The Effects of an Imagined Scent and/or Image on Memory Quality

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Abstract

The Proust Phenomenon is described as an effect which explains the occurrence of involuntarily retrieving autobiographical memories caused by smelling something. In this research, autobiographical memories are investigated through the dependent variable 'memory quality', which consists of how vivid, detailed and emotional a certain autobiographical memory is. Then, it was examined whether multimodal sensory modalities would outperform unimodal sensory modalities on memory quality when looking at autobiographical memories evoked through imagined scents, imagined images or both at once. A questionnaire was conducted and 193 responses were recorded, with a mean age of 27.20 and a variety of countries of origin, as well as a variety of education levels. Three conditions were maintained; 'imagined scent', 'imagined image' and 'imagined scent plus image'. A between-subject design was used. Furthermore, ANOVA and Planned Contrasts analyses were conducted, but showed no significant results. Since no significance was found, evidence for the hypotheses that multimodal imagined sensory modalities would outperform unimodal imagined sensory modalities on memory quality (1) and that the imagined scent condition would outperform the imagined image condition (2), was not found. Nevertheless should this be researched further; as the subject of multimodality is studied upon rather little, but serves high ecological validity.

Keywords: Proust Phenomenon - Sensory Modalities - Imagined Odours - Imagined Images - Evoked Memories - Autobiographical Memories

The Effects of an Imagined Scent and/or Image on Memory Quality

Memories are important and interesting phenomena. A pine tree, for example, can make a lot of people think of Christmas. Not only because pine trees are traditionally seen a lot around Christmas time, but also because they have a distinguishing scent. Consequently, smelling a pine tree evokes Christmas memories. This sudden, unconscious retrieval of specific, old memories is also known as 'The Proust Phenomenon' (i.e. Hackländer et al., 2019).

Multiple research has been conducted on the 'Proust Phenomenon', which will be referred to as 'PP' in this study. The PP indicates that odour-evoked memories are more effective for generating autobiographical memories than other types of cues (de Bruijn & Bender, 2018; Chu & Downes, 2000; Hackländer et al., 2019). A definition for the PP is given by Larsson et al. (2014), who interpreted the phenomenon using the **LOVER** acronym. This means that autobiographical memories (referred to as 'AM') evoked by odour are '**L**imbic', '**O**ld', '**V**ivid', '**E**motional' and '**R**are', which will be elaborated in the following paragraphs. The elaboration will be done still based on the study by Larsson et al. (2014).

Limbic and paralimbic systems, such as the piriform cortex and the entorhinal cortices, but also the amygdala and the hippocampus, are activated during the retrieval of an odour-evoked AM (Arshamian et al., 2013),. The reason for this activation is the close connection of the previously stated (para)limbic systems and the olfactory receptors (Gottfried, 2010). Furthermore, Herz et al. (2014) showed that odour-cued memory retrieval related to stronger activations in the amygdala and hippocampal regions than visual-cued memory retrieval.

Old relates to the indication that the autobiographical information derived from olfactory cues is ontogenetically older than the autobiographical information evoked by auditory, visual or verbal cues (Chu and Downes, 2002; Willander and Larsson, 2006, 2007). Moreover, the AMs

evoked by odour target older childhood memories (< age 10) most of the times, which indicates that olfactory information is formed and saved at a young age, while still accessible through exposure to event-congruent olfactory information at an older age (Yeshurun et al., 2009).

Vivid describes the stronger feelings of reliving the AM received from olfactory cues (de Bruijn & Bender, 2018; Chu and Downes, 2002; Herz et al., 2004; Willander & Larsson, 2006). Furthermore, the odour-evoked AMs seemed to be more detailed than AMs evoked by other sensory cues (Chu & Downes, 2002).

Emotional indicates that AMs evoked by olfactory cues trigger more emotions than AMs evoked by other sensory cues, such as verbal and visual cues (de Bruijn & Bender, 2018; Herz & Cupchik, 1992; Herz, 1998; Larsson & Willander, 2009), since the olfactory sense is an emotional system (Lundström et al., 2010). Furthermore, high vividness is associated with higher emotionality (Todd et al., 2013).

