the meaning of a past positive event in relation to the (current negative) self-concept results in unfavorable evaluation, dampening the positive emotional response during observer perspective imagery. Interestingly, behavioral studies investigating the role of imagery perspective in relation to depression, reveal that depression is related with a tendency to objectify the self (as falling short). This tendency is suggested to prime observer memories in which the objectified self can be evaluated, which is likely to lead to unfavorable self-evaluations (Kuyken & Howell, 2006). However, future research should first aim to replicate these findings in (sub-clinically) depressed individuals, to clarify whether differences between imagery perspectives at the neurobiological level are not by itself influenced by the presence of depressive symptoms.

The precuneus, also part of the default mode network, has shown to play a role in a range of higher-order cognitive functions, amongst others self-evaluative processing, but also visuospatial imagery (Cavanna & Trimble, 2006). Therefore, an alternative interpretation for increased precuneus activity during observer perspective as compared to field perspective imagery (or less decrease in activity relative to the visual search control task) could be based on its role in spatial processing. In the context of spatial processing a distinction has been made between egocentric frame of reference, defined as subject-to-object relations, and allocentric frame of reference, defined as object-to-object relations (e.g. Zaehle et al., 2007). In an egocentric framework locations are represented in relation to “a personal agent and his physical configuration” (Vogeley & Fink, 2003, p. 39), while an allocentric framework is “independent from the agent’s position” (Vogeley & Fink, 2003, p.39). Research on the role of the precuneus in egocentric and allocentric spatial processing has produced mixed results showing involvement of the precuneus during allocentric spatial representation (e.g. Zhang & Ekstrom, 2013), but also during both egocentric and allocentric spatial processing although stronger during egocentric spatial coding (Zaehle et al., 2007). Both ‘forms’ of spatial processing have thus been related to activity in the precuneus. Importantly, the distinction between egocentric and allocentric reference frames should be separated from the distinction between field and observer perspective (Vogeley & Fink, 2003). Both field and observer perspective imagery are centered on the body of an agent, but an observer perspective requires a translocation of the egocentric perspective (Vogeley & Fink, 2003; David et al., 2006). However, given the role of the precuneus in visuospatial processing, this could suggest that taking an observer perspective when imagining an autobiographical event is associated with more elaboration on spatial relations than when adopting a field perspective. Thus while there may be less activity within the precuneus during memory recall, relative to the visual search control task, adopting an observer perspective retains greater involvement of the precuneus

than during a field perspective. This is in line with behavioral findings showing that memories imagined from an observer perspective include more information about visuospatial relations (McIsaac & Eich, 2002). We cannot exclude that differential activity in the precuneus during imagery perspectives reflects both differences in self-referential/self-evaluative processing and visuospatial processing. These can reflect different and possibly parallel mechanisms through which imagery perspective has an influence on the type of information that is recalled and the intensity of the emotional response.

There are several limitations to this study that are worth mentioning. First is the lack of control over the content of the memories. However, the difference in content of memory across individuals could also be seen as an advantage as observed activity in the brain is less likely to be related to content aspects of the recalled memories instead of the mechanisms underlying imagery of autobiographical memory. Moreover, an event that is perceived to be positive or neutral for one person might not necessarily be perceived in the same way for another person. Therefore, in the current study participants decided themselves on past events that they perceived as neutral and positive. Secondly, we did not control for memory remoteness, apart from that the event had to have taken place a minimum of one week ago. Previous research has shown that memory remoteness is related to imagery perspective (Rice & Rubin, 2009). However, in the current study we gave explicit instructions on imagery perspective, which limits the confounding influence of differences in memory remoteness. Furthermore, analyses on the influence of memory remoteness on the extent to which participants adopted a field and observer perspective during imagery revealed no significant influence of memory remoteness (after correcting for multiple testing). Nonetheless, memory remoteness may have had an influence on the visual and sensory details available in memory. Therefore, it would be good for future research to limit memory age. Third, although in designing the study we sought to find a balance between sufficient power and not increasing

the total scan time too much -in order to avoid tiredness in the participants which could influence the results- the scan time per condition might have limited the power to detect interactions of imagery perspective and emotional valence. A final limitation is that the interpretation of the results is limited to young, healthy females and cannot be generalized to a broader population.

