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Exploring the Role of Visual Imagery in the Recall of Emotional Autobiographical Memories

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Abstract

A large body of evidence demonstrates that emotion impacts memory. Although visual information dominates emotional memories, previous studies have not examined the role of visual imagery as an individual difference variable in the representation of emotional memories. This study examines the role of visual imagery skills (namely, object and spatial imagery) on emotional memories. Participants (N = 115) recalled positive, negative, and neutral events in response to the cue words and then rated the phenomenological characteristics of each event. Event accounts were coded for episodic detail categories (event, place, perceptual, time, emotion-thought details). The results showed that visual imagery skills contributed to the remembrance of the episodic details of positive memories and the phenomenology of both positive and negative events. Overall, this study emphasizes the importance of considering the individual differences in memory research and highlights the differences between emotional and neutral events.

Keywords: mental imagery; emotional memory; spatial

Introduction

Compared to neutral events, memories imbued with emotion are easier to remember and rich in detail (Kensinger & Ford, 2020, for review). They are higher in the subjective phenomenology (Kensinger & Corkin, 2003), the number of sensory details (Comblain et al., 2005), clarity of visual details, and level of vividness (Schaefer & Philippot, 2005). Proposed mechanisms for this emotional enhancement were heightened attention, sensory processing (Talmi et al., 2008), and arousal (Madan et al., 2017). In the present study, we focus on visual imagery as part of the reason for why emotional memories are enhanced in terms of subjective phenomenology and episodic content.

Typically, emotion's influence on memory representations is studied at two levels: episodic content (e.g., details of the events) and subjective phenomenology (e.g., sense of reliving, vividness). Content of emotional events are preserved better than neutral events in episodic memory (see Buchanan & Adolphs, 2002; Hamann, 2001). This effect has been also extended to autobiographical memory studies such that emotional memories contain a higher number of event details and emotion-thought details than neutral events (St. Jacques & Levine, 2007; Wardell et al., 2021). Regarding the effect of valence, negative emotion has shown to be strengthening memory performance for central details yet impairing it for peripheral details (e.g., Easterbrook, 1959; L. J. Levine & Edelstein, 2009) due to interfered skills for binding these details (Bisby & Burgess, 2014) Similarly, autobiographical memories higher in negative emotion contained fewer place details than positive and neutral events (Wardell et al., 2021). Positive emotion, on the other hand, seems to foster memory for both central and peripheral details (Yegiyan & Yonelinas, 2011) through the increased association skills (Madan et al., 2019).

In terms of subjective phenomenology, episodic and autobiographical memory studies draw a mixed picture. Negative emotion leads episodic memories to be remembered more vividly (Cooper et al., 2019), with more visual details than positive and neutral events (Kensinger et al., 2007). On the other hand, autobiographical memory literature suggests either both positive and negative emotion increase the phenomenology (sensory and contextual details: (Comblain et al., 2005); visual details and vividness: (Schaefer & Philippot, 2005; Wardell et al., 2021), or only positive emotion rises the phenomenology since it is has been found to be related to higher vividness, sensory, temporal, and contextual details (D'Argembeau & Van der Linden, 2008; Destun & Kuiper, 1999; Raspotnig, 1997). Moreover, they point out the importance of arousal, such that if a negative event is highly arousing, it has a higher vividness level than a positive event (e.g., flashbulb memories, Brown & Kulik, 1977).

Interestingly, the increase in subjective phenomenology observed in emotional events could not be mapped into the content of memory, in other words, emotional memories with higher phenomenology ratings do not necessarily contain more details than those with lower ratings.

Taken together, the available evidence shows that the presence of memory details and subjective phenomenology is differently influenced by emotion. This is an odd pattern given that what gives rise to subjective phenomenology, such as the sense of re-experiencing the event or vividness, is thought to be determined by the amount of sensory information (Cooper et al., 2019) and the number of retrieved memory details (Folville et al., 2021).