Rare is the notion that olfactory cues are more specific and less frequent than verbal or visual cues (Rubin et al., 1984; Willander & Larsson, 2007). Moreover, the AMs evoked by olfactory cues have often been thought about less than otherly-evoked cues (Rubin et al., 1984). Thus, the low frequency, implicitness and specificity of AMs evoked by odours, give it the feeling of rareness (Larsson et al., 2014). Thus, the **LOVER** model serves as general theory and guidelines for how to interpret and research the PP.

Though, on the other hand, different studies looked not at odour-evoked AMs, but *imagined* odour-evoked AMs. Although, support for olfactory imagery is ambiguous. For instance, Crowder and Shab (1995) even stated that scents cannot be imagined by people at all. Djordjevic et al. (2004) indicated that some people can perform olfactory imagery, and others cannot. Carrasco & Ridout (1993), Kosslyn (2003), Stevenson & Casa (2012) and all supported

the idea that olfactory imagery exists. Followingly, in a study by Willander & Larsson (2008) the differences between word and odour imagery were examined. Participants were asked to fill in AMs based on the condition they got placed in (word vs odour imagery). Odour-imagined memories were older and contained more sensory experiences than word-imagined memories, although other phenomenological qualities did not differ.

Similarly, two studies went deeper into the PP by looking at differences between unimodal versus multimodal sensory modalities. Karlsson et al. (2013) presented participants with a visual, auditory, olfactory or multimodal retrieval cue. The participants were asked to recall an AM. The strength of the AMs was determined by looking at the semantic information received. The results showed that the three unimodal conditions generated significantly different semantic information, while the multimodal condition, where the auditory plus visual modalities contributed the most, presented the most semantic information. Although, the study indicated that the multimodal condition seemed to be a combination of the three different unimodal conditions. Furthermore, Willander et al. (2015) found likewise results: multimodal retrieval seems to use the auditory plus visual modalities the most. Nevertheless, no significant differences were found in the number of retrieved AMs or in the experiential ratings.

Nonetheless, Willander et al. (2015) specifically mentioned that multimodal cues are highly important to investigate, looking at the ecological perspective. Logically, sensory modalities are used more multimodally, rather than unimodally, as life is experienced using multiple sensors. Even though the PP has been researched multiple times, when looking at multimodal imagined sensory modalities, little research is found (Willander & Larsson, 2008). The lack of research on multimodal imagined sensory modalities, as far as the PP is concerned, means that science could benefit from new perspectives on this subject, filling a gap in the

current knowledge. Performing research on this subject is of practical importance as well; memories often consist of different sensory information, derived from the different sensory modalities (Willander et al., 2015). As memories have different qualities to them, given by the different sensory modalities, this could indicate that multimodal imagery makes for stronger AMs than unimodal imagery, which could help people remember their memories better. Thus, this study will further investigate multimodality, but looking at imagined multimodal cues, rather than physical ones.

Though, to examine the strength of an AM and to see whether there really is a Proust-effect, the **LOVER** model is used more as a theory, rather than a testing variable. Although, to determine significance in AMs, a variable named 'Memory Quality' is seen through multiple studies (de Bruijn & Bender, 2018; Chu & Downes, 2002). Memory Quality (referred to as 'MQ') consists of four variables, as seen in the research from Chu and Downes (2002); 'Vivid', 'Detailed', 'Emotionale' and 'Old'. The reason for these variables is that the PP affects these four elements of AMs. This study, though, will focus only on 'Vivid', 'Detailed' and 'Emotional', since the focus will be on childhood memories specifically, which are old by definition. To look at childhood memories specifically is seen in the study by de Bruijn and Bender (2018) as well, and therefore chosen in this study too.

