

## Determinants of quality, specificity, and stability of emotional episodic memories in a fine-dining context

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### ABSTRACT

For theoretical and practical reasons, it is of great interest to understand how accurate and persistent episodic memories of enjoyable experiences are formed and maintained, for example, in the context of gastronomy and other instances of experience design. Here, we investigated factors that might affect the quality (a measure of coherence) of immediate and long-term emotional episodic memories of individual dishes of a long and complex dinner in a fine-dining restaurant. We also assessed long-term recognition memory for pictures of the dishes. Intra-class correlations revealed good immediate emotional episodic memory, which remained stable over three months. Contributing factors to these kinds of memory were assessed with path modelling. The quality of emotional episodic memory was enhanced by the hedonic intensity of the most valued dishes during the meal and was impaired with the hedonic intensity of the least valued dishes. Enjoying the final dish positively affects emotional memory after the experience. Interestingly, when diners reported to have been distracted from the meal, presumably by communicating with their meal companions about the food, it had a positive effect on the long-term emotional episodic memory. Personality traits of the diners had no substantial impact on either type of memory. Alcohol intake during the meal modestly affected recognition memory but – interestingly – had no statistically significant effect on emotional episodic memory. Altogether, this study provides novel information about the main determinants of the precision and temporal stability of emotional episodic memory and nonemotional recognition memory for a meal. These findings contribute to the psychological foundations of designing memorable experiences in gastronomy and other areas.

*Implications for gastronomy:* Knowing what factors may determine whether a gastronomic experience would be memorable to diners is the holy grail of any chef. The design of a gastronomic experience should provide intense emotional moments to the diners aiming to increase the quality of emotional memory of those moments. Different factors contribute to this stability, for instance, how the diner interacts with the food and the food itself. In this regard, serving in a dining course very tasty and less delicious dishes thereafter can enhance the memorability of the former, but not so much of the latter, as it may be disturbing for the diner. Critically, enjoying the final dish positively affects emotional memory after the experience. In addition, most gastronomic events are shared with companions. Far from being a distracting element, social relationships in a table seem to increase the memorability of the experience, as communication deeply elaborates and reinforces memory traces. In the reinforcement of emotional memories for foods, alcohol has a negligible effect. Although our findings have been obtained in a fine-dining context, the implications of our current findings might be generalizable to other, more standard contexts. The critical point is to focus on having positive specific episodes rather than having a

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positive global valuation. All these outcomes would converge to increase the probability of repeating the gastronomic experience, regardless of whether it is a high-level restaurant or a standard one.

## 1. Introduction

Fine-dining restaurants are exciting and fashionable places, where chefs aim to provide user-centered experiences as multidimensional events (Lee et al., 2020; Lee, 2021; Palczak et al., 2020; Stierand and Dörfler, 2012; Spence and Youssef, 2018). How consumers appraise and remember the most enjoyable moments might depend on multiple factors, for example, person-specific variables (preferences, expectations, personality traits, habits, etc.), characteristics of the foods (design complexity, product salience, appeal, etc.), and the atmosphere surrounding the experience (social, physical, task-related, cultural, etc.) (Forlizzi and Battarbee, 2004; Köster, 2009; Spence and Youssef, 2018). From a psychological perspective, it is interesting to know whether and how this collection of factors may implicitly impact the diners' cognition and behavior during the gastronomic experience. Such experience combines sensory characteristics while the diner is interacting with food (visual, taste, olfactory, etc.) and idiosyncratic features like preferences and personality traits (Köster, 2009; Mojet and Köster, 2002; Spence, 2022). The outcome of fine-dining (or any dining) is a subjective state that is associated with reward (or punishment) that may be implicitly evaluated as pleasant (or unpleasant) (Rolls, 2014; Rolls et al., 2003). In addition, a positive or negative emotional state may be induced (Rolls, 2016). As a result, sensory properties, reward value and emotional valence are encoded in the long-term for further mental or physical actions (e.g., decision-making, going for dinner again in the same place). This unified view is empirically supported by neurocognitive models, as we describe below.

At the core of the diner-food relationship is emotion and the reward value that the diner attributes to the overall dining experience. Apparently, such episodic contents are implicitly encoded in memory, not only during the experience itself but also thereafter (Edwards et al., 2016; Giboreau and Meiselman, 2018). Deciphering the optimal combination of these factors to maximize memorability based on hedonic evaluation in both the short- and long-term should be of great interest to food and consumer researchers and gastronomists. To meet this challenge, in the present study, we applied an integrated approach and explore several factors that might predict the encoding of food memory. In particular, we aimed to elucidate the multidimensional and joint effects of certain person- and gastronomy-specific factors on the memorability of hedonic experiences in a fine-dining context.

Previously we reported the relations between a range of food- and personality-related factors and global hedonic evaluations of a fine-dining experience, and which of these factors impact memorability (Muñoz et al., 2018). We demonstrated that some factors (e.g., high liking of the final dish, agreeability, interest, etc.) predicted the overall evaluation of a meal experience in immediate and long-term retrospective. While the final dish of a multi-course meal had a positive impact on the overall evaluation at both time points, any dishes rated as being below average had a negative influence on long-term hedonic evaluation. Moreover, diners with more agreeable personalities, as measured with the big five inventory, gave higher overall long-term evaluations of the meal.

In the present study, we aim to go beyond global subjective hedonic evaluations and seek for objective and fine-grained measures of memory. Specifically, we examined the precision of remembering the appraisal of the momentary pleasures in specific dishes (remembered utility; Kahneman, 2000; Kahneman et al., 1997). To do so, we used the coherence between instant and remembered utilities as an index of the quality of episodic emotional memory retrieval (Rolls, 2016, pg. 822) for a fine-dining experience. Importantly, we investigated the determinants of the quality of emotional episodic memory as contrasted with

non-emotional recognition memory and modelled the influence of various factors on these memories over three months. The three-months period was considered as a compromise between retention in long-term memory and decay over time (Zhang, 2019).

### 1.1. How affective moments impact the quality of episodic memories

Tulving and Thomson (1973) described episodic memory as a neurocognitive system that enables humans to remember past experiences, including their feelings associated with these experiences. However, when recalling an experience, usually neither perceptual nor affective components of those episodes are precisely reproduced (Conway, 2009). Instead, emotional episodes are reconstructed by integrating post-experience information, current emotion, memory elaboration, and retrospective appraisals and feelings (Buchanan, 2007; Cowley, 2007; Levine and Safer, 2002). Additionally, enduring characteristics like personal preferences, personality traits, expectations, or cultural constraints may impact the recalled episodes and how individuals relate to them (Higgs, 2016; Nisbett and Wilson, 1977). Interestingly, perceptions that were encoded together with an arousing emotional state have a higher probability to be vividly and confidently recalled and are forgotten more slowly (Berntsen and Rubin, 2002; Plutchik and Kellerman, 2013; Tambini et al., 2017). In other words, emotions are components of episodes that survive extinction over time, as they are consolidated more strongly and retrieved more quickly than perceptual components alone (LeDoux, 1996). Conversely, studies focusing on how well individuals remember their initially reported emotions in the long-term, reported moderately sized agreement rates ( $r = 0.50$  or above; Levine and Safer, 2002). Allen, Kaut and Lord (2008) proposed a neurocognitive model that integrates emotion and episodic memory with a special emphasis on the affective component. This model suggests an interplay of the amygdala (emotional processing), the ventromedial prefrontal cortex (emotional executive functions) and the dorsolateral prefrontal cortex (executive attention) in the encoding and retrieval of episodic memories (Allen et al., 2005; Bechara; Damasio, 2005; Buchanan, 2007; Kilpatrick and Cahill, 2003). Overall, there is convincing evidence that episodic memory also involves contributions of affect and emotion.

Despite their importance, yet the mechanisms and determining factors of episodic memory for real life contexts are not well investigated. For the gastronomic context, Zandstra (2006) emphasized that for decision-making in food choice the memory of food is more important than the actual food. Importantly, Köster (2009) not only stressed that emotion is a crucial element of episodic memory for food, but also that it is a special type of implicit memory. Emotions drive food-related behaviour to a large part implicitly or unconsciously. Hence, when experiencing a meal, the learning processes may be mostly incidental and implicit rather than explicit or conscious. In the following, we will introduce evidence on how various psychological factors impact episodic memory with special emphasis on food and affect in gastronomic contexts.