In conclusion, the behavioral results of our study showed that different ways of imagining positive autobiographical memories, from a field perspective or an observer perspective, can influence the emotional response to imagery. At the neurobiological level, an observer perspective, when directly compared to a field perspective, was associated with greater activity, that is, less decrease relative to the visual search control task, in the right TPJ and right precuneus. Relative greater activity in the right TPJ could reflect the necessity for a greater shift of perspective and mental state during observer perspective imagery than field perspective imagery. Differential activity in the precuneus seems to reflect that during observer perspective imagery as compared to field perspective imagery, individuals are more likely to engage in both (self-) evaluative processing and visuospatial processing, in line with previous behavioral research. Through different or possibly parallel mechanisms this could influence the type of information that is recalled and the emotional response. Given the potential role mental imagery can play in psychotherapy, it will be important for future research to further investigate differences between imagery perspectives and how this may influence the likelihood of evaluative processing to occur during memory recall. That would further strengthen the idea based on behavioral findings, that adopting an observer perspective influences emotional intensity (increasing/decreasing) depending on how the imagined situation is perceived or evaluated in relation to the self-concept (Libby & Eibach, 2011). As a consequence though, individual differences in self-beliefs could qualify the perceived meanings of events, and thereby influence the emotional response (Libby & Eibach, 2011)



and make observer perspective imagery possibly less adaptive in terms of emotion regulation or for the self-generation of positive emotions.

### **Acknowledgements**

This research was supported by Grant BOF10/GOA/014 for a Concerted Research Action of Ghent University awarded to Rudi De Raedt. This work was also supported by the Ghent University Multidisciplinary Research Partnership “The integrative neuroscience of behavioural control.” Funding sources had no involvement in study design, data collection, analysis and interpretation of data, writing of the report, nor in the decision making to submit the article for publication.

We thank dr. Eric Eich and dr. Todd Handy for their willingness to share the control, visual search task and Steffi De Paepe for her valuable help in testing the participants.

### References

- Arzy, S., Thut, G., Mohr, C., Michel, C.M., & Blanke, O. (2006). Neural basis of embodiment: Distinct contributions of temporoparietal junction and extrastriate body area. *The Journal of Neuroscience*, 26, 8074-8081. Doi: 10.1523/JNEUROSCI.0745-06.2006
- Blanke, O., Mohr, C., Michel, C.M., Pascual-Leone, A., Brugger, P., Seeck, M., ... Thut, G. (2005). Linking out-of-body experience and self processing to mental own-body imagery at the temporoparietal junction. *The Journal of Neuroscience*, 25, 550-557. Doi: 10.1523/JNEUROSCI.2612-04.2005
- Cabeza, R., & St. Jacques, P. (2007). Functional neuroimaging of autobiographical memory. *Trends in Cognitive Sciences*, 11, 219-227. Doi: 10.1016/j.tics.2007.02.005
- Cahill, L. (2003). Sex-related influences on the neurobiology of emotionally influenced memory. *Annals of the New York Academy of Sciences*, 985, 163-173. Doi: 10.1111/j.1749-6632.2003.tb07080.x
- Cavanna, A.E., & Trimble, M.R. (2006). The precuneus: a review of its functional anatomy and behavioural correlates. *Brain*, 126, 564-583. Doi: 10.1093/brain/aw1004
- Clark, D.A., Beck, A.T., & Alford, B.A. (1999). *Scientific foundations of cognitive theory and therapy of depression*. New York, NY: Wiley
- Critchley, H.D., Wiens, S., Rothstein, P., Öhman, A., & Dolan, R.J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience*, 7, 189-195. Doi: 10.1038/nn1176
- Davidson, R.J., Pizzagalli, D., Nitschke, J.B., & Putman, K. (2002). Depression: Perspectives from affective neuroscience. *Annual Review of Psychology*, 53, 545-574. Doi: 10.1146/annurev.psych.53.100901.135148