Nevertheless, will this be conducted using a questionnaire, hence containing the mentioned variable 'MQ'. This research will then use olfactory imagery, as well as visual imagery for the conditions. The reason for this is simply that the study will be executed online, due to COVID-19 measures. Since the study will be executed online, comparing olfactory imagery with verbal imagery, as seen in Willander and Larssons study (2008), would give verbal cues an unfair advantage over olfactory cues, since the olfactory condition will take place only in

the mind of participants, and the verbal cue will be seen on the screen of the participant. Consequently, a visual cue would be imagined from only the mind, just like an olfactory cue, since no images will be provided.

Therefore, based on the studies about multimodal sensory modalities of Willander et al. (2015) and Larsson et al. (2013), based on the study of olfactory imagery of Willander and Larsson (2008) and based on the measuring methods seen in the studies of Chu and Downes (2002) and de Bruijn and Bender (2018), the research question will be: "Is the performance on Memory Quality higher when using multimodal sensory modalities, rather than unimodal sensory modalities, when looking at olfactory and visual imagery?" Or, in other words: will multimodal imagined sensory modalities produce stronger AMs and have a bigger Proust-effect than unimodal imagined sensory modalities.

Willander et al. (2015) and Larsson et al. (2013) showed that multimodal sensory modalities produce more sensory information, while the theory of the PP itself states that olfactory cues produce more vivid, detailed, emotional and old AMs (Hackländer et al., 2019), as well when using olfactory imagery (Willander & Larsson, 2008). Hence, two hypotheses derive from this. The first hypothesis is that the multimodal-condition will outperform the unimodal conditions on MQ. The second hypothesis is that the olfactory-condition will outperform the visual-condition on MQ.

Method

Participants

For this study, 193 responses were collected and were used in the analysis. Out of the 193 participants, 83 were male, 107 were female and 3 participants preferred not to say.

The mean age in this study was 27.20, with a maximum of 71 and a minimum of 11. Lastly, a great variety of ethnicities and education levels are seen in this study, even though most of the participants were from The Netherlands (N=41) and from Germany (N=75). Rather similarly, most of the participants have finished high school as their highest level of education (N=68), their bachelor's degree (N=75) or their masters degree (N=36).

As far as the sampling method is concerned, this study used convenience sampling. Participants were recruited via friends, family members and other (undergraduate) psychology students. Also, social media was used as a means to gather more participants. A priori power analysis was conducted and revealed that 300 participants were necessary in order to obtain enough power $(1 - \beta = 0.80)$ to be able to spot an effect. The target was not fully obtained.

Further, multiple exclusion criteria were maintained. This includes: not having filled in the questionnaire seriously, having filled in a score of 2 or less on the question: 'How much effort did you put into filling out this survey? Please be honest, and remember that this survey is anonymous.' (1= None at all, 7= A great deal), or not having completed the questions about memory retrieval (these will be elaborated below).

Lastly, the ethical aspects of this research were examined and none were considered to be unethical, since the participants were asked for their informed consent (elaborated below under the procedure section) and had to agree before filling in the questionnaire. Further, the participants could stop participating in the experiment at any given moment. Finally, the participants were asked to retrieve an AM, which was not considered unethical by any means.

Design

In order to test whether MQ was higher for unimodal imagined sensory modalities or for multimodal imagined sensory modalities, three conditions were maintained. Firstly, the

Imagined-Scent condition (ImaS). Secondly, the Imagined-Image condition (ImaI). Lastly, the Imagined-Scent + Image condition (ImaSI). In other words; a between-subjects design was used in this study. Subjects were assigned randomly to either of the three conditions.

Measures

First of all, Crayola crayons are the objects used in this study, when the participants need to imagine an image or a scent. This was chosen based on personal communication with the supervisor of this study, who conducted an unpublished research on what object would be the best when recalling childhood memories. This was a pilot, conducted at Tilburg University in 2018 (N=262) amongst Dutch and International students and it concerned the effects of imagined odours. Crayola Crayons did not score the highest, but the questionnaire used in this study was shared amongst four students performing an individual research. One of the students investigated ethnicity, and Crayola Crayons were the most internationally acknowledged childhood-object. Consequently, questions on nostalgia, ethnicity and timing are not looked into through this research, but still collected, as the questionnaire was shared with three other students who needed data on those variables.