The discrepancy between memory details and subjective phenomenology has been observed in a couple of studies. Wardell et al. (2021) observed that even though participants reported higher vividness for the emotional memories, these memory accounts did not contain the corresponding perceptual and sensory information that is expected to contribute to

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their subjective sense of vividness. Findings from the flashbulb memory literature is also in line with this where vividness of the memories was reported to be quite high whereas the recall of the personal context details of the negative public event do not back up this strong subjective sense (Talarico & Rubin, 2003). Wardell et al. (2021)'s interpretation was that the higher vividness in emotional memories might be due to the lively but single snapshots of events rather than the continuing unfolding of an event with every detail in mind (Muzzulini et al., 2020). These single images of emotional events would lead to reporting a higher phenomenology (e.g., vividness, reliving) but prevent elaborating on further event details. Therefore, an implicit assumption is that the subjective phenomenology is driven by visual imagery (i.e., the snapshots of the events). If it is true that people rely on single snapshots in emotional memory for enhanced vividness, it follows that those individuals with certain imagery skills (e.g., object imagery) should report higher phenomenology. Similarly, if negative emotion leads to remembering central details at the expense of peripheral, spatial context details (Berntsen, 2002; Talarico & Rubin, 2003) it is possible that stronger spatial imagery skills (e.g., spatial imagery) may act as a buffer and more episodic details are remembered due to increased binding between central and peripheral details (Sheldon et al., 2017).

In fact, it has been previously shown that different types of visual imagery are recruited for episodic details and subjective phenomenology (Aydin, 2018; Clark et al., 2019). Object imagery is the preference to imagine features of objects such as color, shape, and size rather than their relationship (see Blajenkova et al., 2006). It has been shown to be associated with the presence of sensory and perceptual information (Aydin, 2018; Vannucci et al., 2020), the recollective experience, emotional reliving (Vannucci et al., 2020), and vividness (Clark & Maguire, 2020). On the other hand, spatial imagery, which is the preference for imagining spatial relations among objects, people, and locations as abstract representations, has been related to the binding of all the components of a memory (Sheldon et al., 2017; Sheldon & Levine, 2016) as followed by the elaboration of the episodic details (Aydin, 2018). It was previously demonstrated to be instrumental to construct a context or a space for the event and unfold it (Hassabis & Maguire, 2007; Mullally & Maguire, 2014). Thus, visual imagery constructs are differently related to memory characteristics and details. Specifically, spatial imagery is expected to be positively related to the binding of memory details, which, as noted above, is particularly impaired in negative memories (Palombo et al., 2021; Wardell et al., 2021), while object imagery is expected to be related to phenomenology.

The Current Study

The present study aims to investigate whether (1) positive, negative, and neutral autobiographical memories differ regarding memory details and subjective phenomenology and whether (2) visual imagery skills are recruited differently by positive, negative, and neutral event details. We know of no previous studies which investigate the role of spatial and object imagery to answer why negative and positive emotions have changeable roles in memory representations. Therefore, the present study is the first study to delve into how spatial and object imagery as well as their performance-based metrics, are recruited in emotional memories with a specific focus on the types of episodic details, and phenomenology. To assess spatial and object imagery, objective tests; namely Mental Rotation Task (MRT; Peters et al., 1995; Vandenberg & Kuse, 1978) and Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) as well as a self-report measure, the Object and Spatial Imagery Questionnaire (OSIQ; Blajenkova et al., 2006) were used. Since this study is part of a larger project, Scene Recall Imagery Test (SRIT; Rubin, 2020) was also administered, however we do not focus on those findings here.

Method

Participants

One hundred nineteen Turkish-speaking participants were recruited through the research pool of Sabancı University. In order to achieve adequate power for a linear model with .05 alpha, .95 power, and medium effect size (f = .25) (Pan et al., 2018), 80 participants were needed. Four participants were excluded due to not being in the required age range (N = 1), getting scale scores close to zero (N = 1), and not providing the required number of memory narrative entries (N = 2). The final sample consisted of 115 participants (73 female, 2 other, 40 male, $M_{age} = 21.87, SD_{age} = 1.37$).