### 1.2. The peak-end effect on the quality of emotional episodic memory

One of the factors that might determine the quality of emotional episodic memories of complex experiences is the peak-end effect (Fredrickson and Kahneman, 1993; Fredrickson, 2000). Kahneman et al. (1997) defined the peak-end effect as an arousing state in which the experienced utility of an episode is based on the most intense moments and the final moment of this episode. In previous research we observed that both peak and end moments have substantial impact on global

hedonic judgments about a meal in the short- and long-term (Muñoz et al., 2018). Moreover, negative or trough moments (minimum liking ratings) during a meal impacted long-term global hedonic evaluations. We concluded that inserting (relatively) less delicious dishes in between more delicious ones might enlarge the contrast between moment-to-moment appraisals, possibly enhancing emotional episodic memory. In fact, other studies have found that this intensity contrast may result in even lower liking ratings of trough moments, as an effect of perceptual change rather than as a behavioural change (*hedonic contrast and condensation effects*, Zellner et al., 2006, 2009). Therefore, the peak-end rule seems to be a useful heuristic to explain how people make retrospective global hedonic judgments based on averaging over the best (and worst) moments of the experience as well as its end state (Montgomery and Unnava, 2009). However, there is little empirical evidence on whether the peak-end effect may also contribute to the encoding and retrieval of episodic memories in gastronomic contexts. As the peak-end rule encompasses the average of the most arousing moments (both delicious and unpleasant), it seems likely that the higher the intensity of the peaks (or troughs), the higher the coherence between actual and remembered hedonic ratings.

### 1.3. The diner-food interaction and individual differences in memory for food

Most, if not all, hedonic meal experiences are designed in a user-centered way, integrating knowledge from experiential (e.g., tastiness, food appearance, beverage pairings, etc.) and psychological (e.g., attention, feelings, motivation, etc.) research (e.g., Benz, 2014). The way diners perceive food and drinks is central for making a hedonic meal experience long-lasting. While experiencing salient and rewarding episodes, diners mobilize food-related cognitive processes, such as executive attention, as well as affect regulation. Such cognitive and emotional processes are key ingredients to encode emotional episodes in memory (Higgs, 2016; Brunstrom et al., 2012). Arguably, perceptually appealing dishes more likely elicit a mental image in working memory by recruiting attentional resources (for a review on mental imagery see Moulton et al., 2009). If this mental image is further re-accessed and elaborated, it will create a consolidated long-term memory trace (Higgs, 2016). In line with this idea, Shepherd's (2006) neurobiological human brain flavour system model suggests that neocortical systems consciously process food-related sensory information, whereas limbic circuits unconsciously process emotional and motivational aspects. The model emphasizes the critical role of language for the consumers' experience appraisal. Thus, we may infer that specific components or characteristics of food may be more effectively encoded if other contextual information is concurrently present, for example, when chatting with others about the consumed meal. This reasoning is also in line with the *congruency Subsequent Memory Effect* (cSME; Staresina et al., 2009), that is, the bolstering of episodic memory for congruous events by semantic associations generated and relationally integrated via left inferior frontal gyrus (LIFG) – hippocampal encoding mechanisms.

Although most food-related behaviours entail implicit processes (Köster, 2009), some become explicit and can be assessed via questionnaires. For instance, we used a Meal Experience Questionnaire (MEQ, described in our previous work, also in Appendix; Muñoz et al., 2018). We observed that interest in novel and surprising dishes positively impacted the global hedonic experience in both short- and long-term (Vad Andersen and Hyldig, 2015). Hence, diners may orient their attention to reexperience vivid episodes in memory, in turn eliciting strong hedonic responses (Belasco, 2008). We also observed that *tastiness* (*valence*) of food was associated with ratings of global experience in the short-term but not in the long-term (Muñoz et al., 2018), possibly as a hedonic component of food reward (Higgs, 2016).

Interestingly, we (Muñoz et al., 2018) found a strong commensality effect, that is, diners sharing a table showed high consistency in their

global hedonic ratings (whether good or bad), presumably due to also sharing opinions about the meal. Arguably, commensality and related activities may also have disruptive effects on encoding episodes of the food experience, because of depleting general cognitive resources to build a mental image of the food (Robinson et al., 2013). Conversely, commensality may be positive if the information shared between the meal companions is related to the consumed food (Park et al., 2014). If despite being distracted by interpersonal communication, the quality of the episodic memory about the food and its experience is high, this may be evidence that implicit or unconscious processes, congruent with the food experience, are modulating the memory for food to form an enriched mnemonic trace (effect of congruency on memory formation, Craik and Tulving, 1975).

Memory for food and the related experience may also depend on the alcohol consumption that often accompanies meals. Different experimental contexts yielded controversial results on the impact of alcohol on cognitive processing, e.g., working memory, episodic memory retrieval, semantic memory. For instance, Knowles and Duka (2004) found alcohol intake before an event to cause anterograde impairments but intake after the experience to cause retrograde facilitation, especially for emotional material (reinforcement effect of alcohol). Alcohol decreased performance, especially in recognition memory tasks (lower proportion of items identified as old, relative to new ones). Therefore, we considered it relevant to explore whether blood alcohol concentration (BAC) affects the mental image of dishes as revealed by recognition memory (e.g., discriminating pictures of dishes eaten vs. distractor dishes). Mojet and Köster (2002) observed good discrimination performance for target versus non-target dishes by following the cognitive strategy of discarding non-target dishes (correct rejections) rather than determining the characteristics of the target dishes themselves (hits). This strategy may be impacted by higher BAC. Regarding episodic memory in general, alcohol may have a differential effect on encoding and retrieval, as described by the asymmetric state-dependent effect (Mintzer, 2007). In the present study, we were also interested in whether the BAC attained by the end of the meal would affect emotional episodic memory.

Finally, characteristics of the individual, such as personality, food preferences, or motivation, may be critical for the appraisal of hedonic meal experiences, as well as for the encoding of affective moments in episodic memory. For instance, personality traits (extraversion, neuroticism, agreeableness, etc.) may impact affective mechanisms across different cognitive processes like attention, memory, or decision-making (reviewed by Dolcos et al., 2017; see also Hamann and Canli, 2004). Hooker et al. (2008) observed different profiles of amygdala-hippocampus activation depending on personality dimensions, indicating that emotional episodic memory may be modulated by positive (extraversion) and negative (neuroticism) emotion-related personality traits. High negative affect, as typical in neuroticism, may bias emotional processing and, thus, the encoding of affective episodic memories. Allen et al. (2005) found a relation between changes in episodic memory and levels of emotional activation that paralleled changes in neural activity in connections between the amygdala, hippocampus, anterior cingulate and the insula (Kilpatrick and Cahill, 2003; Dolcos et al., 2017). Our previous study (Muñoz et al., 2018) showed that agreeableness was positively associated with long-term overall hedonic judgments, while higher conscientiousness went along with lower hedonic judgments. We expected similar relationships of personality and the quality of emotional episodic memory.

### 1.4. The present study

Although there are some reports on memory for food, as reviewed above (e.g., Zandstra, 2006; Higgs, 2016; Köster, 2009), research on emotional memory for specific dishes at different moments is scarce, particularly in realistic contexts. There is also little information on the factors that modulate the emotional memory for meals, especially in the long-term. Uncovering such factors is of particular interest for its

implications on experience design in terms of hedonic utility. Therefore, the present study aimed to shed light on these questions by testing the relation between immediate hedonic dish-by-dish ratings and in retrospect (emotional episodic memory). We further aimed to analyse the stability of these relations across two time points, that is, immediately the meal and three months later. In addition to emotional episodic memory, we studied non-emotional recognition memory for the dishes consumed during the meal. According to the theoretical background and the previous empirical results reviewed above, we predicted the following: A) The quality of the emotional episodic memory is a function of the hedonic rating of dishes; B) the stability of emotional episodic memory (agreement between EMO1 and EMO2, see below) for food items over time should be robust because it is grounded in affective content; C) global hedonic evaluations after the meal and after three months are positively related with the quality of episodic emotional memory for food and its recognition in the long-term; D) regarding utility parameters (peak-and-end rule), peak and end evaluations of dishes are positively associated with the quality of the emotional episodic memory and non-emotional recognition memory, whereas we expect the opposite for trough evaluations of dishes; E) meal experience dimensions as measured by the MEQ (distraction, valence, etc.) as well as F) alcohol accompanying the food (BAC) is related with the quality of both emotional episodic memory and non-emotional recognition memory; finally, G) agreeableness and conscientiousness, respectively, are positively and negatively related with the diners' emotional episodic memory over the long-term.

