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Does emotion modulate the efficacy of spaced learning in recognition memory?

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Abstract: Memory for repeated items improves when presentations are spaced during study. Here, two experiments assessed the so-called spacing effect on a yes–no recognition memory task using affective and neutral words. In Experiment 1, a group of participants was asked to orient their attention to semantic features of target words (deep semantic analysis) that were consecutively repeated or spaced, while another group was engaged in a graphemic shallow analysis of words (Experiment 2). The depth of word processing approach was meant to highlight the role of repetition priming mechanisms in the generation of spacing effects. We found that spacing effects occurred for both affective and neutral words (Experiment 1). However, following shallow analysis of words, the spacing effect was reduced for both affective and neutral words (Experiment 2). No differences were detected in terms of positive versus negative words. These results suggest that spaced learning operates when the to-be-remembered material is also affectively charged and that, under certain circumstances, it may enhance recognition memory as affective connotation does.

Subjects: Behavioral Sciences; Cognitive Psychology; General Psychology

Keywords: spacing effects; recognition memory; emotion

1. Introduction

Items that are repeated during learning are better remembered if their second occurrence is experienced after one or more intervening items from the first occurrence (spaced presentation) compared with a condition in which the second occurrence of an item immediately follows the first one (massed presentation). A decade of experiments in our labs showed that the so-called spacing effect is a very robust phenomenon that has been observed in explicit memory tasks like free recall, recognition, cued-recall, and frequency estimation (for a review see Russo, Mammarella, & Avons, 2002). Various theoretical accounts have been put forward to explain the spacing effect in explicit

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Nicola Mammarella is a professor of General Psychology at the University of Chieti (Italy). His main research interest is short-term and long-term memory. Nicola and his collaborators (Beth Fairfield and Alberto Di Domenico) are currently conducting a series of experiments that focus on the interaction between memory and emotion.

PUBLIC INTEREST STATEMENT

A larger number of studies have shown that spaced schedules increase retention in the classroom. Consequently, exploring whether spacing effects also occur when the to-be-learned content is affectively charged (e.g. as happens when students learn something they either like or dislike) may have relevant implications for planning efficient learning strategies.

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memory tasks, and it is now believed that a theoretical account of this effect should be multifactorial (for a review see Greene, 2008; Toppino, Fearnow-Kenney, Kiepert, & Teremula, 2009). With regard to cued-memory tasks (e.g. yes–no recognition, frequency estimation), the dominant theoretical view is an automatic deficient-processing account based on repetition priming mechanisms (Challis, 1993; Russo, Parkin, Taylor, & Wilks, 1998) that are semantically based with familiar, meaningful material and perceptually based with unfamiliar, nonsense targets (e.g. Mammarella, Russo, & Avons, 2002; Russo & Mammarella, 2002).

More specifically, this account suggests that the first presentation of a target in the study list primes the second occurrence of the target item, thus reducing its semantic processing. Moreover, repetition priming effects appear to be stronger when the delay between the prime and the target is short (e.g. Kirsner, Smith, Lockhart, & King, 1984), thus less semantic processing should be given to the second occurrence of items in massed presentation than in spaced presentation. This mechanism provides spaced items with more extensive semantic processing than massed items and, as a consequence, it provides a basis for the spacing effect to emerge.

The presence of a reliable spacing effect for words within a semantic repetition priming account of spacing effects in cued-memory tasks is now a well-established finding in the literature. However, it is not clear if the presence of the spacing effect is simply contingent on the use of neutral words as target items, or if it can be generalized to affective verbal material. The majority of spacing effects studies, in fact, did not control for affective dimensions of target words. The reason being that spacing effects in cued-memory tasks should occur independently of affective valence as repetition priming effects should operate for both neutral and affective words. In particular, as for neutral words, the first presentation of an affective word in the study list should prime the second occurrence of the target item, thus reducing its affective processing. Moreover, affective repetition priming effects also appear to be stronger when the delay between the prime and the target is short (e.g. Wong & Root, 2003); thus, less affective processing should be given to the second occurrence of items in massed presentation than in spaced presentation. This mechanism will provide spaced items with more extensive affective processing than massed items and, as a consequence, better recognition memory for spaced items. However, the role of affective variables on the generation of spacing effects may have been underestimated. There are a number of evidence suggesting that it may be the case.