Materials and Procedure

Participants were directed to the online link of the survey through the research system of the university. After consenting, they were explained what constitutes a *specific* event and a *general* one (adopted from Aydin, 2018). Then, they received two cue words for each emotion condition (positive, negative, and neutral) to write down personal memories that were specific in time and place. The participants received the neutral cues first. Positive and negative cue words were presented in a mixed order. Within each emotion block, the order of the cues was also randomized. The cue words were selected from the Turkish Emotional Word Norms List (Kapucu et al., 2021) to reflect similar arousal levels since memory detailedness is influenced by emotional arousal (Sheldon et al., 2020).

After each event recall, participants were also asked to rate (Likert type) the following characteristics of each memory in a select set of questions: *vividness, reliving, intensity, mental time travel, importance, temporal distance, verbal details, and valence of emotions* (based on the Autobiographical Memory Questionnaire; AMQ and the Memory Characteristics Questionnaire; MCQ, Berntsen & Rubin, 2006; Butler et al., 2016; Johnson et al., 1988; Rubin et al., 2003) as well as sensory detail questions: *visual, auditory, olfactory,*

odor-taste, tactile details (from Aydin, 2018; Boyacioglu & Akfirat, 2015; Johnson et al., 1988). There were also manipulation check ratings to control for the mismatches between participants' report of the emotional valence of the event and the assigned condition.

Participants then continued on to complete the imagery scales. They first started with The Mental Rotation Task (MRT; Peters et al., 1995; Vandenberg & Kuse, 1978, as the original) which determines spatial ability by asking people to select two identical but rotated versions of the 3-D target objects in 24 questions within a time limit. Participants received full points only if they can select both correct options. After that, they proceeded to the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) that instructs participants to imagine four scenes and rate the vividness of each image on a 5-point scale. Lastly, they completed the Object and Spatial Imagery Questionnaire (OSIQ; Blajenkova et al., 2006) which aims to measure object (constructing vivid, colorful, detailed images of objects) and spatial imagery (constructing schematic representations and spatial relationships between objects) with thirty 5-point scale questions. Because in the previous studies, not all items loaded clearly to one imagery type (e.g., Fan et al., 2021), a principal component analysis (PCA) was conducted with the varimax method, and loadings higher than .4. This analysis left perfectly loaded 12 object imagery and 14 spatial imagery items at the end. The session ended with the participants providing demographic information.

Coding Six written event accounts were collected from each participant and then were coded using the Autobiographical Interview's coding scheme (AI; B. Levine et al., 2002). Two independent researchers first identified each memory's main event and then coded the event details in two categories: internal and external. Internal details are about the main event, such as the event's unfoldings (event details), perceptual information about the event, such as the color of the sky and the warmness of the day (perceptual details), time of the event (time details), the place where the event happened (place details), emotions and thoughts of people during the event (emotion-thought details). All other details in the narrative, such as, semantic details related to schematic knowledge about the self and facts about the world, repetitions, and other details that do not fit any detail category coded as external details. Each unique piece of information received one point, and the overall score for each event was calculated for each detail category. Randomly selected 153 events corresponding to 22% of all data were coded to calculate the inter-rater agreement. The intraclass correlations (ICC; one-way random effects model; McGraw & Wong, 1996) were calculated to evaluate the reliability of internal and external details. Coefficients for internal (.98) and external details (.93) indicated excellent agreement (Koo & Li, 2016).

Results

Data Analytic Strategy

Due to repeated measurement of individuals for several memories nested within people, all the analyses were conducted in HLM 8: Hierarchical linear and nonlinear modeling (Raudenbush et al., 2019). There were two levels of data. Memories were at level 1 (N = 670), and individuals were at level 2 (N = 115). The memories were clustered for each individual. Because the emotion of the events is related to the memories, dummy variables of negative and positive emotions were added to the models as level 1 predictors. Dependent variables were also located in level 1 Castro, 2002. Since individual differences scores (MRT, VVIQ, OSIQ) differ across participants but stay the same within the individual, all these variables were incorporated as level 2 predictors. Regarding the model structure, all level-1 predictors were uncentered, and the other variables were grand-centered so that they could reflect the variance of the sample. All slopes and intercepts were enabled to vary among individuals. The fit of the models was evaluated with the chi-square statistic that compares the current model with a comparison model. First, null models (intercept only, no predictors) for each dependent variable were calculated. Then negative and positive emotions were entered into these models to be compared with null models. After that, individual differences scores were included and compared with models with only emotional events. As one of the examples (for vividness) demonstrated below, all the models and summary results tables are included in the Appendix.