This study looked at the three conditions and MQ, for which three tasks in the form of open questions and three Likert-Scale questions were conducted. Each condition had one specific task description. Firstly, **ImaS**: "Try not to be distracted while executing this task. Take a moment and think about Crayola Crayons. What do they exactly smell like? You're holding them up close to your nose: what smell do you pick up? After you've used the crayons, what smell is left on your fingers? Now, please try to imagine the scent of Crayola Crayons and describe the memory that you associate with this scent as clearly as possible. There is no limit to the number of words that you can use.". Secondly, **ImaI**: "Try not to be distracted while executing this task.

Take a moment and think about Crayola Crayons. What do they exactly look like? In what colours do they come? What does the box look like in which the crayons are? How does it look when you are holding one in your hand? Now, please try to imagine an image of Crayola Crayons and describe the memory that you associate with this image as clearly as possible. There is no limit to the number of words that you can use." Lastly, **ImaSI**; but this task description was a combination of both the previously mentioned conditions and is, therefore, not worth mentioning specifically. These tasks were created specifically for this research and were made like this in order to help the participants maximally to retrieve an AM.

As for the Likert-questions about MQ, the following have been conducted: "Please answer the following questions about your memory and indicate which of the options applies the most. I would describe my memory as…", after which the participants were asked to fill in a Likert-scale ranging from '1 = Not at all' to '7 = Extremely' for the variables 'Vivid', 'Detailed' and 'Emotional'. These Likert-questions were based on the study of de Bruijn and Bender (2018) in which the same measurement for MQ was used.

Procedure

The participants were asked for informed consent. This included information about how long the survey would take, that the survey was completely voluntary and anonymous, that personal data could not be identified, and that filled in data would be stored for 10 years. An email was given for any further questions. Lastly, if the participants clicked 'I consent', they could continue to the rest of the questionnaire.

Participants got a brief description of the subject of the questionnaire, which was rather short, so that the participants' answer was not influenced by prior knowledge of the subject, which could possibly have made them too aware of what was getting researched. The

participants were randomly put in one of three conditions: ImaS, ImaI or ImaSI. Participants then were asked to recall a memory related to the Crayola Crayons and write this down. After this, the participants were asked the Likert-questions on vivid, detailed and emotional. Further, demographic questions were asked. Finally, the participants got a brief description of what the study was about. The duration of the survey was 10 minutes.

Statistical analysis

This research used an ANOVA to see whether differences between conditions exist. After the ANOVA, Planned Contrasts were used to determine *where* the differences were. This way, the research question and hypotheses were examined; did ImaSI score higher than ImaS and ImaI, and did ImaS score higher than ImaI? This will be done using the program 'SPSS'. Further, Conbach's alpha was tested to check the reliability of the variables vivid, detail and emotional. Lastly, a Descriptives table was formed, containing the means and standard deviation per variable (vivid, detail, emotional) per condition.

Results

Data preparation

For this questionnaire, 223 finished responses were recorded. Out of those 223, 14 participants did not fill in the Likert-questions for vivid, detailed and emotional, nor the memory retrieval task. Furthermore, another 18 responses were left out, because the participants wrote down that they do not recall a memory, or do not know the specific 'Crayola Crayons'. In the end, 193 responses were used in this research.

The internal consistency of the remaining dataset was inspected. MQ was the main and dependent variable in this research, which consisted of how vivid, detailed and emotional the memories were. A reliability analysis was performed with Cronbach's alpha = 0.74. Since this

showed that the internal consistency of the items was strong enough, the three variables (vivid, detail and emotional) were computed in the variable 'MemoryQuality', by taking the sum of all three and then dividing it through three. Moreover, the three conditions were put together in 1 computed variable as well, so the independent variable 'Conditions' can be examined.