First, some studies (e.g. Storbeck & Clore, 2008) have found stronger semantic and affective priming effects with positive words. This finding indirectly informs us that the size of spacing effects may be larger with positive compared to negative and neutral words.

Second, as far as we know, the only study which directly investigates the role of affect on the occurrence of the spacing effect was the one by Elmes, Dye, and Herdelin (1983). They asked participants to affectively judge massed and spaced neutral words along a pleasant/unpleasant dimension and found that massed words were judged as less pleasant than spaced words. Furthermore, when participants were asked to recall a series of positive and negative words, the spacing effect did not occur. Although data on the spacing effects in free recall tasks are explained by different theoretical accounts (e.g. see Toppino & Bloom, 2002), these findings point to the assumption that valence may somehow modulate the occurrence of the spacing effect in memory tasks.

Third, many laboratory studies have confirmed that individuals are more likely to remember valenced information than neutral information (e.g. LaBar & Cabeza, 2006). Thus, if participants are shown a series of affective and neutral stimuli intermixed at study, they will later recall or recognize a greater proportion of the affective stimuli than of the neutral stimuli. This "emotional memory enhancement effect" has been replicated in many studies (e.g. Kensinger & Corkin, 2003). The main idea is that individuals may be more likely to elaborate on items with valence (activating either semantic or autobiographical information), which could lead to an enhancement in the ability to remember these stimuli (because these items would then have been encoded in a more distinct

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fashion than neutral stimuli). In light of the mentioned evidence and in order to test the generalizability of earlier findings (e.g. Mammarella, Avons, & Russo, 2004; Mammarella et al., 2002; Russo et al., 2002), the present work intended to investigate the possibility of obtaining a reliable spacing effect in a yes/no recognition memory task for affective verbal material. The final aim is to study how the affective connotation of stimuli influences the generation of spacing effect. The questions concerned with whether the "emotional enhancement" in memory may somehow modulate the occurrence of spacing effects in cued-memory tasks: do affective items capture attentional and memory resources to the extent that spacing effects do not occur with neutral items? Is the size of the spacing effect comparable across affective and neutral words? Is the power of spacing effect in memory comparable to the one observed for affective items?

To do so, we asked participants to study and remember a series of words that were either repeated consecutively or spaced following deep/conceptual processing (Experiment 1), or a shallow or perceptual analysis (Experiment 2). The levels-of-processing effect refers to the finding that memory for a list of words is better when the meaning or semantic information of the word is encoded (deep processing), relative to focusing on more superficial aspects of the word (shallow processing) such as its perceptual, phonological, or orthographic characteristics (e.g. Craik & Lockhart, 1972; Rugg et al., 1998). Many tasks have been developed to orient participants' attention to different semantic or perceptual features of words and consequently vary the level of verbal encoding. For example, Rugg et al. (1998) asked participants to incorporate each word into a short sentence versus indicate whether the first or last letter of each word was in alphabetical order. Other studies instructed participants to indicate whether each word was animate or inanimate versus in alphabetical order (Otten, Hensonal, & Rugg, 2001) or to create an image of each word's meaning versus in alphabetical order (Walla et al., 2001). Also deciding whether each study word was "pleasant" led to better recall on a subsequent test compared to deciding whether it contained the letter "e" (Hyde & Jenkins, 1969; 1973). Although these tasks may vary in terms of the degree of semantic analysis, the main idea is that this type of processing activates more relevant knowledge than shallow processing, and this activated information (e.g. decision about a word's meaning, an affective connotation, etc.) becomes associated with the word to form a more elaborate memory trace.

This level of processing approach was used here in two separate experiments to highlight the role of repetition priming mechanisms in the generation of spacing effects. In fact, repetition priming effects are larger following the semantic encoding of words, while they are reduced following shallow processing (e.g. Smith, Theodor, & Franklin, 1983) leading to a subsequent modulation of the spacing effect strength (e.g. Russo et al., 2002).

