

# MOOD-CONGRUENT MEMORY IN HEALTHY ADULTS: A SYSTEMATIC REVIEW

*MEMÓRIA CONGRUENTE AO HUMOR EM ADULTOS SAUDÁVEIS:  
UMA REVISÃO SISTEMÁTICA*

*MEMORIA CONGRUENTE CON EL ESTADO AFECTIVO EN ADULTOS SANOS:  
UNA REVISIÓN SISTEMÁTICA*

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## RESUMO

A memória congruente com o humor (MCH) é definida como a facilitação para se recordar de determinado material emocional quando sua valência emocional é congruente ao humor atual. Esse fenômeno tem importantes implicações clínicas, principalmente por seu envolvimento com transtornos de humor, como a depressão. Esta revisão sistemática discute os fatores que contribuem para a ocorrência de MCH em adultos saudáveis, assim como suas implicações teóricas e clínicas. Argumentamos que as características do material usado na tarefa de memória (e.g., estrutura, intensidade de valência, autorreferência vs referência ao

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outro) e as características dos participantes (e.g., personalidade, excitação fisiológica) são fatores capazes de modular a presença de MCH. Em última análise, há necessidade da realização de estudos que investiguem o fenômeno em ambientes mais ecológicos e que explorem os correlatos neuroanatômicos subjacentes ao efeito de MCH.

*Palavras-chave:* emoção; humor; cognição; memória; memória congruente com o humor.

## ABSTRACT

Mood-congruent memory (MCM) is defined as the facilitation to remember emotional material when the emotional valence of this material is congruent with current mood. This phenomenon has important clinical implications, especially because of its involvement in mood disorders, such as depression. This systematic review discusses the factors contributing to the occurrence of MCM in healthy adults and its theoretical and clinical implications. We argue that characteristics of the material used in the memory task (e.g., structure, valence intensity, self vs other-reference) and characteristics of the participants (e.g., personality, physiological arousal) are factors likely to modulate the presence of MCM. Ultimately, there is a need for further research investigating the phenomenon in more ecological settings and exploring the neuroanatomical correlates underlying the effect of MCM.

*Keywords:* emotion; mood; cognition; memory; mood-congruent memory.

## RESUMEN

La memoria congruente con el estado afectivo se define como la facilitación para recordar material emocional cuando la valencia emocional de este material es congruente con el estado afectivo actual. Este fenómeno tiene importantes implicaciones clínicas, especialmente por su implicación en los trastornos del estado de ánimo, como la depresión. Esta revisión sistemática analiza los factores que contribuyen a la aparición de la memoria congruente con el estado afectivo en adultos sanos y sus implicaciones teóricas y clínicas. Se argumenta que las características del material utilizado en la tarea de memoria (por ejemplo, estructura, intensidad de valencia, autoreferencia frente a la de otros) y las características de los participantes (por ejemplo, personalidad, estimulación fisiológica) son factores aptos a modular la presencia de este fenómeno. Por último, existe una necesidad de realizar más estudios que investiguen el fenómeno en entornos más

ecológicos y que exploren los correlatos neuroanatómicos subyacentes al efecto de la memoria congruente con el estado afectivo.

*Palabras clave:* emoción; estado afectivo; cognición; memoria; memoria congruente con el estado afectivo.

## Introduction

During the last two decades, numerous studies explored the influence of emotional state on cognitive processes (Eich et al., 2000). However, the relationship between mood and cognition, and in particular between mood and memory, has been discussed for centuries. Already in the eighteenth century, the French thinker Voltaire wrote<sup>1</sup>: “We retain by heart despite yourself and that is why we say, ‘remember by heart’, because what touches the heart is engraved in the memory” (1764, p. 150). Throughout the twentieth century, cognitive science demonstrated a link between memory and emotions through a variety of ideas, amongst them, the concept of Mood-Congruent Memory (MCM) (Blaney, 1986; Bower, 1981).

MCM is the phenomenon through which the recovery of emotional material is facilitated when the emotional valence of this material is congruent with current mood (Bower, 1981). For example, when feeling sad, it is easier to retrieve stimuli with a negative emotional valence. Bower (1981) theory discussed the existence of a memory network, in which every concept forms a node linked to other nodes of associated concepts. According to this view, a specific emotional state would spread its activation through nodes of related concepts, including autobiographical memories. Within the context of the activation of an emotional node, people tend to be more attentive to mood-congruent information linked to this specific concept (Bower, 1981).

The high susceptibility of encoding or retrieval of a specific stimuli, given the valence of current mood, places MCM as highly implicated in a diverse range of psychological research and social judgments, such as biased eye witness reports (Fiedler et al., 2001; Loftus, 2004), as personal events tend to be affectively charged (Miranda & Kihlstrom, 2005). Fiedler et al. (2001) discussed how MCM influence on both recall and recognition not only affect witnesses’ imagination, but actually increase their discrimination ability (Fiedler et al., 2001). MCM may also be relevant to research into emotional processing and regulation. Smith and Petty (1995) studied personality traits of healthy subjects and suggested the occurrence of an effective mood regulation strategy among

high self-esteem individuals, as their results demonstrated that, after negative mood induction, individuals with high self-esteem retrieved more positive memories than those with low self-esteem (Smith & Petty, 1995). Finally, the study of MCM may also shed light on general mechanisms of memory function. As indicated above, MCM potentially highlights the network-like structure of memory (Bower, 1981). Similarly, MCM phenomena support the idea of memory as a dynamic system, comprised of active constructions and centered on the combination of stored previous information and inference rules (Fiedler et al., 2001).

In clinical practice, this phenomenon has been of interest because of its potential involvement in the genesis of emotional disorders, such as depression. Indeed, cognitive theories of depression support the hypothesis that MCM may be a critical factor for vulnerability to depression and also for the maintenance of depressive symptoms (Teasdale, 1983; van Wingen et al., 2010; Watkins, 2002), for example through the rumination of negative information which involves a process akin to MCM (Nolen-Hoeksema, 1991, 2000). Delgado et al. (2012) also associated bipolar disorder with MCM, suggesting that positive-biased memory processing and the symptoms of the disease may be interconnected, depending on the disease severity (Delgado et al., 2012). Mood and affect are then described as crucial parts in memory processing, directly influencing performance in this condition (Delgado et al., 2012).

MCM is distinct from Mood-Dependent Memory (MDM), which in turn is part of the global phenomenon of State-Dependent Memory (SDM) in which memory is enhanced if the state at encoding and retrieval of information is generally the same (Eich, 1980). In the case of SDM, the state represents the physiological, internal environment of the subject and can be psychopharmacological (Darley et al., 1974; Duka et al., 2001) or emotional, which is the case in MDM (Bower, 1981; Eich & Metcalfe, 1989; Nutt & Lam, 2011). Therefore, MDM is defined as the ability to increase the recall of any type of material, when the subject's emotional state is the same at the time of encoding and at the time of retrieval, regardless of the content of the material.

This work focuses on the exploration of MCM, an effect for which results are variable. However, this variability is likely to be partly due to methodological differences between studies, rather than weak statistical properties of the effect (Barry et al., 2004; Ellwart et al., 2003; Watkins, 2002). Researchers have used different experimental procedures, with variations in the type of task (e.g., explicit memory, implicit memory) and mood induction procedure (e.g., hypnosis, viewing videos, listening to music, reading sentences with emotional

valence). These variations in experimental procedures make the generalization of results difficult. The MCM studies may be tapping into different contextual memory phenomena, depending on how different memory systems are being utilized. Moreover, only a few studies have compared positive, negative and neutral emotional states in MCM, and the limited literature available has shown asymmetrical results when comparing the effects of positive and negative mood (Isen et al., 1978; Mayer et al., 1990). This highlights the need to conduct a systematic review of the literature concerning this phenomenon in order to understand better the mechanisms of MCM.