Level 1:

$$Vividness = \beta_{0j} + \beta_{1j} * (NEGATIVE) + \beta_{2j} * (POSITIVE) + r_{ij}$$

Level 2:

$$B_{0j} = \gamma_{00} + \gamma_{01} * (VVIQ) + \gamma_{02} * (OBJECT) + u_{0j}$$
$$B_{1j} = \gamma_{10} + \gamma_{11} * (VVIQ) + \gamma_{12} * (OBJECT) + u_{1j}$$
$$B_{2j} = \gamma_{20} + \gamma_{21} * (VVIQ) + \gamma_{22} * (OBJECT) + u_{2j}$$

Mixed Model:

$$Vividness = \gamma_{00} + \gamma_{01} * (VVIQ)_j + \gamma_{02} * (OBJECT)_j + \gamma_{10} * (NEGATIVE)_{mj} + \gamma_{11} * (VVIQ)_j * (NEGATIVE)_{mj} + \gamma_{12} * (OBJECT)_j * (NEGATIVE)_{mj} + \gamma_{20} * (POSITIVE)_{mj} + \gamma_{21} * (VVIQ)_j * (POSITIVE)_{mj} + \gamma_{22} * (OBJECT)_j * (POSITIVE)_{mj} + u_{0j} + u_{1j} * (NEGATIVE)_{mj} + u_{2j} * (POSITIVE)_{mj} + r_{ij}$$

Descriptives and Manipulation Check

Prior to the analysis, memories were checked for whether they met the expectations for time (e.g., happening at least one month ago) and content (e.g., being personal memories rather than dreams or narrations of videoclips). Six hundred-seventy memories were included in the final analyses. For the manipulation check questions, a Wilcoxon signed-rank test indicated that valence ratings significantly differed between

neutral (*Mdn* = 4) and positive (*Mdn* = 2), T = 1.398, z = -7.99, $p < .001$; neutral and negative (*Mdn* = 7), T = 15.242, z = -11.06, $p < .001$, and positive and negative conditions, T = 12, z = -12.40, $p < .001$. For the arousal ratings, positive (*Mdn* = 4) and negative (*Mdn* = 6) events (T = 1.490, z = -8.89, $p < .001$), as well as negative and neutral events (*Mdn* = 4) were significantly different, T = 13.291, z = -8.800, $p < .001$. However, positive and neutral events did not differ from each other in arousal ratings, T = 6.530, z = -0.21, p = .91. Overall, these results demonstrated that emotion manipulation worked well to separate event conditions. Neutral and positive memories were not different from each other regarding their level of arousal.

Table 1: Descriptives

Memory-level (N=670)	M /%	SD	Min	Max
Positive Event (%)	33.90			
Negative Event (%)	33.30			
Sex (% female)	58.90			
Age	22.40	1.30	19	26
Vividness	6.43	1.21	1	7
Reliving	4.96	1.80	1	7
Intensity	4.82	1.71	1	7
Importance	4.43	1.94	1	7
MTT	4.85	1.78	1	7
Visual	5.83	1.35	1	7
Auditory	4.56	2.03	1	7
Odor-taste	2.86	2.10	1	7
Tactile	4.09	2.22	1	7
Verbal	2.80	1.83	1	7
Individual-level (N = 115)				
MRT	8.75	4.75	0	21
VVIQ	60.10	8.25	43	79
OSIQ - Object	3.63	0.76	1.58	5
OSIQ - Spatial	2.63	0.76	1	4.29

Memory Details

We first examine the influence of emotion on the episodic detail categories (e.g., internal, event, place, perceptual, emotion/thought details). Event and emotion-thought details were expected to be higher in emotional memories. We also predicted the negative memories to have lower number of place details based on Wardell et al. (2021). The results confirmed these expectations except for the event details. The addition of emotions as variables to the model improved the null model for internal details, $\Delta\chi^2$ (Δdf = 10) = 4347.81, p = .001, place details, $\Delta\chi^2$ (Δdf = 10) = 38.09, $p < .001$, and emotion and thought details, $\Delta\chi^2$ (Δdf = 8) = 27.22, $p < .001$. Emotion/thought details were higher in both positive (b = .31, SE = .011, t(114) = 2.762, p = .007) and negative memories than in the neutral ones (b = .28, SE = .120, t(114) = 2.321, p = .022). Place details were lower in number in the negative memories compared to the neutral ones (b = -.31, SE = .094, t(114) = -3.300, p = .001). Emotion did not affect any other categories.