Finally, studying the relationship between affect and spacing effects may be also significant from a practical point of view. In fact, a larger number of works have shown that spaced schedules increase retention in the classroom (e.g. for a review see Sobel, Cepeda, & Kapler, 2010). Consequently, it may be worth exploring whether spacing effects also occur when the learning content may be affectively charged as happens when students learn something they either like or dislike. However, it may also happen that even when students are not interested in the study material, they must study it. Thus, showing whether spacing effects enhance memory independently of affective dimensions may have relevant implications for planning efficient learning strategies.

2. Experiment 1

In this experiment, affective and neutral words were used as targets. These were selected so that they were comparable in terms of arousal level but different in terms of valence. As done in numerous previous studies (e.g. Russo & Mammarella, 2002; Russo et al., 2002), participants incidentally learned the target information through orienting tasks that promoted a semantic/affective analysis of the items (e.g. evaluating each item in terms of pleasantness or imaginability level). Given that the presence of valenced target items may affect recognition memory discrimination, we assessed the impact that valence manipulation could have on the size of the spacing effect. For example, if

the magnitude of the spacing effect for neutral words is reduced compared to affective words following deep semantic/affective processing, this reduction could be explained as being due to the general effect of the affective connotation on recognition memory performance and/or to the different strength of affective priming mechanisms. On the other hand, if the occurrence of spacing effects in the recognition memory task is not modulated by valence, then comparable spacing effects should be observed for affective and neutral stimuli pointing out to a robust phenomenon that is resistant to affective manipulations. As far as we know, the only study which used a recognition memory task with affective words is the one developed by Kahana and Greene (1993, Exp. 4). The authors detected a significant spacing effect. However, they only used positively connotated words, while our design included neutral, positive, and negative words mixed together. Again, if spacing effects are independent of valence, we should replicate and extend this finding to negative words as well.

2.1. Method

2.1.1. Participants
Fifty-four students from the University of Chieti, Italy, took part in Experiment 1. All participants were native Italian speakers. Their mean age was 29.3 (SD = 4.1). They were 30 females and 24 males. The number of positive and negative emotions as measured by PANAS (Watson, Clark, & Tellegen, 1988) did not differ in this group (31 for positive and 20 for negative emotions, $t < 1$).

2.1.2. Materials
Eighty words were used in Experiment 1. These items were selected from a larger database developed in our laboratory (Montefinese, Ambrosini, Fairfield, & Mammarella, 2014). Positive words had a mean valence rating of 7.87 (SD = 0.39) and a mean arousal of 5.56 (SD = 0.89), whereas negative words had a mean valence of 1.98 (SD = 0.24) and a mean arousal of 5.82 (SD = 1.27). Finally, neutral words had a mean valence of 5.36 (SD = 0.22) and a mean arousal of 2.75 (SD = 0.81). As in previous studies (e.g. Mammarella et al., 2002), words were of medium frequency according to the Montefinese et al.'s (2014) norms.

The 30 positive words were divided into three main sets (A, B, and C), each composed of 10 words. Items were randomly assigned to each set. To create three different study lists, we repeated this process three times. Each study list was used 10 times. The typical study list contained two sets of items (i.e. A and B): Items from Set A were repeated twice in a massed way (Lag 0), whereas those from Set B were repeated after six intervening words (Lag 6). The set of items not presented during study (i.e. C) was used to provide the distractor items in the test list. The same procedure was adopted for the 30 negative words. In order to have a comparable number of emotional and neutral items at study, 20 neutral words were assigned to Set A, 20 neutral words to Set B, and 10 neutral words to Set C (not presented at study). To create the list, neutral items were randomly assigned to each set and this process was repeated three times.

The structure of each study list was obtained by repeating a template twice. This template consisted of a total of 87 item presentations. Forty targets were presented twice at Lag 0, 40 targets were presented twice at Lag 6, and 4 fillers were presented at both the beginning and end of the template. Three other fillers were repeated twice in a spaced way. Massed and spaced items were randomly intermixed in the template. Therefore, each study list was made of 174 occurrences. Because participants performed two different semantic orienting tasks on the same target during study, one for each of the two presentations of each target item, five items from each subset were displayed with an asterisk next to the first occurrence, and the remaining five items were displayed with an asterisk next to the second occurrence. The presence or absence of an asterisk next to a target was associated with the requirement to perform different orienting tasks during learning. This procedure was used for both Sets A and B. A similar arrangement was also applied to the fillers. Finally, the test list contained all 80 items from the three sets (i.e. A, B, and C) in random order.