The purpose of the current article is to present a systematic review of the literature on MCM in healthy adults. This will allow us to: (1) clarify the characteristics of this phenomenon; (2) explain the contribution of the factors behind the variation in findings; and (3) explore the typical presentation of this phenomenon in healthy people, comparing it to MCM in clinical groups. In addition, by identifying methodological limitations in the existing literature, this work aims to provide guidelines to improve the design of future studies in this area.

## Method

### *Literature search*

This study was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021). Searches were conducted in PubMed and PsycINFO databases and updated until April 16, 2022. We used combinations of the following keywords: ‘context’ OR ‘state’ OR ‘mood’; ‘dependent’ OR ‘congruent’; and ‘memory’ OR ‘learning’ OR ‘retrieval’ OR ‘encoding’ OR ‘bias’. We employed filters to restrict the search to articles involving only human adults, and published in English. No limit of time period was applied to this search. An *a priori* decision was made to search only published work and to control for publication bias in a posterior analysis.

### *Inclusion/exclusion criteria*

Original articles found had their titles and abstracts screened, and were only included if they involved healthy participants and explored the impact of

emotional state on retrieval of emotional material. In addition, articles regarding clinical populations, such as major depressive disorder or anxiety disorder, were excluded, as well as articles involving studies with animals and those exploring mathematical models. Furthermore, reviews and case reports were not analyzed in this systematic review.

Whenever possible, eligible studies were retrieved in full text for screening (using the same criteria used to screen the abstracts). Finally, the references of the articles selected were checked for additional relevant articles.

### *Quality assessment*

E.B. performed the quality assessment of included studies. A quality assessment form was devised which focused on sampling, measurement of outcomes and analysis (Table 1). In accordance with the Cochrane Collaboration recommendations (Higgins & Green, 2008), an overall score was not generated, with a risk of bias judgment of “yes”, “no” or “unclear” being given instead for individual domains. If a study received more than two “no” or three “unclear” judgments, the study was considered as having poor quality and was excluded from the review.

**Table 1 — Quality assessment criteria for included studies**

|             | <b>Judgment<br/>(yes/no/unclear)</b>                                       |
|-------------|--|
| Sampling    | Was the study design appropriate to answer the research question?          |
|             | Was the sampling method appropriate?                                       |
|             | If applicable, was the control group comparable to the experimental group? |
| Measurement | Was a suitable measurement used?   |
|             | Were potential confounding variables measured?                             |
| Analysis    | Was the analysis appropriate?  |

## Results

The search generated a list of 607 articles. Only 38 of them met the inclusion criteria. An additional 22 articles were identified for the review by scanning the reference lists of these studies. Out of the 60 resulting articles, 41 were selected after application of the qualitative assessment, with a total of 68 studies being included (see Figure 1 and Table 2, for a summary).

**Figure 1 — Studies included in the final review**

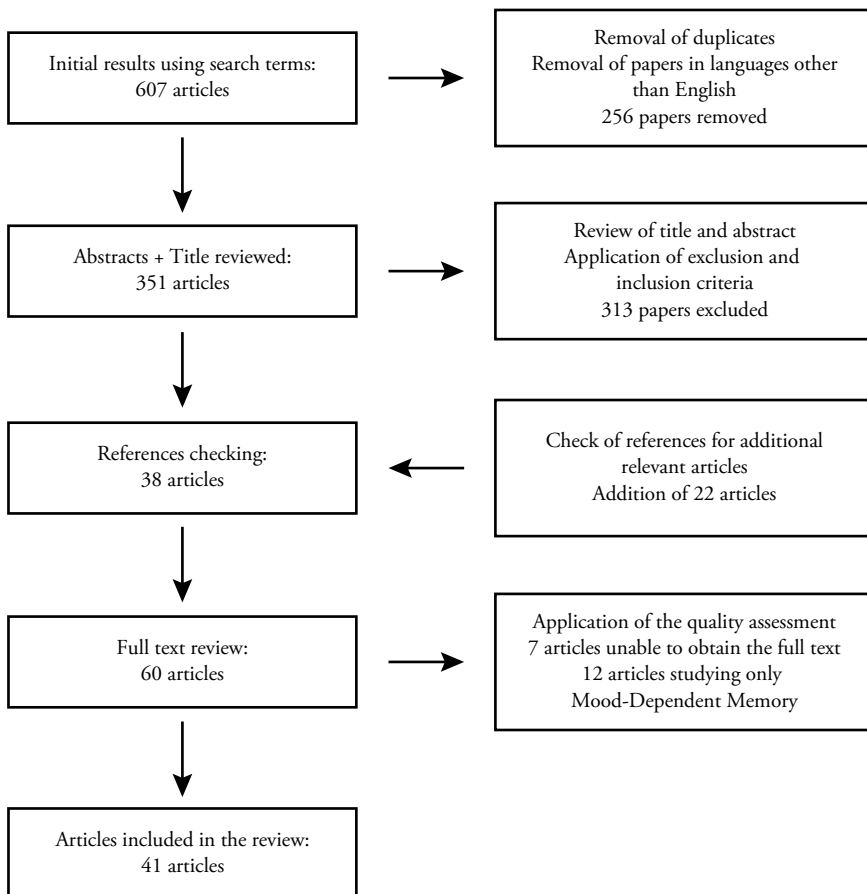


Table 2 — Characteristics of the studies reviewed

| Authors (Year)                | N° subjects | Sample  | MIP (Type of MIP)                  | Evaluation of mood | Memory task             | Memory task material | MCM demonstrated |
|-------------------------------|-------------|---|------------------------------------|--------------------|-------------------------|----------------------|------------------|
| <b>Bower et al. (1978)</b>    |             |   |                                    |                    |                         |                      |                  |
| Exp. 1                        | 10          | undergraduates  | Yes (hypnosis)                     | self reported      | explicit retrieval      | word list            | No               |
| Exp. 2                        | 16          | undergraduates  | Yes (hypnosis)                     | self reported      | explicit retrieval      | word list            | No               |
| Exp. 3                        | 24          | 10 undergraduates and 14 non-students (14 females and 10 males) | Yes (hypnosis)                     | self reported      | explicit retrieval      | word list            | No               |
| <b>Isen et al. (1978)</b>     |             |   |                                    |                    |                         |                      |                  |
| Exp. 2                        | 47          | students  | Yes (success or failure to a game) | None               | explicit retrieval      | word list            | Yes              |
| <b>Teasdale et al. (1980)</b> |             |   |                                    |                    |                         |                      |                  |
|                               | 20          | students (females; mean age=19.2)                               | Yes (Velten procedure)             | self reported      | autobiographical memory | neutral word cues    | Yes              |
| <b>Bower et al. (1981)</b>    |             |   |                                    |                    |                         |                      |                  |
| Exp. 1                        | 16          | undergraduates  | Yes (hypnosis)                     | observation        | explicit retrieval      | story                | Yes              |
| Exp. 2                        | 16          | mental health professionals (adults)                            | Yes (hypnosis)                     | none               | explicit retrieval      | story                | No               |
| Exp. 3                        | 32          | students (19 females and 13 males)                              | Yes (hypnosis)                     | none               | explicit retrieval      | story                | Yes              |
| Exp. 4                        | 16          | undergraduates  | Yes (hypnosis)                     | self reported      | explicit retrieval      | story                | No               |
| Exp. 5                        | 16          | undergraduates  | Yes (hypnosis)                     | self reported      | explicit retrieval      | story                | Yes              |