Spatial imagery was expected to be positively associated the memory details. The results partially confirmed this hypothesis. The model with emotions improved with the addition of MRT and OSIQ – Spatial for only internal details, $\Delta\chi^2$ (Δdf = 9) = 17.6, p = .04. Scene Recall Imagery Test scores (SRIT; Rubin, 2020) were also added to the models with exploratory purposes but they are neither significant nor reported here. According to the model with both emotion, MRT and OSIQ – Spatial, the effect of emotion stayed intact. Both positive events (b = .31, SE = .11, t(111) = 2.820, p = .006) and negative events still had a higher number of emotion-thought details (b = .28, SE = .12, t(111) = 2.322, p = .022) and negative events had lower place details compared to neutral events (b = .31, SE = .094, t(114) = -3.300, p = .001). Considering individual differences in spatial imagery, an interaction between MRT and positive memories was observed. Memory narratives by individuals with higher MRT scores included higher number of internal details (b = 1.03, SE = .43, t(113) = 2.38, p =.019), event details (b = .55, SE = .026, t(111) = 2.08, p = .04), and perceptual details (b = .23, SE = .11, t(111) = 2.02, p = .045) for their positive memories only. However, OSIQ – Spatial decreased the internal details (b = -.89, SE = .043, t(111) = -2.056, p = .04), event details (b = -.56, SE = .25, t(111) = -2.258, p = .026), and perceptual details (b = -.29, SE = .11, t(111) = -2.529, p = .013). To sum up, having higher MRT scores was associated with a higher number of episodic details only in the positive memory condition. No interaction between these individual differences with negative memories was observed. In addition, OSIQ – Spatial was negatively related with memory details contrary to our hypotheses (see Table 2 for summary).

Phenomenological Characteristics

Again, we first examined the role of emotion on phenomenology. Emotion was expected to be positively related with all the phenomenological characteristics. The results confirmed this expectation except for vividness ratings. The addition of negative and positive emotion improved the null models for vividness, $\Delta\chi^2$ (Δdf = 10) = 597.14, $p < .001$, intensity, $\Delta\chi^2$ (Δdf = 8) = 57.37, $p < .001$, importance, $\Delta\chi^2$ (Δdf = 8) = 99.69, $p < .001$, auditory details, $\Delta\chi^2$ (Δdf = 8) = 16.92, p = .03, odor-taste details, $\Delta\chi^2$ (Δdf = 8) = 16.78, p = .032, verbal details, $\Delta\chi^2$ (Δdf = 10) = 26.34, p = .004, and visual details, $\Delta\chi^2$ (Δdf = 10) = 21.94, p = .015. Auditory details in both negative (b = .46, SE = .018, t(114) = 2.471, p = .015) and positive memories reported as higher than neutral events (b = .49, SE = .015, t(114) = 3.230, p = .002). They both rated as more important (positive, b = .29, SE = .014, t(114) = 2.011, p = .047; negative, b = 1.46, SE = .017, t(114) = 8.448, $p < .001$). Intensity (b = .96, SE = .014, t(114) = 6.656, $p <.001$) and verbal details (b = .38, SE = .016, t(114) = 2.391, p = .018) were higher in negative events compared to neutral events. In contrast, only vividness ratings were significantly lower in negative memories than neutral memories

(b = -1.38, SE = .012, $t(553)$ = -11.534, $p < .001$). Also, the number of odor-taste details was higher in the positive memories than the neutral memories, b = .59, SE = .014, $t(114)$ = 4.168, $p < .001$. (See Table 3 for summary).