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2.1.3. Design and procedure

Two within-subject variables were manipulated: the spacing between repeated targets during study (massed vs. spaced; i.e. Lag 0 vs. Lag 6) and the type of words repeated at study (affective: positive versus negative and neutral).

In the study phase, each participant saw a sequence of items on a computer screen. Each item was displayed for 3 s with a 1-s interstimulus interval. Learning occurred incidentally. Participants were told that if an item appeared with the asterisk next to it, they had to rate each word in terms of pleasantness on a seven-point scale (from 1 absolutely unpleasant to 7 absolutely pleasant). Otherwise, they had to evaluate each word in terms of the level of imaginability on a seven-point scale (from 1 absolutely difficult to be imagined to 7 absolutely easy to be imagined). Two different ratings of the same target, instead of the same rating repeated twice, were used to prevent the participants from basing their responses to the second occurrence of an item on their memory for the first occurrence, because this has been suggested to induce an artifactual spacing effect (Greene, 1989).

Participants spoke of their responses and were told that these were recorded, whereas in fact, none were recorded. During the 5-min retention interval, participants were asked to perform a digit-cancellation task. At test, participants were asked to perform a yes–no recognition memory test.

Studied and new words were presented in random order. Each item remained displayed on the screen until participants responded. They had to press either the key marked *yes*, if they remembered having seen the item during the incidental study phase, or the key marked *no,* if they could not remember having seen the item during the incidental learning phase. The experimental session lasted about 25 min.

2.2. Results and discussion

Percentages of hits, false alarms (FA), and *d'* scores obtained in Experiment 1 are presented in Table 1. Statistical analyses were conducted on *d'* scores, for this and the following experiment, using the correction factor suggested by Snodgrass and Corwin (1988). In particular, as done in numerous previous studies (e.g. Mammarella et al., 2002, 2004; Russo et al., 2002), we calculated the discrimination measure derived from the two-high-threshold model of recognition memory to obtain a more precise index of memory accuracy. The discrimination index is a corrected memory accuracy score computed with the following formula: dL = ln [hit (1 − FA)]/[(1 − hit) FA] where ln = natural log. If hit and FA rates are equal to either 0 or 1, they are adjusted by 0.01.

For each type of word, we used the corresponding FAs.

First of all, we were interested in studying whether spacing effects occur with both affective and neutral words.

A 2 (Spacing: Lag 0 vs. Lag 6) X 2 (Type of Word: Affective vs. Neutral) within-subject analysis of variance (ANOVA) showed the classical emotion enhancement effect in recognition memory; $F(1,53) = 18.99$, $p < 0.001$, MSE = 2.85 as affective words (3.19) were better recognized than neutral

Type of word	Lag 0				Lag 6					
	hits	SD	*d'*	SD	hits	SD	*d'*	SD	FA	SD
Positive	0.81	0.22	1.54	1.27	0.86	0.18	1.70	1.26	0.30	0.36
Negative	0.84	0.17	1.45	1.31	0.90	0.12	1.68	1.28	0.34	0.37
Neutral	0.81	0.21	2.03	1.21	0.88	0.15	2.35	1.10	0.31	0.24

Table 1. Proportion of words in Experiment 1 correctly recognized as old (hits), FAs, and *d'* scores

Note: *d'* scores refer to corrected scores.

words (2.19). There was a significant effect of Spacing, $F(1,53) = 37.81$, $p < 0.001$, MSE = 0.17, indicating that spaced items (2.87) were better discriminated than massed items (2.51). The Spacing X Type of Word interaction was not significant, $F < 1$, indicating that the size of the spacing effect was similar across affective and neutral words. Follow-up analyses showed that spacing effects occurred for both affective ($p < 0.001$) and neutral words ($p < 0.001$).