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| Authors (Year)                           | N° subjects | Sample  | MIP (Type of MIP)                 | Evaluation of mood          | Memory task                                  | Memory task material                  | MCM demonstrated         |
|--|-------------|---|-----------------------------------|-----------------------------|--|---------------------------------------|--------------------------|
| <b>Snyder &amp; White (1982)</b>         |             |   |                                   |                             |  |                                       |                          |
| Exp. 1                                   | 30          | undergraduates (females)                                | Yes (Velten procedure)            | self reported               | autobiographical memory                      | none                                  | Yes                      |
| Exp. 2                                   | 97          | undergraduates (females)                                | Yes/No (Velten procedure)         | self reported               | autobiographical memory                      | list of activities                    | Yes                      |
| Exp. 3                                   | 50          | undergraduates (females)                                | Yes (Velten procedure)            | none                        | autobiographical memory                      | list of activities                    | No                       |
| <b>Natale &amp; Hantas (1982)</b>        |             |   |                                   |                             |  |                                       |                          |
|  | 54          | undergraduates (females; age range=17-32)               | Yes (hypnosis + Velten procedure) | self reported + psychomotor | autobiographical memory + explicit retrieval | none / word list (personality traits) | Yes                      |
| <b>Teasdale &amp; Russell (1983)</b>     |             |   |                                   |                             |  |                                       |                          |
|  | 32          | students (20 females and 12 males; mean age=20.4)       | Yes (Velten procedure)            | self reported + psychomotor | explicit retrieval                           | word list                             | Yes                      |
| <b>Gilligan &amp; Bower (1983)</b>       |             |   |                                   |                             |  |                                       |                          |
|  | 16          | students and mental health professionals                | Yes (hypnosis)                    | none                        | autobiographical memory + explicit retrieval | phrases                               | No/Yes                   |
| <b>Mecklenbräuker &amp; Hager (1984)</b> |             |   |                                   |                             |  |                                       |                          |
|  | 64          | 80% students (35 females and 29 males; age range=18-32) | Yes (Velten procedure)            | self reported               | explicit retrieval                           | story                                 | No                       |
| <b>Clark &amp; Teasdale (1985)</b>       |             |   |                                   |                             |  |                                       |                          |
| Exp. 1                                   | 64          | students (mean age=19.1; SD=1.52)                       | Yes (music)                       | self reported + psychomotor | explicit retrieval                           | word list (personality traits)        | Yes (only for the women) |
| <b>Fiedler et al. (1986)</b>             |             |   |                                   |                             |  |                                       |                          |
|  | 50          | students (females and males)                            | Yes (Velten procedure)            | self reported               | explicit retrieval                           | sentences describing social behavior  | No                       |

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| Authors (Year)                         | N° subjects | Sample  | MIP (Type of MIP)            | Evaluation of mood | Memory task   | Memory task material           | MCM demonstrated |
|--|-------------|---|------------------------------|--------------------|---|--------------------------------|------------------|
| <b>Fiedler &amp; Stroehm (1986)</b>    | 36          | students                                      | Yes (mental imagery)         | none               | explicit retrieval                                    | photographs                    | Yes              |
| <b>Alexander &amp; Guenther (1986)</b> |             |   |                              |                    |   |                                |                  |
| Exp. 1                                 | 21          | psychology undergraduates                     | Yes (Velten procedure)       | none               | autobiographical memory + explicit retrieval          | word list (personality traits) | Yes              |
| Exp. 2                                 | 40          | psychology undergraduates                     | Yes (Velten procedure)       | none               | autobiographical memory + explicit retrieval          | word list (personality traits) | Yes              |
| <b>Perrig &amp; Perrig (1988)</b>      |             |   |                              |                    |   |                                |                  |
| Exp. 1                                 | 26          | psychology students (15 females and 11 males) | simulating mood              | self reported      | explicit retrieval                                    | word list                      | Yes              |
| Exp. 2                                 | 40          | psychology students (27 females and 13 males) | simulating mood              | none               | explicit retrieval                                    | word list                      | Yes              |
| <b>Salovey &amp; Singer (1989)</b>     |             |   |                              |                    |   |                                |                  |
| Exp. 1                                 | 60          | undergraduates                                | Yes (self-generated imagery) | self reported      | autobiographical memory (childhood memories)          | none                           | No               |
| Exp. 2                                 | 36          | undergraduates                                | Yes (self-generated imagery) | self reported      | autobiographical memory ("last week" memories)        | none                           | Yes              |
| Exp. 3                                 | 66          | undergraduates                                | Yes (self-generated imagery) | self reported      | autobiographical memory (childhood + recent memories) | none                           | Yes              |

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| Authors (Year)                     | N° subjects | Sample  | MIP (Type of MIP)                        | Evaluation of mood               | Memory task                                  | Memory task material | MCM demonstrated |
|------------------------------------|-------------|---|--|----------------------------------|--|----------------------|------------------|
| <b>Lewis &amp; Williams (1989)</b> | 28          | students  | Yes (hypnosis)                           | None                             | explicit retrieval                           | word list            | Yes              |
| <b>Bower &amp; Mayer (1989)</b>    |             |   |  |                                  |  |                      |                  |
| Exp. 1                             | 48          | students  | Yes (hypnosis)                           | self reported                    | explicit retrieval                           | word list            | Yes              |
| Exp. 3                             | 24          | students  | Yes (hypnosis)                           | self reported                    | explicit retrieval                           | word list            | Yes              |
| <b>Bullington (1990)</b>           | 48          | students  | Yes (Velten procedure) + simulating mood | self reported + psychomotor      | autobiographical memory + explicit retrieval | word list            | Yes              |
| <b>Parrott &amp; Sabini (1990)</b> |             |   |  |                                  |  |                      |                  |
| Exp. 1                             | 124         | social psychology students (58 females, 34 males and 32 missing sex data) | No                                       | self reported + exam performance | autobiographical memory                      | none                 | No               |
| Exp. 2                             | 65          | students (38 females and 27 males)  | No                                       | self reported                    | autobiographical memory                      | none                 | No               |
| Exp. 3                             | 20          | undergraduates (females)  | Yes (music)                              | self reported + psychomotor      | autobiographical memory                      | none                 | Yes              |
| Exp. 4                             | 46          | undergraduates (28 females and 18 males)                                  | Yes (music)                              | self reported                    | autobiographical memory                      | none                 | No               |
| Exp. 5                             | 31          | undergraduates (23 females and 8 males)                                   | Yes (music)                              | self reported                    | autobiographical memory                      | none                 | No               |
| <b>Mayer et al. (1990)</b>         | 136         | students  | Yes (imagery + music)                    | self reported                    | explicit retrieval                           | word list            | Yes              |