Regarding visual imagery, VVIQ and OSIQ – Object were expected to be related to the phenomenology ratings, especially for the emotional memories. When VVIQ and OSIQ – Object were added to the models with positive and negative emotion variables, the models for reliving, $\Delta\chi^2$ (Δdf = 6) = 28.06, $p < .001$, intensity, $\Delta\chi^2$ (Δdf = 6) = 26.77, $p < .001$, importance, $\Delta\chi^2$ (Δdf = 6) = 13.61, p = .034, mental time travel, $\Delta\chi^2$ (Δdf = 6) = 26.23, $p < .001$, visual details, $\Delta\chi^2$ (Δdf = 6) = 31.01, $p < .001$, and auditory details, $\Delta\chi^2$ (Δdf = 6) = 25.47, $p < .001$ were improved. Similar to the previous models with emotion variables only, negative memories had a higher number of verbal details (b = .37, SE = .15, $t(112)$ = 2.426, p = .017) and intensity (b = .97, SE = .14, $t(112)$ = 6.695, $p < .001$) but lower level of vividness than neutral events (b = -1.37, SE = .11, $t(112)$ = -11.97, $p < .001$). Both negative (b = 1.46, SE = .17, $t(112)$ = 8.498, $p < .001$) and positive events (b = .28, SE = .14, $t(112)$ = 2.026, p = .045) were rated as more important and with higher auditory details than neutral ones, (positive: b = .47 SE = .18, $t(112)$ = 2.541, p = .012; negative: b = .50, SE = .15, $t(112)$ = 3.252, p = .002). Again, odor-taste details were higher in the positive memories compared to the neutral ones (b = .59, SE = .14, $t(112)$ = 4.177, $p < .001$). VVIQ led to a higher reliving (b = .38, SE = .015, $t(112)$ = 2.550, p = .012), a higher number of odor-taste (b = .31, SE = .015, $t(112)$ = 2.080, p = .040), and visual details (b = .31, SE = .09, $t(112)$ = 3.389, $p < .001$). Moreover, VVIQ displayed an interaction with negative emotion. Even though negative emotion decreased the vividness, having higher levels of VVIQ scores led to remember negative memories more vividly than neutral memories (b = .34, SE = .12, $t(112)$ = 2.642, p = .006). Finally, individuals with higher VVIQ scores had a decreased sense of mental time travel in positive events only (b = -.34, SE = .015, $t(112)$ = -2.310, p = .023). OSIQ – Object was not related to any of the phenomenological characteristics. Overall, VVIQ increased the phenomenology ratings as predicted. At the same time, its interaction with emotion types displayed mixed results by decreasing mental time travel ratings in positive events but increasing vividness in negative events.

Discussion

In the present study, we adopted an individual differences approach to investigate the role of visual imagery on emotional memories to clarify the underlying mechanisms behind emotional memories as suggested by previous researchers (Kensinger & Ford, 2020, p. 256). In parallel with earlier findings (St. Jacques & Levine, 2007; Wardell et al., 2021), emotional memories were rich in detail and phenomenology and they benefited from different visual imagery skills. While the effects of MRT and VVIQ differed for positive and negative memories, OSIQ – Object was not influential on phenomenology and OSIQ – Spatial negatively influenced the memory details.

Memory Details

Regarding memory details, our findings replicate the recent literature (St. Jacques & Levine, 2007; Wardell et al., 2021) except for the findings for event details. Both positive and negative memories were richer in emotion/thought details available in the narratives which implies that people recall the feelings and opinions regarding an emotional event more than a neutral one. Negative events had fewer place details (Wardell et al., 2021). As Wardell et al. (2021) discussed, fewer place details may indicate that negative emotion has an impairing effect on peripheral and contextual details of a memory. Since this finding is also aligned with previous laboratory studies of emotional memory (L. J. Levine & Edelstein, 2009), it is worth studying the underlying mechanisms in future studies.