When we introduced Valence (positive and negative) in the analysis, we found that spacing effects occurred for both positive and negative words. The mean differential *d'* score between massed and spaced items was −0.16 for positive and −0.23 for negative words.

To compare recognition memory benefits obtained with spaced learning under deep semantic analysis with the one deriving from the classical "emotional enhancement" effect, we first calculate an emotional enhancement effect measure as the difference between affective and neutral trials. Then, we obtained a spacing effect measure by subtracting massed trials to spaced trials. A repeated-measure one-way ANOVA showed no significant differences across these two measures, $F(1,53) = 1.28$, $p = 0.26$, MSE = 1.86.

Overall, the results of this experiment showed that it was possible to obtain reliable spacing effects for affective words in cued-memory tasks and that the "emotional enhancement" effect did not affect the occurrence of spacing effects with neutral words. These data evidenced that spacing effects in cued-memory tasks are not influenced by the affective connotation of stimuli and are not contingent on the valence of verbal material. Finally, the effect of spaced learning on recognition memory observed in this study is similar to the classical "emotional enhancement" effect.

3. Experiment 2

The next experiment attempted to further investigate whether repetition priming is the basic mechanism that can explain the generation of spacing effects across both affective and neutral words. In particular, in the following experiment, target items were incidentally learned using orienting tasks that addressed the attention of participants to the structural features of the stimuli. At study, subjects were asked either to count the number of letters extending above or below the main body of the visually presented targets, or to count the number of letters with enclosed parts. These incidental orienting tasks have been shown to minimize both the semantic and affective analysis of targets (e.g. Russo & Mammarella, 2002; Russo et al., 2002; Spruyt, De Houwer, Hermans, & Eelen, 2007) and, as a consequence, spacing effects should be reduced. The reduction in a spacing effect for target affective words after graphemic processing would thus extend to affective verbal items, similar results typically obtained with neutral stimuli. However, if semantic/affective analysis of targets is not the only mechanism that generates spacing effect in cued-memory tasks, then a reliable spacing effect should be detected with these targets as for Experiment 1. In fact, a study by Ferré (2003) showed better memory for positive stimuli even after shallow processing of words, pointed out to the possibility of obtaining different results, at least, with valenced words.

3.1. Method

3.1.1. Participants

Fifty-four students from the University of Chieti, Italy, took part in Experiment 2. None had taken part in the previous experiment. All participants were native Italian speakers. Their mean age was 30.4 (SD = 5.2). They were 28 females and 26 males. The number of positive and negative emotions as measured by PANAS (Watson, Clark, & Tellegen, 1988) did not differ in this group (33 for positive emotions and 21 for negative, $t < 1$).

3.1.2. Materials
The material was identical to the one used in Experiment 1.

3.1.3. Design and procedure
The design and the procedure used in Experiment 2 were almost identical to the ones used in Experiment 1. The only difference was that, in this case, the presence or absence of an asterisk next to a target was associated with the requirement to perform a different orienting task. Participants were told that if an item appeared with the asterisk next to it, they had to count the number of letters extending above or below the main body of the word. Otherwise, they had to count the number of letters with enclosed parts.

3.2. Results and discussion
Percentages of hits, FAs, and *d'* scores obtained in Experiment 2 are presented in Table 2.

Again, we were interested in studying whether spacing effects occur with both affective and neutral words under shallow analysis of targets.

A 2 (Spacing: Lag 0 vs. Lag 6) X 2 (Type of Word: Affective vs. Neutral) within-subject ANOVA showed the classical emotion enhancement effect in recognition memory; $F(1,53) = 27.62$, $p < 0.001$, MSE = 0.85 as affective words (1.11) were better recognized than neutral words (0.47). There was a significant effect of Spacing, $F(1,53) = 11.57$, $p < 0.001$, MSE = 0.18, indicating that spaced items (0.88) were better discriminated than massed items (0.68). The Spacing X Type of Word interaction was not significant, $F < 1$, indicating that the size of the spacing effect was similar across affective and neutral words. Follow-up analyses showed that spacing effects occurred for both affective ($p < 0.03$) and neutral words ($p < 0.03$).