Main analysis

After comparison of the descriptives of the three conditions (ImaS, ImaI and ImaSI), the means of ImaI seemed to be higher for vivid and detailed, but not for emotional or the computed variable MQ. This is not in line with the hypothesized direction (See **Table 1**). Though, the mean for MQ is higher when looking at ImaSI, which is in line with the hypothesized direction. The confidence intervals ranged from 1.33 to 6.67 for the conditions ImaS and ImaI, whereas the condition ImaSI ranged from 1.00 to 6.00.

Next, an ANOVA was conducted. The dependent, computed variable 'MemoryQuality' and the independent, computed variable 'Conditions' were used. After the ANOVA, Planned Contrasts were performed, comparing the ImaSI to ImaS and ImaI (1), and comparing ImaS to ImaI (2).

No significant results were found. For the ANOVA, Levene's test (F = 0.37) was not significant, which means that equal variance was assumed. The performed one way ANOVA (p = 0.77), thus, showed insignificant. Though, the first assumption about independence of observations was not violated; the observations were independent. The second assumption about the normal distribution was violated; a normal distribution was not seen. Although, the ANOVA showed to be robust (dfw = 190). Lastly, the third assumption about homogeneity of variances

was not violated either, since the same variables were assumed. Furthermore, the effect size showed to be 0.003.

Then, the Planned Contrasts were conducted. Since the third assumption was not violated, equal variances are still assumed. The first contrast (1) showed insignificant (p = 0.63, (d = 0.08), as well as the second contrast (2) (d= 0.10). These are small effect sizes.

Table 1. Descriptives

Likert items per condition	Imagined Image *(n=71)* M (SD)	Imagined Scent *(n=60)* M (SD)	Both Imagined *(n=62)* M (SD)
Scent/Image (Crayola Crayons)			
Vivid	4.20 (1.83)	4.03 (1.56)	3.98 (1.75)
Detailed	3.92 (1.67)	3.72 (1.66)	3.77 (1.59)
Emotional intensity	3.32 (1.71)	3.27 (1.88)	3.72 (2.00)
Memory Quality	3.81 (1.43)	3.67 (1.38)	3.85 (1.44)

Discussion

The current study examined whether multimodal imagined sensory modalities produced stronger AMs (and a stronger Proust-effect) than unimodal imagined sensory modalities (See Karlsson et al., 2013; Willander et al., 2008, 2015). To test this, three conditions (ImaS, ImaI and ImaSI) were compared based on the computed variable MQ, which consisted of vivid, detailed and emotional (See de Bruijn & Bender, 2018; Chu & Downes, 2002). The predictions were that ImaSI would perform better than ImaS and ImaI, but that ImaS would perform better than ImaI (See Karlsson et al., 2013; Willander et al., 2008, 2015). The results of the current study indicate that there is no evidence for multimodal imagined sensory modalities producing stronger AMs

than unimodal imagined sensory modalities. Neither effect was found for olfactory imagery producing stronger AMs than visual imagery. The found effect sizes were small.

The findings of the current study, thus, differ from what was seen in other studies. Whereas other studies (i.e. de Bruijn & Bender, 2018; Chu and Downes, 2002; Hackländer et al., 2019) found that odour-evoked memories are more vivid, detailed and emotional than other-evoked memories, and that scents evoke stronger AMs than other cues, this study did not find that. Moreover, AMs evoked by multimodal sensory modalities were found to be containing more sensory information (Karlsson et al., 2013; Willander et al., 2015) than AMs evoked by unimodal sensory modalities, which was not found in the current study either. Furthermore, AMs derived from olfactory imagery were indicated to contain more sensory experiences than AMs derived from verbal imagery (Willander & Larsson, 2008). Although the current study examined visual imagery instead of verbal imagery, conclusions cannot be drawn based on the current results, in contrast to the study of Willander & Larsson (2008).