Regarding the impact of visual imagery, MRT was found to interact with emotion; in particular, it increased the internal, event and place details in positive events. OSIQ – Spatial, on the other hand, decreased the internal, event, and place details regardless of their valence. Why would MRT play a role only in positive events? The role of MRT in upholding memory details in positive events might indicate that spatial ability is somehow influential for memory details but is not sufficient to compensate for the disruption of negative emotion. Rather it might benefit memory details when people can remember their memories freely. This interpretation is in line with the previous findings, suggesting that a positive mood increases cognitive flexibility (Baas et al., 2008). In a similar vein, individuals might feel more flexible when recollecting positive events, and at this point, these skills rely on mental flexibility and might get in charge. So, people with spatial skills (e.g., MRT) may benefit from this cognitive flexibility when constructing positive events. Future research should examine the contribution of individual differences in visual imagery to functional memories to test this argument.

Phenomenological Characteristics

In line with the literature, both positive and negative memories were found to have higher phenomenology ratings, namely auditory details and importance. However, positive and negative memories differ from each other in the other ratings. While the presence of verbal details and emotional intensity were higher and vividness was lower in negative events than in neutral events, positive events had more odor-taste details than neutral events. Thus, positive events seem to be protected regarding its sensory information with a greater number of sensory details, while negative events tend to be preserved verbally. Given that representing emotional events verbally may decrease the original level of emotion of the memory by lowering the amygdala activation (Lieberman et al., 2007), it is possible that individuals may want to reduce the emotional activation of the negative memory in purpose.

Table 2: Summary of Findings - Memory Details

Model with:		Internal Details	Event Details	Emotion-thought Details	Place Details	Perceptual Details
Emotion	Positive			↑		
	Negative			↑	↓	
Emotion + Spatial Imagery	MRT					
	MRT*Positive	↑	↑			↑
	OSIQ-S	↓	↓			↓

Table 3: Summary of Findings - Phenomenological Characteristics

Model with:		Vividness	Mental Time Travel	Intensity	Importance	Verbal Details	Odor - Taste Details	Auditory Details
Emotion	Positive				↑		↑	↑
	Negative	↓		↑	↑	↑		↑
Emotion + Object Imagery	VVIQ							
	VVIQ*Positive		↓					
	VVIQ*Negative	↑						

When the effects of VVIQ and OSIQ – Object are considered, only VVIQ interacts with emotion, and it is related to phenomenology. People with higher scores in VVIQ had higher sense of reliving, a higher number of visual, and odor-taste details. But more importantly, VVIQ increased the vividness of negative memories even though negative emotion impairs the vividness. So, individuals with better visual imagery skills may suffer more from negative memories since they cannot suppress the vividness as an emotion regulation strategy (D'Argembeau & Van der Linden, 2008). However, the influence of VVIQ was limited to vividness only.

Lastly, the reasons as to why OSIQ – Object had no influence on memory and OSIQ – Spatial reflects an opposite pattern than hypothesized are worth considering. Since MRT and OSIQ – Spatial as well as VVIQ and OSIQ – Object aim to capture the same skills and they were correlated in previous studies (Aydin, 2018; Rizza & Price, 2012), and they were expected to be related to memory metrics in a similar way. However, this was not the case in the current study. One important difference is the nature of these scales. OSIQ is a subjective self-report; however, MRT and VVIQ depend on performance. Therefore, OSIQ might be reflecting preference which are very different from its performance-based equivalents which are MRT and VVIQ.

Limitations and Future Directions

This study has a limited scope to provide a complete picture of the role of visual imagery on emotional memories for several reasons. Firstly, it is limited regarding the sample characteristics. The current results only reflect memory patterns in young adults. Since memory characteristics and details alter with age (B. Levine et al., 2002; St. Jacques & Levine, 2007), future research should examine the role of these individual differences in the older population to obtain a comprehensive picture. Also, since the participants are young adults, their memories were mostly from their childhood and adolescence since, on average, the age of the events occurred 7.5 years ago. Therefore, the content of memories may differ regarding the number of details in a sample covering a wider age range.

Applied Relevance

Despite the progress in the laboratory studies which aim to clarify the power of emotion on memories, studies that investigate the role of emotion on personal memories are limited in number. This study illuminates the characteristics of mildly emotional daily memories, which are more applicable to real-world contexts. Importantly, this type of research establishes a standard for determining how emotional memories of neurotypical populations differ from the memories of patients. Since the specificity of personal memories is associated with better mental health (Kleim & Ehlers, 2008), several techniques are employed as interventions to increase memory specificity (Erten & Brown, 2018; Madore et al., 2014; Watkins, 2009). Understanding the mechanisms behind emotional events and especially considering the effect of visual imagery is important for designing further interventions that aim to increase the specificity of autobiographical memories. The current work suggests training on visual imagery, especially mental rotation skills may contribute to the memory specificity levels.