- Eich, E., Nelson, A.L., Leghari, M.A., & Handy, T.C. (2009). Neural systems mediating field and observer memories. *Neuropsychologia*, 47, 2239–2251. doi: 10.1016/j.neuropsychologia.2009.02.019
- Genovese, C.R., Lazar, N.A., & Nichols, T. (2002). Thresholding of statistical maps in functional neuroimaging using the false discovery rate. *NeuroImage*, 15, 870-878. Doi: 10.1006/nimg.2001.1037
- Goebel, R., Esposito, F., & Formisano, E. (2006). Analysis of Functional Image Analysis Contest (FIAC) data with BrainVoyager QX: From single-subject to cortically aligned group general linear model analysis and self-organizing group independent component analysis. *Human Brain Mapping*, 27, 392–401. Doi: 10.1002/hbm.20249
- Holmes, E.A., Arntz, A., & Smucker, M.R. (2007). Imagery rescripting in cognitive behavior therapy: Images, treatment techniques and outcomes. *Journal of Behavior Therapy and Experimental Psychiatry*, 38, 297-305. Doi: 10.1016/j.jbtep.2007.10.007
- Holmes, E. A., Coughtrey, A. E., & Connor, A. (2008). Looking at or Through Rose-Tinted Glasses? Imagery Perspective and Positive Mood. *Emotion*, 8, 875-879. Doi: 10.1037/a0013617
- Holmes, E.A., Lang, T.J., & Shah, D.M. (2009). Developing interpretation bias modification as a “cognitive vaccine” for depressed mood: Imagining positive events makes you feel better than thinking about them verbally. *Journal of Abnormal Psychology*, 118, 76-88. Doi: 10.1037/a0012590
- Holmes, E.A., & Mathews, A. (2005). Mental imagery and emotion: A special relationship? *Emotion*, 5, 489-497. Doi: 10.1037/1528-3542.5.4.489
- Holmes, E.A., & Mathews, A. (2010). Mental imagery in emotion and emotional disorders. *Clinical Psychology Review*, 30, 349-362. Doi: 10.1016/j.cpr.2010.01.001

- Holmes, E.A., Mathews, A., Dalgleish, T., & Mackintosh, B. (2006). Positive interpretation training: Effects of mental imagery versus verbal training on positive mood. *Behavior Therapy, 37*, 237-247. Doi: <http://dx.doi.org/10.1016/j.beth.2006.02.002>
- Jackson, P.L., Meltzoff, A.N., & Decety, J. (2006). Neural circuits involved in imitation and perspective-taking. *NeuroImage, 31*, 429-439. Doi: 10.1016/j.neuroimage.2005.11.026
- Joormann, J. & Siemer, M. (2004). Memory accessibility, mood regulation, and dysphoria: Difficulties in repairing sad mood with happy memories? *Journal of Abnormal Psychology, 113*, 179-188. Doi: 10.1037/0021-843X.113.2.179
- Joormann, J., Siemer, M., & Gotlib, I. H. (2007). Mood regulation in depression: Differential effects of distraction and recall of happy memories on sad mood. *Journal of Abnormal Psychology, 116*, 484-490. Doi: 10.1037/0021-843X.116.3.484
- Koenigsberg, H.W., Fan, J., Ochsner, K.N., Liu, X., Guise, K., Pizzarello, S. ... Siever, L.J. (2010). Neural correlates of using distancing to regulate emotional responses to social situations. *Neuropsychologia, 48*, 1813-1822. Doi: 10.1016/j.neuropsychologia.2010.03.002
- Krall, S.C., Rottschy, C., Oberwelland, E., Bzdok, D., Fox, P.T., Eickhoff, S.B. ... Konrad, K. (2015). The role of the right temporoparietal junction in attention and social interaction as revealed by ALE meta-analysis. *Brain Structure and Function, 220*, 587-604. Doi: 10.1007/s00429-014-0803-z
- Kross, E., Ayduk, O. (2011). Making meaning out of negative experiences by self-distancing. *Current Directions in Psychological Science, 20*, 187-191. Doi: 10.1177/0963721411408883
- Kross, E., Ayduk, O., & Mischel, W. (2005). When asking “why” does not hurt. *Psychological Science, 16*, 709-715. Doi: 10.1111/j.1467-9280.2005.01600.x