## 2. Methods

### 2.1. Participants

The sample used in this study was described in detail in a preview work (Muñoz et al., 2018) and consisted in  $N = 80$  participants, grouped into 20 quartets of two women and two men each. Mean age of the 40 male and 40 female participants was  $46.0 \pm 8.4$  and  $44.5 \pm 9.1$  years, respectively; age range was between 20 and 60 years. When a group of four people had made a reservation at the restaurant, they were invited to take part in our study – as a quartet. Most quartets consisted of people who lived together (couples, families) or saw each other frequently (co-workers or friends). As compensation for participation, all dinners were given at half of the regular price (drinks were charged regularly). After being informed about the requisites and terms of the study, participants signed informed consent. The study had been approved by the ethics committee of the Universidad Complutense de Madrid (UCM).

### 2.2. Location and materials

The study was conducted in the restaurant Mugaritz (Errentería, Spain), awarded with two Michelin stars and at the time of the study ranked 7th in the World's 50 Best Restaurants (<http://www.theworlds50best.com/list/1-50-winners>). The diners belonging to a quartet were seated at a table located next to other tables in the restaurant,

assimilating as much as possible with its general atmosphere. During the meal participants answered short questions via their smart phones. In the frame of a larger project, a set of web cams was located in the middle of the table, though these data were not of relevance in the present study. Diners had consented to be video-recorded (without sound). The regular (sole) menu of the restaurant for the season, consisting of 23 dishes in fixed order (8 starters, 11 main courses and 4 desserts), was served to the participants. Fig. 1 shows an example starter, main course, and dessert. In case of dietary restrictions or nutritional incompatibilities of a participant, the menu was modified by substituting those ingredients without altering the main concept of the dish. Diners completed a number of questionnaires and tasks before, during and after their visit to the restaurant as shown in Table 1.

**Personality Questionnaire and demographics.** One or two weeks before coming to the restaurant, the Big Five Inventory (BFI; Benet-Martinez & John, 1998; John and Srivastava, 1999) was completed online. The BFI consists of 44 items to be answered on 5-point Likert scales, measuring the personality traits Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Demographic data (sex, age) were also collected at this time.

**Questionnaire during and after lunch.** An online platform installed on the participants' smartphones was used to post the questions and recorded answers during and after the lunch. Responses were provided on 5- or 10-point Likert scales. The questions covered the following domains: 1) Hedonic ratings from moment to moment after each dish (10-point scale from "I do not like it at all" to "I like it a lot"); 2) Immediate hedonic ratings on the whole meal (5-point scale from "very bad" to "very good") obtained directly after the meal; 3) Long-term hedonic ratings on the whole meal (5-points scale from "very bad" to "very good") obtained online three months after the meal. Additionally, the *Meal Experience Questionnaire* (MEQ) was administered immediately after the meal on the same platform. This questionnaire has five scales: (1) *Distraction*, the degree of attention towards or distraction from the food, (2) *Interest*, describing how boring vs. interesting the food was, (3) *Subjective well-being*, measuring mood from negative to positive, (4) *Valence*, that is, the degree to which the food was pleasing or liked, and (5) *Sensory Experience*, measuring sensory quality from poor to good. Each scale consists of four to five items (see Appendix), and each item has to be answered on 6-point Likert scales from 1 (completely disagree) to 6 (completely agree). All these scales show very good reliability: *Distraction* ( $\omega = .84$ ), *Interest* ( $\omega = .86$ ), *Subjective well-being* ( $\omega = .85$ ), *Valence* ( $\omega = .91$ ), and *Sensory Experience* ( $\omega = .86$ ). Finally, a recognition memory task was completed three months later.

### 2.3. Procedure

Table 1 provides a summary of the four study phases. In Phase I, after a quartet had arrived at the restaurant, the experimenter explained the general procedure and gave all information necessary to obtain consent to participation. Participants provided demographic data and completed the BFI at this stage. In Phase II, participants consumed the 23-course menu and participated in the regular procedure of the restaurant for



Fig. 1. Three dishes of the of the menu applied in this study. Left: Hand dish - 'Cultural textures. Several layers of dressed Kokotxas', Middle: Main dish - 'Daily catch, beetroot and horseradish', Right: Dessert - 'Anis waffle'.

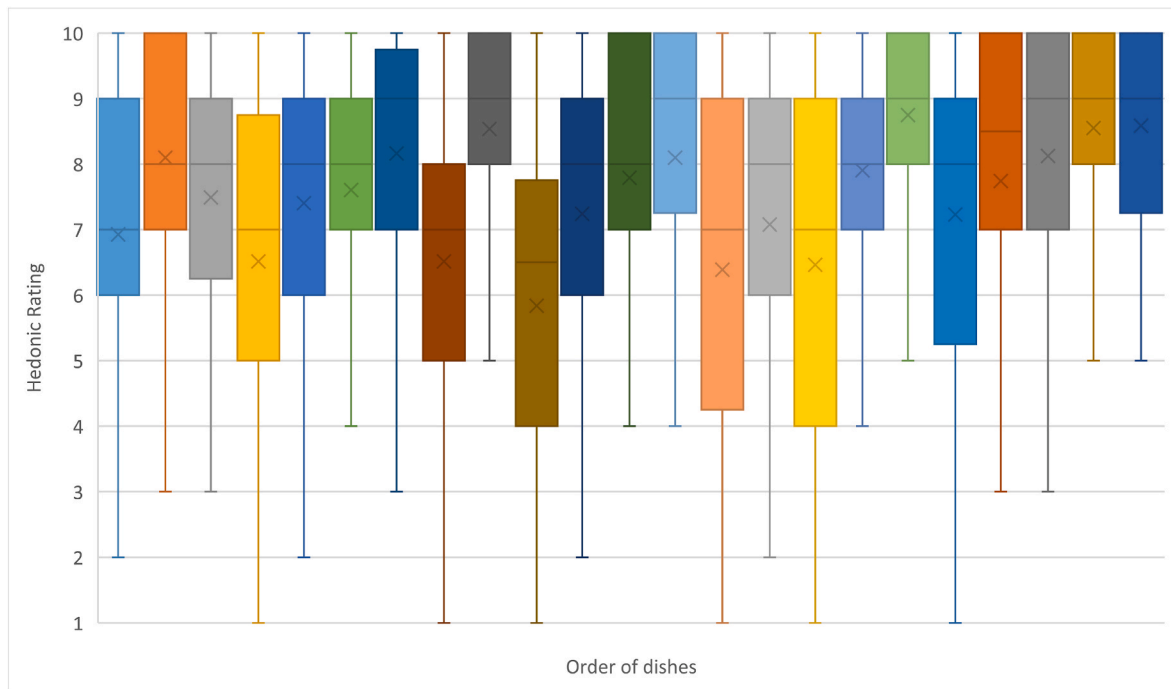


Fig. 2. Box-plot representing the interquartile range (box), with the medians (horizontal line) and means (X) of the hedonic ratings of the 23 dishes in order of dishes.

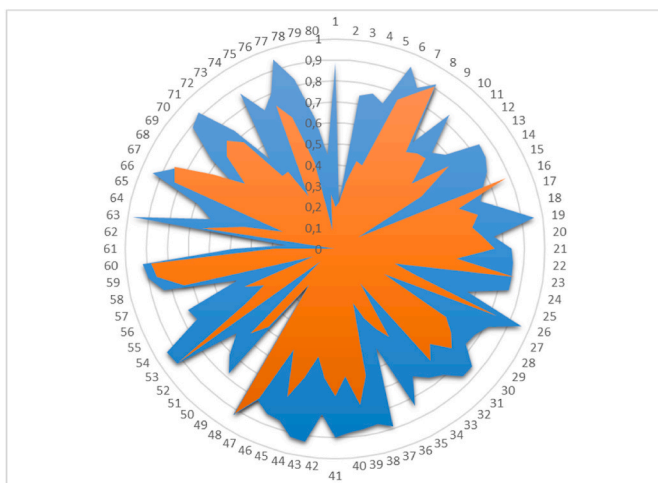


Fig. 3. Graphical overview of the ICCs per participant ( $N = 80$ ) of hedonic evaluations across 23 dishes and emotional memory immediately after the meal (Emotional Episodic Memory 1 = blue) and three months later (Emotional Episodic Memory 2 = orange). Higher ICCs indicate higher agreement between ratings and hence better emotional episodic memory. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

that season (e.g., menu, explanations by the waiter or sommelier, kitchen tour, etc.). The sommelier offered beverages that best matched each particular dish, such as white, red or sweet wines, and other beverages selected by the diners. After each dish, diners rated its hedonic value (moment-by-moment hedonic rating). Phase III began immediately after the meal was finished. Participants evaluated the total experience of the meal (immediate overall hedonic rating) and completed the MEQ. Moreover, they completed a cued recall task in which they were presented with pictures of the dishes, one at a time, and were asked to rate on a 5-point Likert scale how much they had liked each dish. Before leaving the restaurant, the blood alcohol concentration

Table 1

Questionnaires and tasks administered in the four phases of the study.