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| Authors (Year)                  | N° subjects | Sample                                   | MIP (Type of MIP)                     | Evaluation of mood          | Memory task                             | Memory task material | MCM demonstrated |
|---------------------------------|-------------|--|---------------------------------------|-----------------------------|---|----------------------|------------------|
| <b>Parrott (1991)</b>           | 45          | undergraduates (30 females and 15 males) | Yes (music)                           | self reported + psychomotor | autobiographical memory                 | none                 | Yes              |
| <b>Rinck et al. (1992)</b>      |             |  |                                       |                             |   |                      |                  |
| Exp. 1                          | 48          | undergraduates                           | Yes (suggestion technique)            | self reported               | explicit retrieval                      | word list            | Yes              |
| Exp. 2                          | 48          | undergraduates                           | Yes (suggestion technique)            | self reported               | explicit retrieval                      | word list            | Yes              |
| <b>Nasby (1994)</b>             | 84          | undergraduates (females)                 | Yes (Velten procedure)                | self reported + psychomotor | explicit retrieval                      | word list            | Yes              |
| <b>Erber &amp; Erber (1994)</b> |             |  |                                       |                             |   |                      |                  |
| Exp. 2                          | 64          | undergraduates (41 females and 23 males) | Yes (memory elicitation instructions) |                             | autobiographical memory                 | none                 | Yes              |
| <b>Bradley et al. (1994)</b>    | 53          | students                                 | No                                    | self reported               | implicit retrieval + explicit retrieval | word list            | Yes              |
| <b>Mayer et al. (1995)</b>      |             |  |                                       |                             |   |                      |                  |
| Exp. 1                          | 200         | students                                 | No                                    | self reported               | implicit retrieval                      |                      | Yes              |
| Exp. 2                          | 223         | students                                 | No                                    | self reported               | implicit retrieval                      |                      | Yes              |
| Exp. 3                          | 193         | students                                 | No                                    | self reported               | implicit retrieval                      |                      | Yes              |
| <b>Nasby (1996)</b>             | 72          | undergraduates (females)                 | Yes (Velten procedure)                | self reported + psychomotor | explicit retrieval                      | word list            | Yes              |

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| Authors (Year)                       | N° subjects | Sample  | MIP (Type of MIP)        | Evaluation of mood          | Memory task                             | Memory task material   | MCM demonstrated |
|--------------------------------------|-------------|---|--------------------------|-----------------------------|---|------------------------|------------------|
| <b>Boden &amp; Baumeister (1997)</b> |             |   |                          |                             |   |                        |                  |
| Exp. 1                               | 60          | psychology undergraduates (24 females and 36 males) | Yes (video tape)         | none                        | autobiographical memory                 | none                   | Yes              |
| Exp. 2                               | 17          | psychology undergraduates (8 females and 9 males)   | Yes (video tape)         | none                        | autobiographical memory                 | none                   | No               |
| <b>Vamer &amp; Ellis (1998)</b>      |             |   |                          |                             |   |                        |                  |
| Exp. 1                               | 40          | psychology undergraduates                           | Yes (reading statements) | self reported               | explicit retrieval                      | word list              | Yes              |
| Exp. 2                               | 72          | psychology undergraduates                           | Yes (reading statements) | self reported               | explicit retrieval                      | word list              | Yes              |
| <b>Rusting (1999)</b>                |             |   |                          |                             |   |                        |                  |
| Exp. 1                               | 142         | students  | No                       | self reported               | explicit retrieval + implicit retrieval | word list (homophones) | Yes              |
| Exp. 2                               | 79          | undergraduates                                      | Yes (music + imagery)    | self reported               | explicit retrieval + implicit retrieval | word list (homophones) | Yes              |
| <b>Eich &amp; Macaulay (2000)</b>    | 48          | undergraduates                                      | simulating mood          | self reported               | autobiographical memory                 | neutral word cues      | Yes              |
| <b>Maccallum et al. (2000)</b>       | 24          | undergraduates (mean age=20.17; SD=5.50)            | Yes (hypnosis)           | self reported + psychomotor | autobiographical memory                 | emotional word cues    | Yes              |

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| Authors (Year)                     | N° subjects | Sample  | MIP (Type of MIP)   | Evaluation of mood | Memory task             | Memory task material   | MCM demonstrated |
|------------------------------------|-------------|---|---|--------------------|-------------------------|------------------------|------------------|
| <b>Rusting &amp; DeHart (2000)</b> |             |   |   |                    |                         |                        |                  |
| Exp. 1                             | 59          | psychology students (29 females and 30 males)   | Yes (imagery)   | self reported      | autobiographical memory | none                   | Yes              |
| Exp. 2                             | 60          | psychology students (30 females and 30 males)   | Yes (imagery)   | self reported      | explicit retrieval      | word list              | Yes              |
| Exp. 3                             | 60          | psychology students (30 females and 30 males)   | Yes (idiographic negative mood induction / remember past experiences) | self reported      | explicit retrieval      | word list              | Yes              |
| Exp. 4                             | 117         | undergraduates (65 female and 52 males)         | No  | self reported      | autobiographical memory | none                   | Yes              |
| <b>Fiedler et al. (2001)</b>       |             |   |   |                    |                         |                        |                  |
| Exp. 1                             | 57          | students (females and males)                    | Yes (video tape)  | self reported      | explicit retrieval      | word list (synonymous) | Yes              |
| Exp. 2                             | 80          | students (females and males)                    | Yes (video tape)  | self reported      | explicit retrieval      | word list (synonymous) | Yes              |
| <b>Klaassen et al. (2002)</b>      | 27          | 15 female and 12 males (mean age=30.9; SD=10.9) | Yes (pharmaceutical)  | self reported      | explicit retrieval      | word list              | Yes              |

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| Authors (Year)                        | N° subjects | Sample   | MIP (Type of MIP)             | Evaluation of mood            | Memory task             | Memory task material | MCM demonstrated |
|---------------------------------------|-------------|--|-------------------------------|-------------------------------|-------------------------|----------------------|------------------|
| <b>Lewis et al. (2005)</b>            | 14          | 7 female and 7 males (mean age=29)   | Yes (music + emotional faces) | self reported + physiological | explicit retrieval      | word list            | Yes              |
| <b>Miranda &amp; Kihlstrom (2005)</b> | 86          | undergraduates and graduates (58 females and 29 males; age range=17-35; mean age=19.8; SD=2.6)               | Yes (music)                   | self reported                 | autobiographical memory | word                 | Yes              |
| <b>Kiefer et al. (2007)</b>           | 38          | 30 females and 8 males (mean age=26)   | Yes (music)                   | self reported                 | explicit retrieval      | word list            | Yes              |
| <b>Fitzgerald et al. (2011)</b>       | 20          | 14 females and 6 males (mean age=22.8; SD=3.7)   | Yes (video tape)              | self reported                 | explicit retrieval      | word list            | Yes              |
| <b>Blaut et al. (2013)</b>            | 71          | undergraduates (57 females and 14 males; mean age=22; SD=2.5)  | No (n/a)                      | self reported                 | explicit retrieval      | word list            | Yes              |
| <b>Loeffler et al. (2013)</b>         | 55          | undergraduates, high school graduates and trainees (28 females and 27 males; age range=18-45; mean age=25.3) | No (n/a)                      | psychophysiological           | explicit retrieval      | word list            | Yes              |

MIP = Mood Induction Procedure  
n/a = not applicable

### *Sample characteristics*

The total sample sizes ranged from 10 (Bower et al., 1981) to 223 participants (Mayer et al., 1995). The samples in the studies were primarily of undergraduate students. Few studies characterized the sample in more detail, including information on age and gender distribution. In thirteen articles age information was provided, with mean age ranging from 20.17 (SD=5.50) (Maccallum et al., 2000) to 30.9 (SD=10.9) years (Klaassen et al., 2002).

### *Type of mood manipulation*

Studies can be divided into different groups based on the type of mood used to explore the effect of memory congruency to the emotional state. Indeed, most studies used a Mood Induction Procedure (MIP), while a smaller fraction of the studies are based on the “natural” mood of the participants or simulation of a specific mood state.