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All Analyses Models

Model 1

Internal Detailsl$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Event Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Place Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Emotion-thought Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Perceptual Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Vividness$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Reliving$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Intensity$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Importance$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Mental Time Travels$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Visual Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Auditory Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Odort-taste Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Tactile Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Verbal Details$_{mj}$ $= \gamma_{00} + \gamma_{10} * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Model 2

Internal Details$_{mj}$ $= \gamma_{00} + \gamma_{01} * MRT_j + \gamma_{02} * SRIT_j + \gamma_{03} * SPATIAL_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * MRT_j * NEGATIVE_{mj} + \gamma_{12} * SRIT_j * NEGATIVE_{mj} + \gamma_{13} * SPATIAL_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * MRT_j * POSITIVE_{mj} + \gamma_{22} * SRIT_j * POSITIVE_{mj} + \gamma 23 * SPATIAL_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Event Details$_{mj}$ $= \gamma_{00} + \gamma_{01} * MRT_j + \gamma_{02} * SRIT_j + \gamma_{03} * SPATIAL_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * MRT_j * NEGATIVE_{mj} + \gamma_{12} * SRIT_j * NEGATIVE_{mj} + \gamma_{13} * SPATIAL_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * MRT_j * POSITIVE_{mj} + \gamma_{22} * SRIT_j * POSITIVE_{mj} + \gamma 23 * SPATIAL_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Place Details$_{mj}$ $= \gamma_{00} + \gamma_{01} * MRT_j + \gamma_{02} * SRIT_j + \gamma_{03} * SPATIAL_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * MRT_j * NEGATIVE_{mj} + \gamma_{12} * SRIT_j * NEGATIVE_{mj} + \gamma_{13} * SPATIAL_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * MRT_j * POSITIVE_{mj} + \gamma_{22} * SRIT_j * POSITIVE_{mj} + \gamma 23 *$

$SPATIAL_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Perceptual Details$_{mj} = \gamma_{00} + \gamma_{01} * MRT_j + \gamma_{02} * SRIT_j + \gamma_{03} * SPATIAL_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * MRT_j * NEGATIVE_{mj} + \gamma_{12} * SRIT_j * NEGATIVE_{mj} + \gamma_{13} * SPATIAL_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * MRT_j * POSITIVE_{mj} + \gamma_{22} * SRIT_j * POSITIVE_{mj} + \gamma 23 * SPATIAL_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Emotion-thought Details$_{mj} = \gamma_{00} + \gamma_{01} * MRT_j + \gamma_{02} * SRIT_j + \gamma_{03} * SPATIAL_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * MRT_j * NEGATIVE_{mj} + \gamma_{12} * SRIT_j * NEGATIVE_{mj} + \gamma_{13} * SPATIAL_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * MRT_j * POSITIVE_{mj} + \gamma_{22} * SRIT_j * POSITIVE_{mj} + \gamma 23 * SPATIAL_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Model 3

Vividness$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Reliving$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Intensity$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Importance$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Mental Time Travel$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Visual Details$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Auditory Details$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Odor-taste Details$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Tactile Details$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$

Verbal Details$_{mj} = \gamma_{00} + \gamma_{01} * VVIQ_j + \gamma_{02} * OBJECT_j + \gamma_{10} * NEGATIVE_{mj} + \gamma_{11} * VVIQ_j * NEGATIVE_{mj} + \gamma_{12} * OBJECT_j * NEGATIVE_{mj} + \gamma_{20} * POSITIVE_{mj} + \gamma_{21} * VVIQ_j * POSITIVE_{mj} + \gamma_{22} * OBJECT_j * POSITIVE_{mj} + u_{0j} + u_{1j} * NEGATIVE_{mj} + u_{2j} * POSITIVE_{mj} + e_{mj}$