Phase I At home, some days before the meal	Phase II In the restaurant, during the meal	Phase III In the restaurant, after the meal	Phase IV At home, 3 months later
<ul style="list-style-type: none"> <li>• Demographic questions</li> <li>• Big Five Inventory</li> <li>• Informed consent</li> </ul>	<ul style="list-style-type: none"> <li>• Hedonic (liking) ratings of 23 dishes</li> </ul>	<ul style="list-style-type: none"> <li>• Immediate overall hedonic rating</li> <li>• Immediate dish cued recall task</li> <li>• Meal Experience Questionnaire (MEQ)</li> <li>• Blood alcohol concentration measurement</li> </ul>	<ul style="list-style-type: none"> <li>• Long-term overall hedonic rating</li> <li>• Recognition task (Recognition Memory)</li> <li>• Long-term dish cued recall task</li> </ul>

(BAC) in breath was measured with a standard alcoholmeter. Phases II and III lasted around 3 h. The use of smartphones as well as sharing opinions at the table, though inevitable, may have impacted the flow of the meal experience. Nonetheless, as it was similar across the sample, the impact on the main variable of this study (the quality of the emotional episodic memory) should have been similar for all participants. In Phase IV, three months after the restaurant visit, participants were contacted again via the online platform on their smartphones and asked to retrospectively rate their hedonic meal experience (long-term overall hedonic rating). Two additional tasks were completed in order: A) Recognition memory task (Recognition Memory), in which pictures of the dishes actually consumed at the restaurant had to be recognized amongst other dishes (distractor dishes), in a ratio of 1:3. B) The cued episodic emotion memory recall task, where the same pictures of the dishes were presented as done already immediately after the meal and rated on 5-point Likert scales on how much they had been liked during the meal.

2.4. Data analysis

2.4.1. Parameterizing emotional episodic memory and recognition memory

The quality of emotional episodic memory was parameterized by means of an intraclass correlation coefficient (ICC), indicating the agreement between the moment-to-moment hedonic liking ratings (range: 1–10) during the meal and those collected in the dish-cued memory task (range: 1–5) at two time points: in the short- (EMO1) and in the long-term (EMO2). Hedonic ratings in the dish-cued recall task were converted from 1 to 5 to 1–10 points to have a common measurement scale and comparable rating scales when calculating the ICC. Theoretically, the degree of intra-individual agreement (ICCs) measured in EMO1 and EMO2 is an accuracy index of the episodic memory trace across dishes encoded and consolidated over time. Recognition accuracy was additionally measured as proportion of hits in the long-term recognition memory test.

2.4.2. Path analysis

In order to address our research questions, we applied path analysis, asking how different factors jointly determine the quality of emotional episodic memory in the short- and long-term, and recognition memory in the long-term (Boudon, 1965; Duncan, 1966). This multivariate statistical analysis technique aims at simultaneously estimating a system of relationships (paths) between multiple independent (exogenous factors) and dependent (endogenous) variables. Endogenous, dependent variables are predicted in the system of linear equations, but are also used as predictors of other endogenous variables. Here, in all models the quality of emotional episodic memory was considered as dependent variable, and recognition memory was considered as both dependent and as predictor variable. Due to the limited sample size ( $N = 80$ ), path models were specified separately for different sets of predictors. The analyses were conducted with AMOS software (Arbuckle, 1999).

The following models were tested:

**Model 1.** The baseline path model (Fig. 4) estimates the relationships between EMO1 and EMO2, including recognition memory. In this model we additionally tested the effects of BAC as a further independent variable. The subsequent path models were built upon this baseline path model (omitting BAC) and tested how the estimated effects are modulated by further exogenous variables.

**Model 2.** This model is depicted in Fig. 5. The following variables were added to the baseline model: a) Mean-peaks value defined as the average ratings of the 25% highest rated dishes; b) Mean-troughs values defined as average ratings of the 25% lowest rated dishes; c) End peak defined as the value of the last dish (last dessert).

**Model 3.** The dimensions of the meal experience as assessed by the MEQ, namely, Distraction, Interest, Subjective Well-Being, Valence, and Sensory experience, were added as further exogenous variables to the

baseline model (see Fig. 6).

**Model 4.** Personality traits assessed by the Big Five personality dimensions -Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism-were added to the baseline model (see Fig. 7).

**Model 5.** Finally, short- and long-term global hedonic ratings were combined with the baseline model (see Fig. 8).

Standardized path coefficients will be reported as measures of association in the path models, using maximum likelihood estimation. Different measures of fit will be reported (Hair et al., 1998); a well-fitting model will yield a low  $\chi^2$ -value and  $p$  should be  $> .05$ , given the degrees of freedom of the model computed as the difference between the number of observed variables and the number of parameters to be estimated. As alternative fit indices, the *root mean square error of approximation* (RMSEA, Steiger, 1990) and the *comparative fit index* (CFI, Kline, 1998) are provided. RMSEA should be  $< 0.05$  to indicate good fit, whereas the CFI should be  $> 0.90$ . Multivariate normality was tested by Mardia's coefficient (multivariate kurtosis), indicating non-substantial deviation from normality if the associated critical ratio (c. r.) is  $< 1.96$  (Gao et al., 2008).

3. Results

3.1. Intraclass correlation

Mean hedonic ratings of the 23 dishes are depicted in Fig. 2. Fig. 3 illustrates the ICCs for both time points for each participant taken as a measure of the quality of emotional episodic memory relative to their moment-to-moment hedonic ratings. As to be expected, the average ICC in the short-term was higher ( $M_{EMO1} = .77, SD = .16$ ) than in the long-term ( $M_{EMO2} = .55, SD = .23; t_{79} = 10.9, p < .0001$ ). They were both significantly different from zero ( $t_{79} = 42.3, p < .0001; t_{79} = 21.4, p < .0001$ , respectively). From Fig. 3, the decrement between EMO1 and EMO2 becomes apparent as a function of the relative overlap between the surfaces of the graphs.

In the total sample EMO1 and EMO2 were moderately correlated ( $r = .61; p < .001$ ). Mean accuracy in the recognition memory task (Recog Mem 2) was 75.9% ( $SD = 16.03$ ), and was weakly associated with EMO2 ( $r = .23; p < .05$  two-tailed) but not with EMO1 ( $r = -.03; p > .5$  two-tailed). These associations indicate moderate but persistent EMO1 and EMO2 values across dishes and provide empirical indices of the strength of episodic emotional memory traces at both time points. Moreover, the (moderate) correlation between EMO1 and EMO2 indicates that the measurements of emotional episodic memory are fairly stable across time. Recognition memory was weakly but positively associated with EMO2, that is, the higher the quality of emotional episodic memory in the long-term, the better the target dishes were recognized. There was no correlation between recognition memory and EMO1, which may be

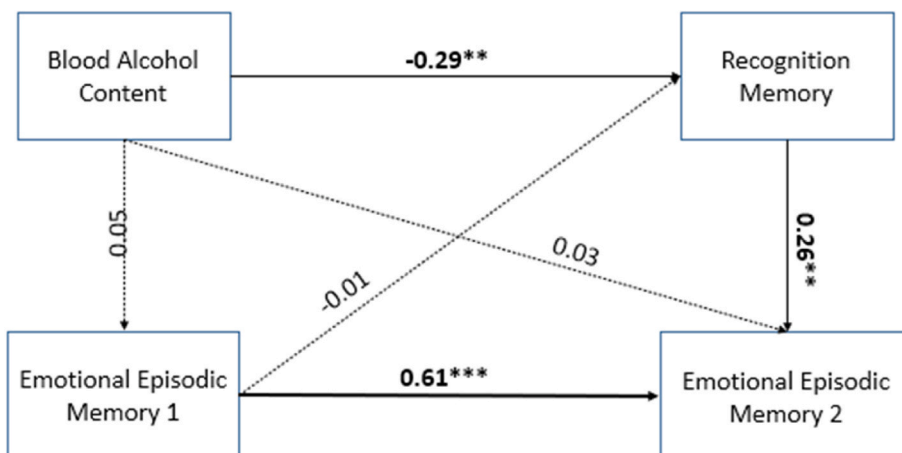


Fig. 4. Baseline path model including blood alcohol concentration as exogenous variable. Emotional Episodic Memory 1: accuracy of emotional episodic memory immediately after the meal; Emotional Episodic Memory 2: accuracy of emotional episodic memory after three months; Recognition Memory: recognition memory performance of pictures of the dishes after three months. Arrows indicate estimated significant (full lines) and non-significant (dotted lines) standardized path coefficients. \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ .

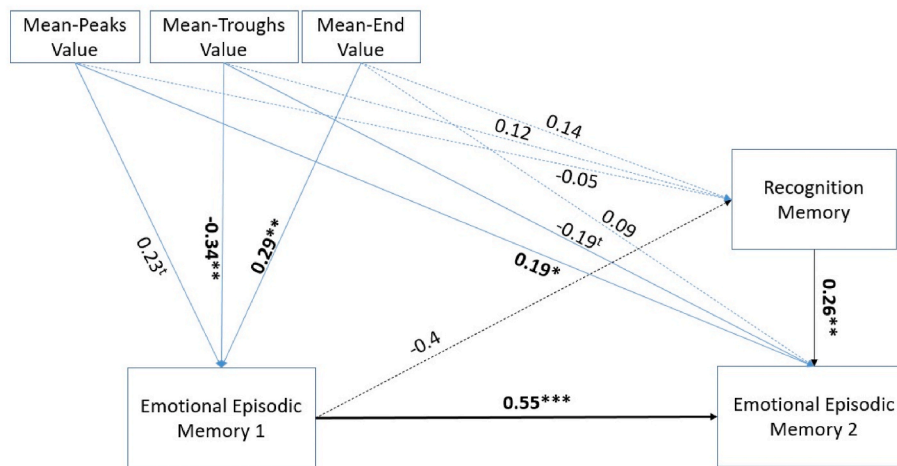


Fig. 5. Path model adding utility parameters to the baseline model. Emotional Episodic Memory 1: accuracy of emotional episodic memory in the short-term; Emotional Episodic Memory 2: accuracy of emotional episodic memory in the long-term; Recognition Memory: recognition memory performance in the long-term. Arrows indicate estimated significant (plain) and non-significant (dotted) standardized path coefficients. \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ .

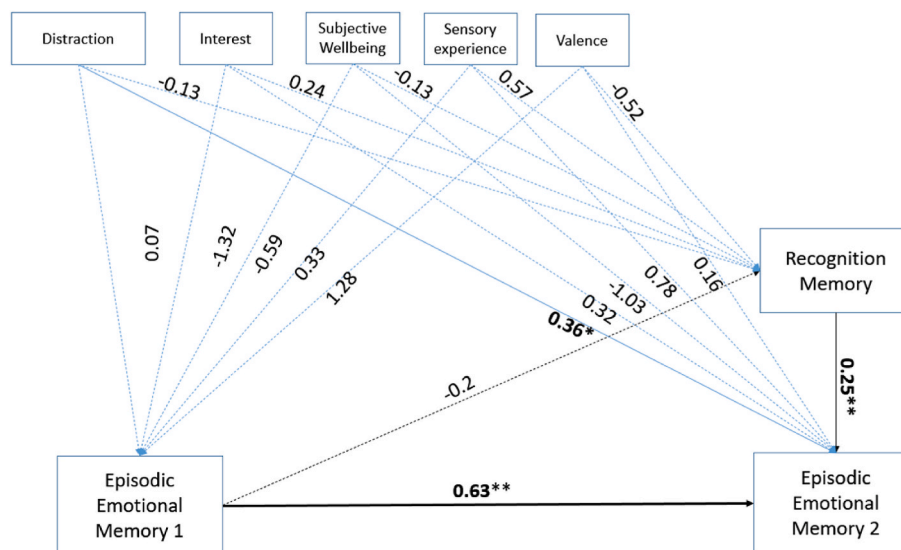


Fig. 6. Path model adding the dimensions of the MEQ to the baseline model. Emotional Episodic Memory 1: accuracy of emotional episodic memory in the short-term; Emotional Episodic Memory 2: accuracy of emotional episodic memory in the long-term; Recognition Memory: recognition memory performance in the long-term. Arrows indicate estimated significant (plain) and non-significant (dotted) standardized path coefficients. \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ .

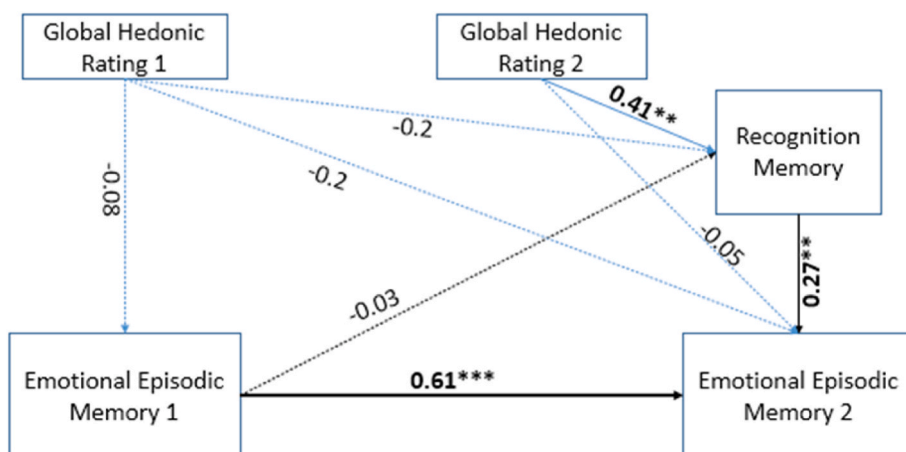
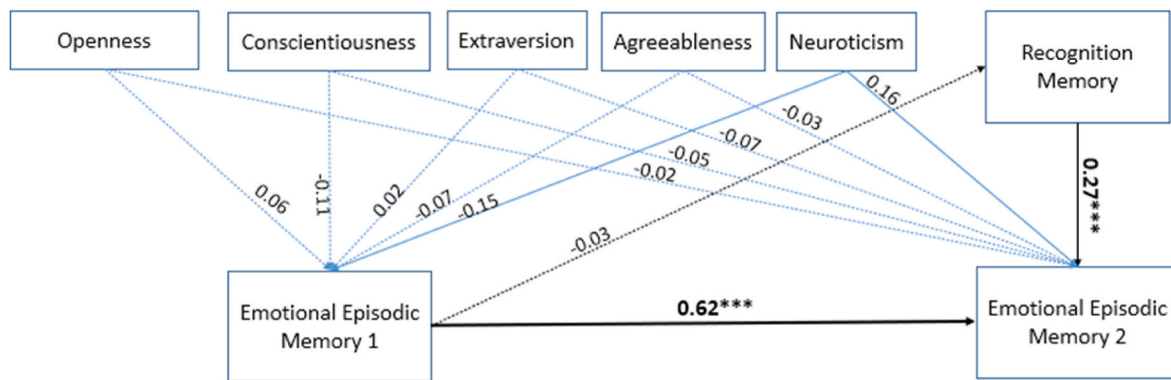


Fig. 7. Path model adding global hedonic ratings to the baseline model. Emotional Episodic Memory 1: accuracy of emotional episodic memory in the short-term; Emotional Episodic Memory 2: accuracy of emotional episodic memory in the long-term; Recognition Memory: recognition memory performance in the long-term; Global Hedonic Rating 1: global hedonic rating in the short-term; Global Hedonic Rating 2: global hedonic rating in the long-term. Arrows indicate estimated significant (plain) and non-significant (dotted) standardized path coefficients. \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ .



**Fig. 8.** Path model adding personality traits to the baseline model. Emotional Episodic Memory 1: accuracy of emotional episodic memory in the short-term; Emotional Episodic Memory 2: accuracy of emotional episodic memory in the long-term; Recognition Memory: recognition memory performance in the long-term. Arrows indicate estimated significant (plain) and non-significant (dotted) standardized path coefficients. \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ .

due to the long interval between these measures.

### 3.2. Theoretically derived path models

#### 3.2.1. MODEL 1. baseline model, including the effect of BAC

The baseline path model depicted in Fig. 4 tested whether EMO1 predicts EMO2 and whether recognition accuracy mediates this relationship. Mardia's coefficient was 1.5;  $c.r. = 1.2$ , indicating non-significant kurtosis and thus multivariate normality. The model is identified as free parameters and known variables are equal (zero degrees of freedom). There was a moderate relationship between EMO1 and EMO2 ( $b = .61$ ;  $p < .001$ ). Furthermore, better performance in the recognition task went along with higher EMO2 ( $b = .26$ ;  $p < .01$ ). As already indicated above by the bivariate correlations, EMO1 was not associated with recognition memory ( $b = -.01$ ).