Since the outcomes between previous studies and the current study differ, explanations should be explored. First and foremost, a difference could exist between how well the two types of imagery (olfactory and visual) were executed. Possibly, a difference in potency of imagining a cue per participant, could alter the results. No specific results show that this would have happened in the current study by definition, but no measures were taken into account for this either. A study from Andrade et al. (2013) shows us that mental imagery can actually be measured. Since mental imagery is ambiguous as it is, the lack of concise information on the potency of mental imagery could explain possible differences. Furthermore, the proposed item (Crayola Crayons) may have altered the possible outcome. Crayola Crayons were chosen through unpublished research, which was retrieved through personal communication. The pilot

study was conducted on Tilburg University psychology students (international and Dutch), but since a lot of the participants in the current study were not psychology students at Tilburg University, the chosen item may have been a less strong stimulus for the participants within this specific study. Hence, this is something that should be taken into consideration in any future research; when picking an item for a memory retrieval task, the item should be chosen based on the group of participants who will do that specific task. This way, the research will have a better internal validity and maybe get more reliable results as well, since the analysis of what item will be used in the study will directly apply to the participants of that same study as well.

Nevertheless, the current study contributes to the existing literature. First of all: no significant results do not imply that there is no effect at all; it implies that no effect was found in this current study. This means that multimodal imagined sensory modalities could still provide stronger AMs than unimodal imagined sensory modalities, but it was just not found in this study. Considering, as seen in the means (and stated previously in the results section), the mean for MQ is the highest for the ImaSI-condition, which actually is the hypothesized direction and in agreement with the study of Karlsson et al. (2013) and Willander et al. (2015). Therefore, further research is advised and needed, and could possibly lead to significant results. Furthermore, as the mean is the highest for the ImaSI condition on MQ, this also strengthens the indication that olfactory imagery is indeed possible (Carrasco & Ridout, 1993; Kosslyn, 2003; Stevenson & Casa, 2012). Besides, the internal consistency of the items was considered to be strong enough, which not only further strengthens the reliability of this measuring method (de Bruijn & Bender, 2018; Chu & Downes, 2002), but also generally agrees with the theory that AMs evoked by olfactory cues consist of these variables, since they are correlated (i.e. Hackländer et al., 2019; Larsson et al., 2014). Lastly, as stated in the introduction section, multimodal imagined sensory

modalities have been researched a few times before, when looking at a Proust-effect or AMs (Willander & Larsson, 2008). Therefore, new perspectives and statistics will help broaden the scientific and empirical knowledge.

Followingly, current research has its limitations as well. Firstly, few have been stated above in this section, such as lack of measuring mental imagery and differences in population between the pilot study and this current study. Secondly, the options were rather limited in this research. Due to the worldwide COVID-19 pandemic, real life experiments were nearly impossible for this kind of research, as well as real life advertising for more participants. If this study could have been conducted in real life, task descriptions could have been provided, as well as a general environment in which the participants could ask questions. Apart from this, the time was rather limited to gather more participants online as well. The participants were gathered in one week, due to a lack of time, whereas multiple weeks of data collection could have provided a larger supply of participants, with which the power needed for this study (see Results section) could have been approximated more closely.

Consequently, advice for further research will be given. Multiple implementations for further research have been implied above, but will be summarized here. First of all, measures to determine mental imagery could give a clearer picture on why differences between the different conditions (olfactory and visual) exist. Secondly, conducting a pilot study on the same sample who will participate in the research is advised as well. Lastly, conducting this experiment in a real life situation would most probably help the participants with clarity about the tasks, as well as providing them with the possibility to ask questions.

In conclusion, no significant results were found when looking at whether multimodal imagined sensory modalities or unimodal imagined sensory modalities provide the largest MQ.

Neither can be said whether unimodal imagined olfactory cues provide a larger MQ when looking at AMs than unimodal imagined visual cues. The means for vivid and detail were higher for ImaI, whilst the means for emotional and the computed variable MQ were higher for ImaSI.

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