When we introduced Valence (positive and negative) in the analysis, we found that spacing effects occurred for both positive and negative words. The mean differential *d'* score between massed and spaced items was −0.11 for positive and −0.13 for negative words.

As for Experiment 1, we compared the spaced learning benefit under deep semantic analysis with the one obtained with the classical "emotional enhancement" effect. A repeated-measure one-way ANOVA showed a significant difference across these two measures, $F(1,53) = 10.30$, $p < 0.01$, MSE = 2.24 as the effect of affective connotation of words on recognition was 1.32, while the spacing effect was 0.40.

Overall, the results of this experiment showed reduced spacing effects for both affective words and neutral words. These data suggest that under shallow processing, semantic and affective priming mechanisms are weaker and consequently spacing effects may suffer. Furthermore, in line with previous studies (e.g. Russo et al., 2002), shallow processing had a deep negative impact on recognition performance. Nevertheless, spacing effects did occur. Finally, the effect of affective connotation on recognition memory was larger compared to the one observed with the spacing effect: this may be due to the fact that shallow processing damaged the generation of spacing effects in general, leaving the influence of "emotional enhancement" unaffected.

Table 2. Proportion of words in Experiment 2 correctly recognized as old (hits), FAs, and *d'* scores

Type of word	Lag 0				Lag 6					
	hits	SD	*d'*	SD	hits	SD	*d'*	SD	FA	SD
Positive	0.53	0.21	0.40	0.75	0.57	0.16	0.51	0.70	0.37	0.24
Negative	0.48	0.21	0.59	0.70	0.54	0.20	0.72	0.67	0.28	0.20
Neutral	0.48	0.18	0.37	0.63	0.54	0.19	0.52	0.54	0.36	0.20

Note: *d'* scores refer to corrected scores.

4. General discussion

Overall, the results obtained in Experiments 1 and 2 support the repetition priming account of spacing effects in cued-memory tasks for meaningful and affective stimuli. Semantic/affective repetition priming effects act to reduce semantic/affective processing of the second occurrence when items are repeated in succession (massed items) but not if repetitions are spaced. Under the assumption that semantic/affective information supports retrieval of meaningful/affective material in cued-memory tests, these differences in the amount of processing between the second occurrence of massed and spaced items provide a basis for the emergence of the spacing effect. Congruent with this view, the present study showed that when repetition priming was reduced, by orienting participants' attention to physical features of words, the size of the spacing effect in a yes–no recognition memory task was reduced. To summarize the results obtained in Experiment 1, a reliable spacing effect was obtained with affective and neutral words. As discussed in the introduction, the "emotion enhancement" effect predicts better memory for affective information compared to neutral one (e.g. Kensinger & Corkin, 2003). We did find a clear-cut supremacy of affective words over neutral words and this seems to have not affected the occurrence of spacing effect for neutral words. The results obtained in our study are also relevant to the debate on the strength of semantic versus affective priming as some studies have shown that repetition priming or, more generally, priming mechanisms may differ across the three types of words, especially with regard to positive and negative words (e.g. Marchewka & Nowicka, 2007; Rossell & Nobre, 2004; Storbeck & Clore, 2008). We only observed a tendency by negative words to show larger spacing effects. This finding is in line with the work by Baumeister, Bratslavsky, Finkenauer, and Vohs (2001) showing a preference toward negative stimuli processing among younger adults.

In Experiment 2, participants were invited to focus their attention to physical features of words. We used this type of orienting task because different works (e.g. Russo et al., 2002) found that shallow processing at study may reduce or even eliminate the effect of repetition priming across different types of words. A comparison across experiments indicated that when repetition priming mechanisms were reduced by shallow processing, so did spacing effects. This finding points to a strong reliance of spacing effects with meaningful material on semantically/affectively based repetition priming.