Fig. 4 also illustrates the baseline model after adding BAC ( $M = 0.35$  mg/1 [IC 95%: 0.29 - 0.4]) as a further exogenous variable. This model tested potential effects of BAC on both EMO1 and EMO2, as well as on recognition memory. After including BAC, Mardia's coefficient was 4.4;  $c.r. = 2.8$ , indicating significant kurtosis, thus multivariate normality cannot be assumed. In this case, univariate normality tests indicated that EMO1 showed higher kurtosis (2.8,  $c.r. = 5.1$ ) compared with the other variables. Bentler (2006) emphasized, however, that  $c.r.s < 5$  do not have a severe impact on the  $\chi^2$ -test statistic. The model is just-identified. BAC did not predict EMO1 or EMO2 ( $b_{EMO1} = .05$ ,  $p > .05$ ;  $b_{EMO2} = .03$ ,  $p > .05$ ), but it had a weak but significant negative effect on recognition memory performance ( $b = -.29$ ,  $p < .001$ ). Other path coefficients were not significant. In both models we observed a moderate stability of EMO1 and EMO2, and non-emotional recognition memory performance was only related to emotional memory in the long-term.

#### 3.2.2. MODEL 2. Utility parameters: Peak and trough moments and the end

In model 2, we tested whether the average moment-by-moment hedonic ratings in the third quartile (peaks) and the first quartile (troughs), as well as the rating of the final dish predict EMO1, EMO2 and recognition memory. The model was identified with zero degrees of freedom. Mardia's coefficient = 4.2,  $c.r. = 1.95$ , indicates non-significant multivariate kurtosis, indicating that the variables were multivariate normal. While the effect size of mean-peak values indicated only a marginal effect on EMO1 ( $b = .23$ ;  $p = .057$ ), both mean-trough values and the end-values revealed moderate and significant relationships ( $b = -.34$ ,  $p = .007$ ;  $b = .29$ ,  $p = .01$ , respectively). For the long-term (EMO2), only the mean-peak values were significant predictors ( $b = .19$ ,  $p = .049$ ), while the effect of mean-trough values was a small trend ( $b = -.20$ ,  $p = .06$ ). The end-values had no long-term effect ( $b = .09$ ,  $p > .1$ ). The associations between EMO1 and EMO2 and non-emotional recognition memory only slightly changed as compared with the baseline model (see

Fig. 5), as was the case also in the following path models. Finally, we added the mean-peaks values and mean-troughs values as predictors of the memory variables of interest. However, these variables revealed no substantial associations. In sum, while end moment and trough moments had positive and negative effects (respectively) on emotional episodic memory at short-term, peak moments only had an effect on emotional episodic memory in the long-term.

#### 3.2.3. Model 3. Meal experience dimensions: distraction, interest, subjective well-being, valence, and sensory experience

The descriptive statistics for the MEQ scores for the various scales were as follows. Distraction:  $M = -.91$ ;  $SD = .62$ , range -1.9 to 0.3; Interest:  $M = .94$ ;  $SD = .69$ , range -.9 to 1.9; Subjective Well-Being:  $M = .87$ ;  $SD = .76$ , range -1.1 to 1.9; Valence:  $M = .59$ ;  $SD = .92$ ; range -1.7 to 1.6; Sensory Experience:  $M = .48$ ;  $SD = .88$ ; range -1.8 to 1.5.

Model 3 was identified (zero degree of freedom). Mardia's coefficient was 5.7;  $c.r. = 2.0$ , indicating significant multivariate kurtosis, and thus non-normal distribution. A univariate normality test indicated that EMO1 showed larger kurtosis (2.8,  $c.r. = 5.1$ ). As illustrated in Fig. 6, this model showed a significant positive relationship between *Distraction* and EMO2 ( $b = .36$ ;  $p = .039$ ), but no effects of any of the other MEQ dimensions on emotional or non-emotional recognition memory. Thus, in this model only the *Distraction* scale had an (negative effect) on emotional episodic memory in the long-term.

#### 3.2.4. MODEL 4. global hedonic ratings

Model 4 tested whether global hedonic liking ratings (GHR) about the meal immediately thereafter and three months later (GHR1 vs. GHR2), are substantial predictors of EMO1 and EMO2, as well as of recognition memory. The model was overidentified (as it has more observations than free parameters to estimate;  $df = 1$ ). Mardia's coefficient was 7.8,  $c.r. = 4.1$ , indicating significant multivariate kurtosis; therefore, multivariate normality cannot be assumed. Large univariate kurtosis was observed in GHR1 and EMO1, but they were not above the critical value ( $k = 2.1$  and 2.8;  $c.r. = 3.8$  and 5.1, respectively). Model fit was good:  $\chi^2 = 0.12$ ,  $p = .73$ ; RMSEA  $< .005$ ; CFI = 1.0. Path coefficients revealed that GHR2 predicted recognition memory ( $b = 0.41$ ,  $p = .005$ ). No other relationships of GHR1 or GHR2 reached significance. Summarizing, this model revealed that global hedonic ratings seemed to be positively related to non-emotional recognition memory at the long-term.

#### 3.2.5. MODEL 5. Personality traits

The descriptive statistics for the personality traits scores were as follows. Openness:  $M = 3.69$ ;  $SD = .52$ , range 2.3 to 4.9; Conscientiousness:  $M = 3.95$ ;  $SD = 0.57$ , range 2.5 to 5; Extraversion:  $M = 3.46$ ;  $SD = .67$ , range 2 to 5; Agreeableness:  $M = 3.81$ ;  $SD = .45$ , range 2.2 to

5; Neuroticism:  $M = 2.4$ ;  $SD = .69$ , range 1 to 4.4. Model 5 (Fig. 8) is overidentified (as it has five observations more than parameters to estimate;  $df = 5$ ). Mardia's coefficient was 10.1,  $c.r. = 3.5$ , indicating significant multivariate kurtosis, and violations of the multivariate normality assumption. Large univariate kurtosis was observed for EMO1 ( $k = 2.8$ ;  $c.r. = 5.1$ ), but it was not above the critical value. The model had a good fit:  $\chi^2 = 3.1$ ,  $p = .69$ ; RMSEA  $< .005$ ; CFI = 1.0. Personality traits, however, did not predict emotional episodic memory at any time point. Our results do not indicate that stable traits of the participants predict emotional episodic memory.

#### 4. Discussion

We investigated the determinants of emotional episodic and non-emotional recognition memory about a multi-course meal in an innovative fine-dining restaurant. Eighty guests of the restaurant were tested for their short- and long-term episodic emotional memory (remembering how much they had liked a particular dish during their visit) and for recognition memory using pictures of the dishes as cues. We assessed several sets of predictor variables for the memory performance by means of path modelling. Specifically, we analysed long-term non-emotional recognition memory for the dishes, blood alcohol concentration at the end of the meal, dish-by-dish hedonic evaluations during the meal, dimensions of a meal experience questionnaire, overall hedonic evaluations in the short- and long-term, as well as personality traits of the diners. In the following, we will first discuss the relationships between the quality in emotional episodic memory and non-emotional recognition memory as assessed in the baseline model, followed by the other variables of interest.

##### 4.1. Emotional episodic memory and non-emotional recognition memory

The quality of emotional episodic memory about the pleasantness of the dishes was parameterized as coherence coefficient between hedonic ratings given directly after eating each dish and then again at the end of the meal (short-term) and after three months (long-term). This analysis indicated a high quality of emotional episodic memory after the meal, which had somewhat decreased three months later. As to be expected, emotional episodic memory in the short-term significantly predicted emotional episodic memory in the long-term, revealing a considerable stability of emotional episodic memories over an interval of three months.

A parsimonious explanation of the slight decrement of episodic memories over time can be based on recency (Greene, 1986). It is likely that more recent and arousing events of a hedonic experience are recalled better than more remote events (Crowder, 1976). This may be due to different processes of re-elaboration during retention at short- as compared with long-term. For instance, post-experience events like sharing opinions, or even searching for similar dishes on the internet, may affect remembered perceptions and therefore the associated memory traces may change (Anderson, 2015). These post-experience effects during consolidation entail re-elaboration processes of memory traces impacting on the vividness and/or the attached reward value (Cabeza and Nyberg, 2000; Shepherd, 2006; Wagner et al., 2005). Our results show that the correlations of liking values (quality of emotional episodic memory) at short-term, though slightly decreased, seemed to be fairly stable in the long-term. This is in line with neurobiological models showing that the retrieval stage consists of an active re-learning process of previously acquired information, eventually affected by post-experienced instances (Cowley, 2007; Nader et al., 2000). Moreover, these models point to high-order cognitive processes that modulate experienced values, based on valence and intensity. They are substantiated in a neural network involving the memory/association systems of hippocampus, amygdala, dorsolateral prefrontal cortex and ventromedial prefrontal cortex.