Kross, E., Bruehlman-Senecal, E., Park, J., Burson, A., Dougherty, A., Shablack, H. ...

Ayduk, O. (2014). Self-talk as a regulatory mechanism: How you do it matters.

*Journal of Personality and Social Psychology*, 106, 304-324. Doi: 10.1037/a0035173

Kuyken, W., & Howell, R. (2006). Facets of autobiographical memory in adolescents with major depressive disorder and never-depressed controls. *Cognition and Emotion*, 20, 466-487. Doi: 10.1080/02699930500342639

Kuyken, W., & Moulds, M.L. (2009). Remembering as an observer: How is autobiographical memory retrieval vantage perspective linked to depression? *Memory*, 17, 624-634. Doi: 10.1080/09658210902984526

Lancaster, J.L., Rainey, L.H., Summerlin, J.L., Freitas, C.S., Fox, P.T., Evans, A.C., ...

Mazziotta, J.C. (1997). Automated labeling of the human brain: A preliminary report on the development and evaluation of a forward-transform method. *Human Brain Mapping*, 5, 238-242. Doi: 10.1002/(SICI)1097-0193(1997)

Lancaster, J.L., Woldorff, M.G., Parsons, L.M., Liotti, M., Freitas, C.S., Rainey, L., ... Fox, P.T. (2000). Automated Talairach atlas labels for functional brain mapping. *Human Brain Mapping*, 10, 120-131. Doi: 10.1002/1097-0193(200007)

Legrand, D., & Ruby, P. (2009). What is self-specific? Theoretical investigation and critical review of neuroimaging results. *Psychological Review*, 116, 252-282. Doi: 10.1037/a0014172

Lemogne, C., Piolino, P., Friszer, S., Claret, A., Girault, N., Jouvent, R., ... Fossati, P. (2006). Episodic autobiographical memory in depression: Specificity, autonoetic consciousness, and self-perspective. *Consciousness and Cognition*, 15, 258-268. Doi: 10.1016/j.concog.2005.07.005

- Libby, L. K., & Eibach, R. P. (2002). Looking back in time: Self-concept change affects visual perspective in autobiographical memory. *Journal of Personality and Social Psychology*, 82, 167–179. Doi: 10.1037//0022-3514.82.2.167
- Libby, L.K., & Eibach, R.P. (2011). Visual perspective in mental imagery: A representational tool that functions in judgment, emotion, and self-insight. *Advances in Experimental Social Psychology*, 44, 185-245. Doi: 10.1016/B978-0-12-385522-0.00004-4
- Mai, J.K., Paxinos, G., & Voss, T. (2008). *Atlas of the human brain* (3rd ed.). Amsterdam: Elsevier
- McIsaac, H.K., & Eich, E. (2002). Vantage point in episodic memory. *Psychonomic Bulletin & Review*, 9, 146-150. Doi: 10.3758/BF03196271
- Nelis, S., Debeer, E., Holmes, E.A., Raes, F. (2013). Dysphoric students show higher use of the observer perspective in their retrieval of positive versus negative autobiographical memories. *Memory*, 21, 423-430. Doi: 10.1080/09658211.2012.730530
- Northoff, G., Heinzl, A., De Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain – A meta-analysis of imaging studies on the self. *NeuroImage*, 31, 440-457. Doi: 10.1016/j.neuroimage.2005.12.002
- Philippe, F. L., Lecours, S., & Beaulieu-Pelletier, G. (2009). Resilience and Positive Emotions: Examining the Role of Emotional Memories. *Journal of Personality*, 77, 139-176. Doi: 10.1111/j.1467-6494.2008.00541.x
- Pollatos, O., Gramann, K., & Schandry, R. (2006). Neural systems connecting interoceptive awareness and feelings. *Human Brain Mapping*, 28, 9-18. Doi: 10.1002/hbm.20258
- Rice, H.J., & Rubin, D.C. (2009). I can see it both ways: First- and third-person visual perspectives at retrieval. *Consciousness and Cognition*, 18, 877-890. Doi: 10.1016/j.concog.2009.07.004