#### *Natural mood*

Ten studies used the current natural emotional state of the participants, that is, their mood was not induced using a MIP. In all studies, the mood state was self-rated by the participants and their degree of current positive or negative affect could then be linked to the extent of mood-congruent material retrieval or otherwise.

Some studies used naturally occurring mood to explore differences within participants, but without manipulating their emotional state. For example, Parrott and Sabini (1990, Experiment 1) evaluated the participants after they received their exam results, assuming that the grade would affect the students' mood. The same group also used the weather as a mood influencer: one group of participants was evaluated on a sunny day and the other on a cloudy day (Parrott & Sabini, 1990, Experiment 2), assuming that this type of context would influence the participants' mood. These two studies were not able to demonstrate a mood congruency effect on memory, when evaluating this effect on retrieval of autobiographical memories.

Rusting and DeHart (2000, Study 4) also used the natural context in order to measure differences of emotional state. They tested the participants on the first



day of classes, assuming that the participants would be in a positive or neutral mood, or in another moment of the semester before an important examination, which was considered as the negative mood condition. In contrast with Parrott and Sabini (1990), these authors were able to show an effect of MCM for the recall of personal events.

One study (Loeffler et al., 2013) explored MCM in everyday life, outside the laboratory and without manipulating participants' mood. The participants were asked to rate their mood every 10-20 minutes and when they were in a positive or a negative state, a memory task was done. This study was able to demonstrate an MCM effect in daily life.

### *Simulated mood*

Three studies used mood simulation, asking participants to behave as if they were in a specific emotional state (positive or negative) without really experiencing this emotion. An MCM effect was demonstrated for autobiographical memory (Perrig & Perrig, 1988) and for explicit retrieval of a word list (Eich & Macaulay, 2000). Bullington (1990) employed simulated mood to explore the effect of demand characteristics on MCM for autobiographical memory. For one group, the emotional state was experimentally manipulated, while the other group was asked to simulate a specific mood. In this study, the author demonstrated an MCM effect for the group who received a MIP but there was no effect in the "simulation" group.

### *Induced mood*

The majority of the studies (55 of 68) used a MIP to explore the MCM effect. Different methodologies have been used to induce specific emotional states, with the most commonly used procedures being the Velten technique and hypnosis.

The Velten procedure consists of reading a series of self-referent statements that are designed to elicit a particular mood state. This MIP was used in twelve studies. Only three studies using this MIP were not able to demonstrate an MCM effect, one evaluating autobiographical memory (Snyder & White, 1982, Experiment 3) and two exploring explicit retrieval of verbal material (Fiedler & Stroehm, 1986; Mecklenbräuker & Hager, 1984).

Natale and Hantas (1982) combined the Velten procedure with hypnosis and showed an MCM effect in an autobiographical memory task and also in an explicit retrieval task for emotionally toned words. In one article, a modified version of the Velten procedure was used (Varner & Ellis, 1998). The two studies described in this article demonstrated an MCM effect evaluating explicit memory for a word list on immediate and delayed free recall.

Hypnosis was used as a MIP in thirteen studies. Only one study used this MIP to explore the MCM effect in autobiographical memory (Maccallum et al., 2000) and the results demonstrated a significant advantage for mood-congruent memories. The twelve other studies using hypnosis explored the explicit retrieval for verbal material (emotional phrases or words with emotional connotation, stories with positive or negative characters). Five studies (Bower et al., 1981; Bower et al., 1978) did not indicate a significant MCM effect, in contrast with others, which were able to show this effect (Bower et al., 1981; Gilligan & Bower, 1983; Bower & Mayer, 1989; Lewis & Williams, 1989).

Similar to the hypnosis technique, Rinck, Glowalla and Schneider (1992) used a suggestion technique, with the difference that this MIP permits the recruitment of non-hypnotizable participants. In the three studies described in that article, the authors showed an MCM effect for explicit retrieval of a word list.

Five studies used film clips (happy, sad or neutral) to induce a specific mood state. From these studies, three evaluated explicit memory for words, and all were able to show an MCM effect. Two studies using film clips as a MIP explored MCM on autobiographical memory. Boden and Baumeister (1997, Experiment 1) demonstrated an MCM effect but they were not able to replicate this result in a complementary study (Boden & Baumeister, 1997, Experiment 2).

Rusting and DeHart (2000, Experiment 1, Experiment 2) used mental imagery to induce negative mood and were able to demonstrate an MCM effect on autobiographical memory retrieval and explicit memory (free recall of a word list). Fiedler and Stroehm (1986) explored the MCM effect by employing the same MIP and also showed a significant effect using visual material (photographs). Also using imagery to induce a positive or a negative mood state, Salovey and Singer (1989) revealed an MCM effect for the retrieval of recent and remote autobiographical memories. The mental imagery technique has also been combined with music listening (Mayer et al., 1990; Rusting, 1999, Experiment 2), leading to an MCM effect for explicit retrieval of a list of emotionally toned words.

Music has also been combined with a procedure in which the participants were asked to look at pictures showing emotional faces (Lewis et al.,

2005) and this study was successful to show an MCM effect for explicit retrieval of a word list. Seven studies used music listening alone to induce a specific mood state. Five of these studies evaluated autobiographical memory. Parrott and Sabini (Parrott & Sabini, 1990, Experiment 4, Experiment 5) did not demonstrate any MCM effect on autobiographical memory, contrary to the three other studies using the same MIP (Miranda & Kihlstrom, 2005; Parrott & Sabini, 1990, Experiment 3; Parrott, 1991). The difference between the studies that have shown an effect and those that have not is that, in the former, participants were asked to modify their mood according to the music, while in the latter, this was not explicitly asked. Two of the studies using music listening as a MIP showed an MCM effect for the retrieval of a list of emotional words (Clark & Teasdale, 1985; Kiefer et al., 2007).

Isen, Shalcker, Clark and Karp (1978, Study 2) employed a success-failure manipulation, assuming that the outcome of a game (involving victory or defeat) would influence the participants' mood (positive or negative mood). The results demonstrated an effect only for positive mood on the recall of positive words.

Klaassen et al. (2002) were the only authors to use a pharmaceutical procedure to induce mood, the "tryptophan (TRP) depletion method" (Young et al., 1985). This method consists of an ingestion of an amino acid mixture without tryptophan, which reduces the production of serotonin in the brain, inducing symptoms of depression. On this study, the recall of positive words was impaired by the TRP depletion, demonstrating an MCM effect.

### *Mood evaluation*

The studies differed on the methodology used to evaluate the current mood of the participants. Thirteen studies did not measure the current emotional state of the participants.

### *Self-reported measures*

Mood state was most commonly measured through self-report questionnaires. Various instruments were used in the studies selected for the review (Likert scale, Beck Depression Inventory). Out of 68 studies, 42 employed only a self-report measure for the evaluation of the participants' current mood, and 32 of them demonstrated an MCM effect.

### *Behavioral measures*

Some behavioral measures, such as psychomotor tasks, have been shown to reflect the emotional state of healthy or clinical participants (Burdick et al., 2009; Johnson, 1937; Nelson & Charney, 1981). The most common tasks were speed writing, letter cancelation and counting. Nine studies combined self-report methods with behavioral measures, and all were able to show MCM effect.

### *Physiological measures*

Numerous studies explored the correlation between mood and heart rate variability, and supported the use of physiological measures to evaluate emotional state (Ekman et al., 1983; Cacioppo et al., 2000; Rainville et al., 2006). Two studies employed physiological measures (heart rate) to evaluate the emotional state of the participants. All studies (Lewis et al., 2005; Loeffler et al., 2013) demonstrated an MCM effect for explicit memory of verbal material (word list).