In summary, our study provided further evidence for the need of a multifactorial approach to completely account for spacing effects in explicit memory tasks. So far, it seems that the presence or absence of affective dimension may modulate the generation of spacing effects according to the type of processing involved. The link between the types of processing engaged during encoding and the likelihood of better remembering spaced items (see Russo et al., 2002) needs to be reconsidered through the lens of affective variables. Combination of these factors may also explain findings of weak or no spacing effects among participants in previous laboratory and ecological studies. Further studies should be conducted with the aim of directly investigate repetition priming mechanisms and the generation of spacing effects with both affective and neutral words. For example, in the study by Mammarella et al. (2004; 2002), a repetition priming phase with a lexical decision task was followed by a recognition memory task. This methodology may help better studying the strength of repetition priming mechanisms across affective and neutral words and the subsequent generation of spacing effects. In addition, inducing positive and negative moods before having participants engaged in these tasks may also be a promising road. For example, a study by Robinson and Kirkeby (2005) found larger priming effects in happy participants. Furthermore, if moods activate valence-congruent concepts, then happy persons should have larger spacing effects with positive words and sad persons would have larger spacing effects with negative words. However, if spacing effects are immune to affective manipulations, we should observe comparable spacing effects independently of mood.

Finally, studying the relationship between affect and spacing effects may have relevant practical implications, especially with regard to an educational learning context. In fact, a series of studies have repeatedly found that spaced schedules benefit retention and learning (e.g. for a review, see

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Sobel, Cepeda, & Kapler, 2010). Consequently, knowing that spacing effects also occur when learning content is affectively charged may shed further light on the mechanisms that are involved in fostering learning when students attribute a positive or negative connotation to the study material. This may be ultimately important for planning efficient learning strategies in the classroom.

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References
Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology, 5*, 323–370. http://dx.doi.org/10.1037/1089-2680.5.4.323

Challis, B. H. (1993). Spacing effects on cued-memory tests depend on level of processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 389–396.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*, 671–684. http://dx.doi.org/10.1016/S0022-5371(72)80001-X

Elmes, D. G., Dye, C. J., & Herdelin, N. J. (1983). What is the role of affect in the spacing effect? *Memory & Cognition, 11*, 144–151.

Ferré, P. (2003). Effects of level of processing on memory for affectively valenced words. *Cognition and Emotion, 17*, 859–880. http://dx.doi.org/10.1080/02699930244000200

Greene, R. L. (1989). Spacing effects in memory: Evidence for a two-process account. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 371–377.

Greene, R. L. (2008). Repetition and spacing effects. In H. L. Roediger III (Ed.), *Learning and memory: A comprehensive reference. Vol. 2: Cognitive psychology of memory* (pp. 65–78). Oxford: Elsevier.

Hyde, T. S., & Jenkins, J. J. (1969). Differential effects of incidental tasks on the organization of recall of a list of highly associated words. *Journal of Experimental Psychology, 82*, 472–481. http://dx.doi.org/10.1037/h0028372

Hyde, T. S., & Jenkins, J. J. (1973). Recall for words as a function of semantic, graphic, and syntactic orienting tasks. *Journal of Verbal Learning and Verbal Behavior, 12*, 471–480. http://dx.doi.org/10.1016/S0022-5371(73)80027-1

Kahana, M. J., & Greene, R. L. (1993). Effects of spacing on memory for homogeneous lists. *Journal of Experimental Psychology: Learning, Memory and Cognition, 19*, 159–162.

Kensinger, E. A., & Corkin, S. (2003). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory and Cognition, 31*, 1169–1180. http://dx.doi.org/10.3758/BF03195800

Kirsner, K., Smith, M. C., Lockhart, R. S., & King, M. L. (1984). The bilingual lexicon: Language-specific units in an integrated network. *Journal of Verbal Learning and Verbal Behavior, 23*, 519–539. http://dx.doi.org/10.1016/S0022-5371(84)90336-0

LaBar, K. S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews Neuroscience, 7*, 54–64. http://dx.doi.org/10.1038/nrn1825

Mammarella, N., Avons, S., & Russo, R. (2004). A short-term perceptual priming account of spacing effects in explicit cued-memory tasks for unfamiliar stimuli. *European Journal of Cognitive Psychology, 16*, 387–402. http://dx.doi.org/10.1080/09541440340000042

Mammarella, N., Russo, R., & Avons, S. (2002). Spacing effects in cued-memory tasks for unfamiliar faces and nonwords. *Memory & Cognition, 30*, 1238–1251.