- Ruby, P., Decety, J. (2001). Effect of subjective perspective taking during simulation of action: a PET investigation of agency. *Nature Neuroscience*, 4, 546-550.
- Ruby, P., & Decety, J. (2004). How would you feel versus how do you think she would feel? A neuroimaging study of perspective-taking with social emotions. *Journal of Cognitive Neuroscience*, 16, 988-999. Doi: 10.1162/0898929041502661
- Schilbach, L., Wohlschlaeger, A.M., Kraemer, N.C., Newen, A., Shah, N.J., Fink, G.R., & Vogeley, K. (2006). Being with virtual others: Neural correlates of social interaction. *Neuropsychologia*, 44, 718-730. Doi: 10.1016/j.neuropsychologia.2005.07.017
- Sheehan, D.V., Lecrubier, Y., Sheehan, K.H., Amorim, P., Janavs, J., Weiller, E., ... Dunbar, G.C. (1998). The Mini-International Neuropsychiatric Interview (MINI): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry*, 59, 22-33.
- Svoboda, E., McKinnon, M.C., & Levine, B. (2006). The functional neuroanatomy of autobiographical memory: A meta-analysis. *Neuropsychologia*, 44, 2189-2208. Doi: 10.1016/j.neuropsychologia.2006.05.023
- Talairach, J., & Tournoux, P. (1988). Co-planar stereotaxic atlas of the human brain. Stuttgart: Georg Thieme Verlag
- Van Strien, J.W., & Van Beek, S. (2000). Ratings of emotion in laterally presented faces: Sex and handedness effects. *Brain and Cognition*, 44, 645-652. Doi: 10.1006/brcg.1999.1137
- Verduyn, P., Van Mechelen, I., Kross, E., Chezzi, C., & Van Bever, F. (2012). The relationship between self-distancing and the duration of negative and positive emotional experiences in daily life. *Emotion*, 12, 1248-1263. Doi: 10.1037/a0028289
- Vogeley, K., & Fink, G.R. (2003). Neural correlates of the first-person-perspective. *Trends in Cognitive Sciences*, 7, 38-42. Doi: 10.1016/S1364-6613(02)00003-7



- Wilson, A. E., & Ross, M. (2003). The identity function of autobiographical memory: Time is on our side. *Memory*, *11*, 137–149. Doi: 10.1080/09658210244000324
- Zaehle, T., Jordan, K., Wüstenberg, T., Baudewig, J., Dechent, P., & Mast, F.W. (2007). The neural basis of the egocentric and allocentric spatial frame of reference. *Brain Research*, *1137*, 92-103. Doi: 10.1016/j.brainres.2006.12.044
- Zhang, H., & Ekstrom, A. (2013). Human neural systems underlying rigid and flexible forms of allocentric spatial representation. *Human Brain Mapping*, *34*, 1070-1087. Doi: 10.1002/hbm21494