### *Type of retrieval*

The studies selected for this systematic review evaluated the mood congruency effect on different forms of memory retrieval. Most studies (65 out of 68) explored explicit retrieval and only six used implicit retrieval tasks.

### *Explicit retrieval*

Verbal material is the most commonly used in these studies, with only a few authors employing visual material.

**Verbal material.** Forty-three studies employed verbal material. Most studies (35/43) used word lists, with a positive or negative valence. In Natale and Hantas (1982), Clark and Teasdale (1985, Experiment 1) and Alexander and Guenther (1986), the words employed were related to positive or negative personality traits. All these studies were able to demonstrate an MCM effect.

Another paradigm used was story recall, in which instead of isolated items there is a logical connection between pieces of the information presented. In Bower et al. (1981), participants were asked to read a story containing information about a sad character and others about a happy character, and to retrieve as much details as they could remember in a delayed free recall. Three of the five studies in that paper were able to demonstrate an MCM effect. Mecklenbräuker and Hager (1984) employed a revised version of the story used by Bower et al. (1981) and also showed an MCM effect. These two articles differed, among other things, on the MIP applied, with hypnosis being used in Bower et al. (1981) and the Velten procedure in Mecklenbräuker and Hager (1984).

Gilligan and Bower (1983) used happy and sad phrases that the participants needed to recall in a free-recall and then in a cued-recall task and the authors were able to demonstrate a significant advantage for mood-congruent phrases. Fiedler, Pampe and Scherf (1986) employed sentences describing an individual with regard to six categories of social behavior, with each description having a positive or negative valence. With this procedure, the authors did not demonstrate any MCM effect for the free recall of these sentences. This result can be explained by the lack of a negative mood condition, considering that the authors only compared the effect of positive induced emotional state with a neutral condition.

**Visual material.** Only one study used pictures to explore the MCM effect. Fielder and Stroehm (1986) used photographs showing either pleasant or unpleasant scenes, some of the pictures organized in thematic categories and other pictures consisting of “isolated” pictures, not belonging to a thematic group. The authors demonstrated an advantage of mood-congruent material in a free-recall task (identifying the pictures with key words), but only for isolated pictures; those depicting material, which were part of a thematic category, did not show this effect. With this study, the authors highlighted the influence of the structure of the stimuli in MCM.

**Autobiographical memory.** Twenty-one studies explored MCM on autobiographical retrieval, and seventeen studies showed an effect. The most common measure for autobiographical retrieval was a free-recall task. This procedure was used in nineteen studies, six of which were not able to demonstrate an MCM effect. In four articles (Eich & Macaulay, 2000; Maccallum et al., 2000; Miranda & Kihlstrom, 2005; Teasdale et al., 1980), word cues (neutral or emotional)

were employed to help participants recollect specific events, and all these studies demonstrated an MCM effect.

Snyder and White (1982, Experiment 2, Experiment 3) asked the participants to indicate, for various types of activity (positive or negative), the frequency with which the event had occurred during the week before the testing session. Using this procedure, the experiment demonstrated an MCM effect on the retrieval of autobiographical memories.

### *Implicit measures*

Six studies explored the MCM effect for implicit material. Despite differences in the type of mood analyzed or in the tasks used, all these studies were able to demonstrate an MCM effect.

Using a primed lexical decision task with participants in a natural mood state, Bradley et al. (1994) demonstrated an MCM effect for subliminally primed and unprimed words but not for supraliminally primed words. Mayer et al. (1995) also explored this effect using the natural mood of the participants, but applying a category-retrieval and an association-retrieval test; in the category-retrieval task, the participants were asked to list a member of the key category that began with a specific letter (e.g., key category: *Weather*; specific letter: *C... clear, cloudy, cold*); in the association-retrieval task, the aim was to free-associate to a key word using a pair of letters (ex: *Marriage, dll... divorcellove*). Using this procedure, the authors were able, in the three studies presented, to demonstrate that implicit retrieval was congruent with the current mood of the participants.

In Study 1, Rusting (1999) also explored the effect with the natural mood of participants, but using a homophone task. The participants were asked to spell each word they heard, with homophones being either positive/neutral or negative/neutral. For this task, implicit effects congruent with their current emotional state were observed. In Study 2 with the same task, the author employed a combination of music and imagery to put the participants in a specific mood. This experiment also showed an MCM effect.

## **Discussion**

The present paper reviewed a subset of the published studies on mood-congruent memory in healthy participants. Our review shows that most of the

studies were able to demonstrate an MCM effect, independently of the type of mood manipulation and the type of retrieval, suggesting the influence of other factors in the occurrence of the effect. Some authors already explored several variables that could mediate the phenomenon of mood-congruent memory. Those factors may concern characteristics of the experiment (e.g., experimental instructions, structure of the information) or characteristics of the participants themselves (e.g., personality, level of arousal).

### *Factors which may influence the occurrence of MCM*

The type of the structure of the information to be remembered was proposed by Fiedler and Stroehm (1986) as a factor mediating the MCM effect. The authors explored this hypothesis using visual material. They presented isolated pictures and pictures organized by thematic categories to the participants and were able to show an advantage of mood-congruent material, but only for isolated pictures; the effect disappeared for the categorized information.

Rinck et al. (1992, Experiment 1) investigated the influence of the valence intensity of the words on MCM effect and showed a mood-congruent learning with the strongly toned words and a mood-incongruent learning with the slightly toned words. The findings were explained by the authors based on the ease of valence determinations, which propose that the ratings of slightly mood-congruent words were facilitated, and the ratings of slightly mood-incongruent words were rendered more difficult. In a second experiment (Rinck et al., 1992, Experiment 2), the findings supported this explanation, showing that the participants took longer to rate the valence of slightly mood-incongruent words than slightly mood-congruent words, increasing the time of processing and facilitating recall.

Nasby (1994) has pointed out two moderators of the MCM effect: self-/other-reference at the moment of the encoding (“Does the following adjective describe you?” vs. “Does the following adjective describe your mother?”) and the affirmative/non-affirmative judgment about the information to be remembered. Indeed, this author showed that when in a positive mood, participants recall better the affirmatively rated positive words for both self- and other-reference conditions, but, when in a negative mood, the advantage for affirmatively rated congruent words was present only in the self-reference condition. For the non-affirmative rated words, no mood-congruent effect was observed. The author replicated his findings in another study (Nasby, 1996),

showing additionally that in an experimenter-reference condition, there is no mood-congruent effect.

Several authors explored the experimenter's demands hypothesis, which propose that the MCM effect was due to participants believing that the experimenter was seeking such a pattern of results (Snyder & White, 1982). To tests this hypothesis, Snyder and White (1982, Experiment 3) used an ineffective mood induction (using the Velten procedure with affectively neutral statements) and were not able to evidence an MCM effect, failing to provide evidence supporting the demand hypothesis. Alexander and Guenther (1986, Experiment 2) addressed the same question but using another methodology, in which participants in the "compatible condition" were told that after the mood induction people tend to recall information compatible with the current mood, and participants in the "incompatible condition" were told that the mood induction can advantage incompatible recall. They reported results that argue against the experimenter's demands hypothesis. Indeed, when asked to report autobiographical events, participants showed an MCM effect in both compatible and incompatible conditions. Bullington (1990) also explored demand effects, using a "simulated mood" condition, and the results did not support the demand hypothesis. In summary, most of the studies argued against the demands hypothesis as a main factor explaining the presence of MCM, but as observed in other types of research into emotion, demand effects may play a role depending on the study design.