Our results also indicate that long-term non-emotional recognition

memory moderately predicts the quality of the long term emotional episodic memory. It seems that diners who were good visual recognizers of dishes – as measured by non-emotional recognition memory – tended to be better in accurately retrieving their corresponding liking values. Visual properties of dishes should act as primers of affective content, as may be indicated by the observed relation of peaks and troughs with emotional episodic memory across the sample (Model 2). Non-emotional recognition memory processes may entail the re-access to the detailed episodes not only in the recognition task, but also when re-playing hedonic appraisals in the long term to discriminate actual from distractor dishes in an active choice task. Mainly for that reason emotional episodic memory and non-emotional recognition memory may be only weakly associated. Supporting such an association, in a study on preferred object multiple-choice task, activation of emotional memory-related areas, like vmPFC and precuneus/posterior cingulate cortex increased, whereas the activation in executive function- and perception-related areas, like dlPFC, posterior parietal cortex and occipital cortex decreased when the preferred object was present compared to when it was not (Deppe et al., 2005).

Blood alcohol concentration (BAC), as measured at the end of the meal, negatively affected non-emotional recognition memory for the pictures of the dishes; the more alcohol the diners had consumed, the worse was their recognition memory after three months. In contrast BAC had no effect on the quality of the emotional episodic memory. Although there was a wide range of alcohol intake among diners (mean: 0.35 g/dl [CI 95%: 0.29 - 0.4]), alcohol did not significantly affect the stability of emotional episodic memory across time. However, alcohol has a general debilitating effect on recognition performance (decreasing hit rates), presumably affecting cognitive processes of creating a mental representation of the event (e.g., Mintzer, 2007; Parker et al., 1976). This apparent differential effect of BAC on emotional episodic memory and non-emotional recognition memory is in line with the opposing retrograde and anterograde effects of alcohol (Knowles and Duka, 2004). Since most diners consumed alcohol during the whole meal, the effects were retrograde for the first few dishes and anterograde for the final dishes. Hence, we speculate that the joint effect of the retrograde facilitation and anterograde impairment has an impact on the process of discrimination between actual from distractor dishes but apparently spares the stability of emotional episodic memory. Therefore, we may assume that non-emotional recognition memory and emotional episodic memory are to some extent dissociable cognitive processes.

##### 4.2. Personality variables were not predictive of emotional episodic memory

Our results did not support that the personality traits studied here were determinants of the quality of emotional episodic memory. We had expected that personal characteristics like extraversion or agreeableness might play a role on how a diner appraises, evaluates, and remembers specific hedonic moments. In our previous study (Muñoz et al., 2018), we found that agreeableness positively predicted long-term overall hedonic judgments of the meal, while conscientiousness had the opposite relation. Such discrepancies between present and previous results may be due to the nature of the dependent variables, that is, the overall hedonic judgments in our earlier work vs. the quality of episodic emotional memory in the present study. Another reason may be the different statistical approach used in the studies: path analysis vs multilevel analysis. The lack of a relationship between personality dimensions and episodic emotional memory in the present analysis was somewhat unexpected given previous results about a relation of emotion-relevant traits and memory. However, it is also possible that personality and emotional episodic memory may be unrelated, irrespective of the statistical approach taken. Holtgraves and Athanassopoulou (1991) and Bradley et al. (1993) demonstrated that during an experience containing positive and negative episodes, participants with depressive/anxious traits or scored high in neuroticism remembered negative episodes better than

positive ones. These results indicate that neuroticism may serve as a predisposition to the preferential processing of stimuli congruent with negative thoughts or negative emotional associations. Similar results were found in extraverted persons being predisposed to recall more positive stimuli (positive words) (Desrosiers and Robinson, 1992; Lishman, 1972). The absence of a relation between the personality traits and the emotional episodic memory in the present data may be due to our non-clinical sample, which mainly exhibited intermediate values on the trait scales (Rusting and Larsen, 1998). Finally, it is possible that personality traits not explored here might be more relevant to food contexts, like sensation-seeking or variety-seeking, which may be studied in future research.

#### 4.3. Pleasant and unpleasant moments modulate the quality of emotional episodic memory

The peak-end effect (Fredrickson and Kahneman, 1993; Fredrickson, 2000) was tested by incorporating independent variables related to utility parameters (peak and trough moments and the final moment) into the basal model. The quality of the emotional episodic memory immediately after the meal was predicted positively by the end state (final dish) and, as a trend, by the more positively judged dishes (peaks). In contrast, it was negatively predicted by more negatively judged dishes (troughs). Three months later, emotional episodic memory was predicted positively and negatively by more positive and more negative moments (peaks and troughs) of the meal, respectively. The final dish did not contribute to the accuracy of long-term emotional episodic memory.

Although referring to the precision of emotional memory, this pattern of results is in line with the peak-end rule in that pleasant and unpleasant moments across a meal experience can disproportionately influence global affective memory (Kahneman, 2000; Rozin and Goldberg, 2004). More specifically, our results indicate that particular hedonic peak and trough values attached to the episodes during the experience may have a different impact in retrieving evaluations in the long-term, that is, the quality of emotional episodic memory. In particular, negatively experienced moments had a deleterious impact on the quality of emotional episodic memory. Some diners may have accumulated unpleasant moments across dishes and, therefore, showed less correlated liking valuations of the actual experience and of the remembered valuations in the short and long term, decreasing the precision of emotional memory. This suggestion was supported by informal reports collected after the meal. Diners who reported disagreement or dissent with the food showed more negative moments over the meal. It can be argued that a sustained negative state has a pervasive impact on what diners pay attention to over the meal. Thus, Egidi et al. (2008) observed that expectations can modulate what consumers pay attention to via brain structures that include the dorsolateral prefrontal cortex.

In contrast to the effects of hedonic troughs, positively experienced moments predicted the quality of emotional episodic memory in the long run, and marginally in the short term. A greater number of relatively pleasant moments across dishes seems to improve the quality of emotional episodic memory. Pleasant moments in a long series of dishes may be encoded better, because of their higher reward value, and hence may be recalled more vividly and precisely, reinforcing episodic memory traces (Gutwin et al., 2016; Moulton et al., 2009). It is worthy to mention that consumers who had the highest pleasant moments also had the most precise memories of the overall experience, regardless of the valence of the individual episodes. In other words, they felt the whole meal experience to be relevant and meaningful, as they reported during debriefing after the experiment. In our previous study we speculated that trough moments mixed with peak moments may have a positive influence on the consolidation of post-experience episodic memory. In the present study, we extended this suggestion by demonstrating that pleasant moments boost memory processes to maintain each instance of the whole experience, both positive and negative.

The experienced intensity of the final dish also predicted the quality of emotional memory in the short term. This result agrees with the mentioned peak-and-end rule by which the final moment has a strong impact, but only on the remembered enjoyment of episodes immediately after the experience. This contrasts with the strong effect of the final dish on the overall hedonic evaluation in both the short and long term, as reported previously. Hence, the end state might affect the emotional gist of the experience but may have no long-term effect on the details and precision of emotional episodic memory.

Taken together, dishes appraised positively yielded more accurate emotional episodic memories. By contrast, negatively experienced dishes impaired such quality as a possible effect of disrupted expectancies. Moreover, negative experiences predicted the quality of emotional memory in both short and long term, indicating that accumulating relatively unpleasant moments have a negative impact on encoding processes. Finally, many pleasurable moments and a positive end state make the details of the emotional experience more memorable, although further elaborations may occur between encoding and retrieval.