Marchewka, A., & Nowicka, A. (2007). Emotionally negative stimuli are resistant to repetition priming. *Acta Neurobiologie Experimentalis, 67*, 83–92.

Montefinese, M., Ambrosini, E., Fairfield, B., & Mammarella, N. (2014). The adaptation of the Affective Norms for English Words (ANEW) for Italian. *Behavior Research Methods, 46*, 887–903. http://dx.doi.org/10.3758/s13428-013-0405-3

Otten, L. J., Henson, R. N. A., & Rugg, M. D. (2001). Depth of processing effects on neural correlates of memory encoding: Relationship between findings from across- and within-task comparisons. *Brain, 124*, 399–412. http://dx.doi.org/10.1093/brain/124.2.399

Robinson, M. D., & Kirkeby, B. S. (2005). Happiness as a belief system: Individual differences and priming in emotion judgements. *Personality and Social Psychology Bulletin, 31*, 1134–1144 . http://dx.doi.org/10.1177/0146167204274081

Rossell, S. L., & Nobre, A. C. (2004). Semantic priming of different affective categories. *Emotion, 4*, 354–363. http://dx.doi.org/10.1037/1528-3542.4.4.354

Rugg, M. D., Mark, R. E., Walla, P., Schloerscheidt, A. M., Birch, C. S., & Allan, K. (1998). Dissociation of the neural correlates of implicit and explicit memory. *Nature, 392*, 595–598. http://dx.doi.org/10.1038/33396

Russo, R., & Mammarella, N. (2002). Spacing effects in recognition memory: When meaning matters. *European Journal of Cognitive Psychology, 14*, 49–59. http://dx.doi.org/10.1080/09541440042000133

Russo, R., Mammarella, N., & Avons, S. (2002). Toward a unified account of spacing effects in explicit memory tasks. *Journal of Experimental Psychology: Learning, Memory & Cognition, 28*, 1–11.

Russo, R., Parkin, A. J., Taylor, S. R., & Wilks, J. (1998). Revising current two-process accounts of spacing effects in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*, 161–172.

Smith, M. C., Theodore, L., & Franklin, P. E. (1983). The relationship between contextual facilitation and depth of processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9*, 697–712.

Snodgrass, J. G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General, 117*, 34–50.

Sobel, H. S., Cepeda, N. J., & Kapler, I. V. (2010). Spacing effects in real-world classroom vocabulary learning. *Applied Cognitive Psychology, 25*, 763–767.

Spruyt, A., De Houwer, J., Hermans, D., & Eelen, P. (2007). Affective priming of nonaffective semantic categorization responses. *Experimental Psychology (formerly "Zeitschrift für Experimentelle Psychologie"), 54*, 44–53. http://dx.doi.org/10.1027/1618-3169.54.1.44

Storbeck, J., & Clore, G. L. (2008). The affective regulation of cognitive priming. *Emotion, 8*, 208–215. http://dx.doi.org/10.1037/1528-3542.8.2.208

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Toppino, T. C., & Bloom, L. C. (2002). The spacing effect, free recall, and two-process theory: A closer look. *Journal of Experimental Psychology: Learning, Memory and Cognition, 28,* 437–444.

Toppino, T. C., Fearnow-Kenney, M. D., Kiepert, M. H., & Teremula, A. C. (2009). The spacing effect in intentional and incidental free recall by children and adults: Limits on the automaticity hypothesis. *Memory and Cognition, 37,* 16–25.

Walla, P., Hufnagl, B., Lindinger, G., Deecke, L., Imhof, H., & Lang, W. (2001). False recognition depends on depth of prior word processing: A magnetoencephalographic (MEG) study. *Cognitive Brain Research, 11,* 249–257. http://dx.doi.org/10.1016/S0926-6410(00)00079-3

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54,* 1063–1070. http://dx.doi.org/10.1037/0022-3514.54.6.1063

Wong, P. S., & Root, J. C. (2003). Dynamic variations in affective priming. *Consciousness & Cognition, 12,* 147–169.

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