Some authors tested another factor likely to moderate the MCM effect, named the subject compliance hypothesis, which argues that it is the participants' effort to maintain the induced mood that creates the mood-congruent recall. Mayer et al. (1990) manipulated the instruction about the mood induction (e.g., condition 2: "the music may or may not cause your mood to change", condition 3: "get into the music and allow your mood to change or stay the same"). The mood congruency effect was unaffected by the manipulation of the instruction, arguing against the subject compliance hypothesis. Parrott (1991) also explored the same hypothesis and showed that, even after telling the participants they can stop maintaining the induced mood, they still presented a mood-congruent recall of autobiographical memories, which is opposed to the subject compliance hypothesis.

Bower and Mayer (1989, Experiment 3) studied the effect of the type of memory instructions, manipulating the attention and learning strategy of the participants. In one condition, they asked the participants to concentrate on learning mood-congruent words, and in the other condition, the instruction was



to pay more attention in learning mood-incongruent words. The incongruent learning condition cancelled the MCM effect showed in the congruent condition, by increasing the quantity of mood-incongruent words recalled. The authors interpreted these results as evidence of the implication of attention and learning processes in MCM effect. Based on the cognitive theories of depression, which argue that attentional bias for negative information is a characteristic of the mood disorder, Blaut et al. (2013) also explored the effect of attention processes on the presence of an MCM effect. They showed that, after an attentional training focusing on neutral words, the participants did not show a better recall for negative words in comparisons to participants who did not receive the attentional training. These results support the implication of attentional bias in the occurrence of MCM effect.

Fiedler and Stroehm (1986) were interested in the effect of arousal as a moderator of the MCM effect. Using a pharmacological treatment to increase the autonomic arousal, they showed that the evaluation of the emotionally toned stimulus differed regarding the condition. However, there were no significant differences on the recall performance between the pharmacologically increased arousal group and the relaxation group, failing to demonstrate an effect of autonomic arousal on mood-congruent recall. In order to compare the effect of cognitive activation and of autonomic arousal on MCM, Varner and Ellis (1998) compared the recall of negative and organizational words in four conditions: negative mood induction, organizational schema induction, physiological arousal induction and neutral condition. The authors concluded that physiological arousal does not seem to have an influence on the occurrence of MCM, contrary to the cognitive activity of the emotional state. In a more recent study, Loeffler et al. (2013) explored the effect of psychophysiological arousal on MCM in the context of daily life and showed contradictory results. Indeed, in the case of a negative situation, physiological arousal seemed to be a necessary condition for the occurrence of MCM; in the absence of physiological arousal, the recall of incongruent memories tended to be better. However, this is not the case in a positive context, where physiological arousal did seem to influence the recall.

Several studies demonstrated that the subject's personality can be a moderator in the occurrence of mood-congruent or mood-incongruent effect. Boden and Baumeister (1997) compared the speed of recall of happy memories in a group of repressors (participants who are less affected by negative stimuli) and a group of non-repressors, in order to explore the impact of this specific personality trait on MCM. The authors showed that the repressor participants

were quicker to recall happy memories when in a negative mood compared to non-repressors. Rusting (1999) revealed significant interactions between personality traits of the participants and the effects of mood on memory, showing, for example, that extraversion was related to a better recall of positive memories and neuroticism to a better recall of negative memories. Rusting and DeHart (2000) manipulated the use of mood regulation strategies and confirmed the relation between personality and MCM, showing that the score on the Negative Mood Regulation Scale, which measures the individuals' beliefs about their capacity to regulate negative mood, influenced the effects of mood regulation strategies on MCM.

To summarize, the studies reported evidences for several mediators of MCM occurrence. The structure and the valence intensity of the material to be remembered seem to influence the MCM effect, just as the self- vs. other-reference of that material; a mood-congruent effect is more probable with more structured, intense and self-oriented material. Regarding the characteristics of the participants that can mediate MCM, personality and attention processes are factors likely to modulate the presence of MCM. In relation to physiological arousal, the results are contradictory but, in real-life settings, a greater psychophysiological arousal appears necessary to generate MCM for negative events. Neither the experimenter's demands nor the subject compliance hypotheses were able to explain the occurrence of MCM effect.

### *MCM models*

The associative network theory suggested by Bower (1981) is the most cited model proposed to explain the mood-congruent phenomenon. This model considers that the memory can be represented by a network, in which every concept forms a node linked to other nodes of associated concepts. For example, the concept of a specific emotion is linked to the physiological reactions, behaviors, words and events associated with this specific emotional state. When a concept/node is activated, this activation spreads into the network, activating associated concepts/nodes. According to this view, when someone is in a positive emotional state, the node "happy" will be activated and this activation will spread to associated nodes, such as positive autobiographical memories, facilitating the recall of these memories. This model explains, for example, that valence intensity of the material is a mediator of MCM. Indeed, Bower et al. (1981) proposed that the activation of the node needs to reach a threshold in

order to spread to associated nodes, which would explain why intensely toned mood-congruent words are better recalled than slightly toned words. The network model also allows explaining the influence of attentional processes on the occurrence of MCM. For Bower et al. (1981), when an emotional node is activated, people should be more attentive to mood-congruent information that are already activated by the spread of the activation in the network.

Nevertheless, some studies demonstrated a mood-incongruent effect (Loeffler et al., 2013; Parrott & Sabini, 1990; Rusting & DeHart, 2000) and also asymmetrical results when comparing the effects of positive and negative moods (Isen et al., 1978; Mayer et al., 1990). These results cannot be explained exclusively by Bower's network theory, and the concept of mood regulation was then proposed to explain the occurrence of these phenomena. The mood regulation hypothesis proposes that people try to regulate their mood by recalling material incongruent with their current mood state, especially when in a negative mood (Bower et al., 1981; Isen, 1985; Singer & Salovey, 1988).

According to Isen (1984) and to Salovey and Singer (1989), the asymmetry in the finding about positive and negative mood states can be explained by a combination of the network theory and the mood regulation concept. In fact, these authors suggested that the neurophysiological activation of the network may lead to a mood-congruent effect, which can be reduced or cancelled by the implementation of mood regulation strategies, where the mood regulation serves to dampen the negative mood state. Unfortunately, most of the studies do not compare positive, negative and neutral emotional states, which may complicate the interpretation of the results and may be seen as a limitation of the field of study.

### ***Mood-congruent learning / Mood-congruent retrieval***

The MCM process can be divided into two processes: mood-congruent learning and mood-congruent recall. The mood-congruent-learning (or mood-congruent judgment/encoding) corresponds to the effect of the mood at the moment of encoding (or learning), while the mood-congruent-recall (or mood-congruent retrieval) corresponds to the exploration of mood influence at the moment of recall. Only fourteen studies out of sixty-eight considered this difference when exploring the MCM effect. Indeed, seven studies explored only the MC-learning effect (Bower et al., 1981, Experiment 1 and Experiment 5; Gilligan & Bower, 1983; Lewis & Williams, 1989; Nasby,

1994; Perrig & Perrig, 1988; Rinck et al., 1992) and seven explored specifically MC-retrieval (Bower et al., 1981, Experiment 2 and Experiment 4; Clark & Teasdale, 1985; Fiedler & Stroehm, 1986; Fiedler et al., 2001; Teasdale & Russell, 1983; Varner & Ellis, 1998). All the studies exploring MC-learning were able to demonstrate an effect, but two studies about MC-retrieval (Bower et al., 1981, Experiment 2 and Experiment 4) were not. This result suggests that the current mood at the moment of the retrieval may have a minimal role in the MCM phenomenon, comparing to the mood during encoding. This support Ellis and Moore's comments (1999), who affirmed that the results regarding the MC-retrieval phenomenon are less conclusive than MC-learning results. These authors also suggested that the results from the studies exploring MCM as a unique process may be biased, especially in the case of autobiographical memory, where the event is always associated with the mood state at the moment of the event, which is also the moment of encoding. Studies exploring the neural basis of the phenomenon may help to understand the role of MC learning and MC retrieval in the MCM effect.