#### 4.4. Distraction dimension of the meal experience enhances quality of emotional episodic memory

The subjective experience of the meal was assessed by the Meal Experience Questionnaire (MEQ) on the dimensions distraction, interest, subjective well-being, valence and sensory experience. Distraction was the only MEQ dimension that predicted the quality of emotional episodic memory in the long-term. Surprisingly, the relation was positive, that is, the higher the reported distraction away from the food, the better the emotional episodic memory three months later. What appears counterintuitive becomes more plausible, when considering the items constituting the distraction dimension. The distraction dimension is defined by (not) “fully focusing on the food”, (not) “forgetting the world over food”, by “mindwandering away from the food”, being “distracted from food”, and “eating the meal rather on the side”. The responses above are compatible with more intense communication among the diners about the food they were just having at the same time. Thus, we speculate, if *distraction*, as measured by the MEQ, reflects communicating and exchanging opinions about the food with companions, it would plausibly explain the positive relationship with the quality of long-term episodic emotional memory. Such communication – whether verbally or nonverbally – should contribute to the elaboration of the memory traces about the hedonic value of the dishes, especially those discussed. In short, individuals who communicate a lot about the food may receive higher distraction scores, but this may be associated with deeper encoding and storing in emotional memory. This is in line with the classical model of Craik and Tulving (1975), according to which deep processing of pre-existing memory based on semantics and meanings results in durable memory traces. It seems that chatting may be understood as a self-assurance about a volatile first impression. This appears as a reasonable consequence of the social linkage established by communicating about the food experience. Across our sample, most quartets sharing a table consisted of (at least some) people who lived together (couples, families) or saw each other frequently (co-workers or close friends). In the lapse of three months, they may have had several opportunities to re-visit (recall) together stored episodes of food from long-term memory, to share and bring their opinions about dishes into agreement, or to re-consider their experience and their emotions about it (e.g., Barsade, 2002; Barhomeuf et al., 2009). The outcome might be an implicit post-experience process of re-elaboration and re-stored back into long-term memory, and a final re-consolidation and strengthening (Cowley, 2007; Tambini et al., 2017). However, we have to concede that our evidence about the effect of social communication on emotional episodic memory is indirect and the suggested conclusions are speculative. Nonetheless, considering the size of the effect – one of the strongest observed here – and the plausibility of the idea, more direct

investigations of this phenomenon appear to be warranted.

Recognition memory was not predicted by any dimension of the MEQ. This may be due to the fact that the non-emotional recognition process is basically different from the recall process when accessing emotional memory. Non-emotional recognition memory requires discriminating dishes actually eaten from distractor dishes based on recognizing a visual image in a multi-choice task, rather than retrieving or reconstructing an affective image from the past (Cowley, 2007; Levine and Safer, 2002; Köster and Mojet, 2007). None of the factors of interest described so far accounted for the performance in the recognition task. However, in all path models recognition accuracy weakly predicted the quality of emotional episodic memory in the long run. This might indicate that some salient visual features of the target dishes privileged the access to emotional memory of the event.

#### 4.5. Global hedonic scores relate to non-emotional recognition memory but not to emotional episodic memory

The overall hedonic evaluation of the meal taken three months after the meal was positively related to non-emotional recognition memory but not to emotional episodic memory, both measured at the same time. The former relationship may indicate that having an aggregated positive memory of the hedonic experience (companions, dishes, drinks, ambience, etc.) in the long run tapped into similar memory processes as recognition memory, that is, the discrimination between actually experienced (seen) vs distractor dishes. Possibly, experienced utility in the long-term was coherent with a vivid access to the mental visual images of the dishes irrespective of how diners hedonically judged them. Already Bartlett (1932) stated that people may recognize material that cannot be described in any detail (mere recognition by familiarity). This implies that our participants might have discriminated dishes based on perceptual cues, but not necessarily accessing or retrieving other information (hedonical, personal experience with that material, etc.). Classic models of recognition memory (e.g., Mandler, 1980) proposed that familiarity of a specific material is the result of intra-event integration of the sensory and perceptual elements. We assume that most members of our sample carried out the recognition test by relying on perceptual fluency rather than on the effortful retrieval of the original context (surroundings). In other words, the information they used in recognition performance may have been superficial (sensory-perceptual elements) (Horton et al., 1993).

Taken together, reconstructing an overall positive appraisal of the whole experience from the episodic memory seems to be associated with a heightened access to sensory-perceptual information, enough to discriminate actual from distractor dishes.

## 5. Limitations

A possible limitation of the present study is that multifactorial modeling requires estimating many parameters in a single model, which in turn demands large samples. We have dealt with this problem by separating the large number of dependent variables into separate models. Future research is desirable, which can either focus on selected variables or use larger samples to increase statistical power. Another conceivable limitation is that the present study was carried out in a fine-dining environment, which might affect generalizability. The procedures of the present study are worthy of being applied to other conditions, as well as to other countries, cuisines, and cultures, in pursuit of a foundation for how diners perceive food. Nevertheless, we presume that the implications of our results about a fine-dining experience might generalize to other, more standard situations where emotional memory may also be of relevance. Indeed, our results should also generalize to meals at home and even to other complex multi-element experiences, such as museum tours and other cultural events. Another point of concern might be the possible impact of the cameras on the naturalness of the situation, although diners reported only minimal disturbance.

Finally, there are a number of factors related to the atmosphere and service of the restaurant that we did not assess, but that might have influenced emotional episodic memory and its stability across time. Nonetheless, these factors, which are an intrinsic part of this kind of experience, were carefully standardized by the restaurant.

## 6. Conclusions and implications

Overall, we found highly acute emotional episodic memory immediately after the meal and -notwithstanding a slight decrease - after the relatively long interval of three months after the meal. Transient perceptual features of dishes are tightly linked to an affective value that may be prevalent for months.

Several aspects of our results may be translated into practical recommendations to boost the memorability of a gastronomic experience and, in turn, the chances to broadcast and repeat the experience. First, the experienced utility of a gastronomic experience: an emotionally intense experience seems to be enhanced by regularly recalling and re-elaborating its specific episodes. Accordingly, restaurants could strategize a “new way of service” incorporating some activities before the restaurant visit or the meal by posing questions considering expectations and collecting some information about the diner’s personality and preferences. Activities along with the experience and after the experience may help keeping alive episodic emotional memories, such as suggesting unusual and engaging questions by the waiters, writing down opinions on the meal, or asking for online evaluations of the experience after the visit. Indeed, post-experience factors (chatting with others about the consumed meal, interchanging the core meaning of dishes, and the personal relevance of the meal as a whole) are expected to re-elaborate perceptual-reward links in diners’ memories. Second, we also observed a reasonably strong positive relationship between emotional episodic memory and the distraction variable, as measured by the MEQ. This association, which was interpreted as reflecting commensality, (i.e., communicating with partners while sharing the meal) implies that social relationships at a table would increase the memorability of the experience, consolidating memory traces. Assuming that social interaction is at the heart of the gastronomic experience, commensality appears worthy of purposed investigation (e.g., Sommer et al., 2013; Sturmer et al., 2018). Third, our results also suggest that accumulating not very engaging dishes across the meal may lead to low quality of emotional episodic memory, both immediately after the meal and in the long run. It seems a good strategy to minimize non-delicious dishes and alternate with highly delicious ones to increase the quality of emotional memory. Less-delicious but “interesting” dishes may be attractive points of discussion, strengthening the precision of emotional memory rather than ruining the experience. Episodic emotional memory should be considered for designing and optimizing the user’s experience. This memory bridges perceptual features and their hedonic value, and that connection may be a critical factor for repeating and disseminating the experience.

### Credit author statement

Francisco Muñoz: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision. Andrea Hildebrandt: Methodology, Validation, Formal analysis, Resources, Writing - Review & Editing, Visualization. Annekathrin Schacht: Conceptualization, Methodology, Writing - Review & Editing. Birgit Stürmer: Conceptualization, Methodology, Validation, Writing - Review & Editing. Felix Bröcker: Conceptualization, Writing - Review & Editing. Manuel Martín-Loeches: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing - Review & Editing, Supervision, Project administration, Funding acquisition. Werner Sommer: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Writing - Review & Editing,

Supervision, Project administration, Funding acquisition.

### Distraction

I was fully concentrated on eating the dish.  
I forgot the world around me while eating.  
My thoughts were digressing again and again while I was eating.  
I was distracted while eating.  
I was eating the dish rather on the side.

### Interest

The dish had a boring taste.  
While eating I was excited to know what the next bite would taste like.  
The dish had an exciting taste.  
While I was eating I absolutely wanted to know what the rest of the dish would taste like.

### Subjective well-being

Eating the dish has lifted my mood.  
The food and taste experience was intensive for me.  
While eating I got more and more calm inside.  
The dish stimulated real emotions within me.  
I was feeling really happy.

### Valence

The eating was a pure delight for me.  
The dish tasted excellent.  
I liked eating the dish.  
I felt pleasure while eating.  
I was completely satisfied while eating.

### Sensory Experience

The dish looked terrible.  
The dish did not have any flavor.  
The dish was well seasoned.  
All the different ingredients of the dish matched perfectly.  
The dish was served appealingly on the plate.  
I liked the dish.

### Declaration of competing interest

The authors have no conflicts of interest to disclose.

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### Appendix

Scales and corresponding items of the meal experience questionnaire (MEQ).

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