### *How MCM in healthy people informs MCM in clinical groups*

MCM research on healthy individuals may also improve our understanding of clinical conditions. Studies on the influence of personality traits in MCM show that healthy subjects with high depression scores tend to recall more negative experiences after the induction of a sad mood condition (Rusting, 1999), supporting the idea of a persistent recollection of aversive and negative memories in depressive patients (Direnfeld & Roberts, 2006). The same mechanism in the opposite direction may also help explaining mania in bipolar disorder (BD). For instance, Delgado et al. (2012) indicate that people with BD show higher scores in a word span with positive content in relation to healthy or depressive individuals (Delgado et al., 2012), suggesting positively-biased memory processing may be connected with symptoms of the disease.

Similarly, recent research on mood-congruent learning and attentional bias in non-clinical populations may clarify MCM in depressed and dysphoric individuals. Both clinical conditions have been associated with sustained attention for negative cues presented for longer durations (Koster et al., 2005; Leyman et al., 2007; Koster et al., 2010). Notably, Koster et al. (2010) suggested that changing attentional focus may lead to positive outcomes, as observed

in cognitive behavior therapy with patients with generalized anxiety disorders (Amir et al., 2009; Koster et al., 2010).

Neuroendocrine research has also reported evidence on the influence of cortisol over MCM phenomena. Under stressful social situations, individuals with elevated cortisol responses tend to show impaired retrieval of emotionally arousing words and emotional images (Kuhlmann et al., 2005; Buchanan & Tranel, 2008). Smeets et al. (2006) described the poor reproduction of neutral words during stress, while emotional words were not affected (Smeets et al., 2006). These findings suggest a potential neurochemical mechanism for MCM, which may help elucidating the relationship between MCM and psychopathology, also indicating potential treatment alternatives for these conditions.

### *Neural basis of MCM*

Studies exploring the neurophysiological correlates of MCM may help to discover whether MCM reflects memory processes during memory encoding or response biases at the moment of the retrieval. However, in our review, only three out of sixty-eight studies explored the neural basis of the MCM effect.

Kiefer et al. (2007) used electroencephalography (EEG) to explore the patterns of neural response during the encoding phase of MCM. The results showed that, depending on the current mood state, positive and negative words seem to be processed in different ways. This suggests that MCM effect is not only a retrieval bias but that it originates at the time of encoding. As the source analysis pointed that structures commonly associated with semantic knowledge (parahippocampal cortex, perirhinal cortex, fusiform gyrus) had different activations depending on mood and valence of the words, the authors also suggested an influence of the semantic processes in the MCM effect. Lewis et al. (2005) explored the neural networks underlying the MCM effect using functional magnetic resonance imaging (fMRI). The framework of this study is the Bower's model (1981) and one of the aims of the authors was to observe neural activity corresponding to the nodes of Bower's model. The results showed that the structures activated for mood-congruent encoding are the same activated for mood-congruent retrieval: the subgenual cingulate for positive words and the right parietal lateral orbitofrontal cortex for negative words, which are structures known to be involved in emotional processing. The authors interpreted these results as a demonstration of the associative model. Also using fMRI, Fitzgerald et al. (2011) showed an implication of frontal structures in

the MCM learning, with activation of the left medial- and inferior-frontal gyri during mood incongruent memory and with activation the left orbitofrontal cortex during mood-congruent memory.

In summary, the few studies exploring the neural correlates of MCM highlighted that the origin of the phenomenon happens during encoding and that frontal structures seem to be implicated in the MCM phenomenon. The results also support Bower's associative model. Nevertheless, these studies were not able to demonstrate a clear pattern of activations and more studies in this field are needed in order to understand the neural mechanisms underlying the MCM effect.

### ***Limitations***

Some limitations to a direct interpretation of data from the MCM literature should be considered. Sample characteristics could also have influenced the results. In fact, most of the participants are undergraduate students, from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies (Henrich et al., 2010). This could limit the ability to generalize results globally. Another limitation associated with this review lies in the heterogeneity of the methodologies used across studies (e.g., explicit memory vs. implicit memory, different types of MIP, and different types of material for the memory task). The latter factor affects reliability of comparisons between different studies. However, those limitations seem intrinsic to the field of research and, as discussed in the next part of this review, further studies are needed in order to understand better the mechanism underlying the MCM effect.

### **Conclusions and future directions**

Mood-congruent memory seems to be a strong phenomenon; however, the factors mediating the occurrence of the effect remain unclear. Characteristics of the material used in the memory task (e.g., structure, valence intensity, self- vs. other-reference) and characteristics of the participants (e.g., personality, physiological arousal) are factors likely to modulate the presence of MCM. Bower's associative network theory combined to the mood regulation concept seem to provide the best available framework to explain the effect, with initial support for this from neuroimaging studies. Authors who explored the neural

correlates of MCM also showed the implication of frontal structures and gave leads regarding the mood-congruent learning vs. mood-congruent recall question. Indeed, the formation of MCM seems to have already its initial stages during the encoding phase.

However, the generalization of these results is limited because of the limited age range of the participants in the studies and also because of the heterogeneity of methodologies used across studies. Therefore, more research using systematic designs and different age groups is needed to be able to generalize the findings regarding MCM.

It is also important to have more studies controlling objectively the efficacy of the mood induction procedure, using physiological measures of the emotional state. Indeed, only two studies in this review ensured objectively that the participants reached the specific mood state, which is the first requirement to be able to interpret the results.

More research exploring the neural correlates of the MCM is also needed in order to understand the mechanism underlying the mood-congruent and mood-incongruent effects. As was the case with previous EEG and fMRI studies, this kind of research may help answer different theoretical questions about MCM and elaborate an actualized model of the phenomenon.

The exploration of MCM in ecological settings, comparable to Loeffler et al. (2013), may be useful to understand the impact of mood on memory in daily life and the relation of this phenomenon in the case of mood disorders. Indeed, some cognitive theories of depression postulate that mood-congruent phenomena may be crucial for developing depression and may contribute for the maintenance of depressive symptoms (Beck, 1976; Mathews & MacLeod, 2005; van Wingen et al., 2010). In line with this, duloxetine antidepressant directly influences memory retrieval, acting on brain regions responsible for modulating emotional memory in a valence-specific manner (Tendolkar et al., 2011). Future studies should explore how the pharmacological response in mood disorders may be mediated by MCM.

Future research should also investigate the site of action of different forms of treatment in association with neural correlates MCM. Lewis et al. (2005) report two specific brain structures as loci for valence-specific associative memory node: the subgenual cingulate and posterior-lateral orbitofrontal cortex (Lewis et al., 2005). The subgenual cingulate is known to be involved in the expression of pathological mood (Mayberg et al., 1999) and in mood disorders (Drevets et al., 1997). Further research may explore shared neural correlates between

MCM and depressive symptoms, potentially leading to the refinement and development of pharmacological and psychotherapy interventions.

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## Notes

- <sup>1</sup>“On retient par cœur malgré soi; et voilà pourquoi nous disons, retenir par cœur; car ce qui touche le cœur se grave dans la mémoire.”

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