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RESEARCH

RESPONSE BIAS SHIFT FOR POSITIVE WORDS IN OLDER ADULTS IN A SURPRISE RECOGNITION MEMORY TASK: AN INCIDENTAL ENCODING STUDY

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Abstract

Introduction: Although the advantages of positive words on memory enhancement have been documented, the specific effects of the two prominent emotional dimensions (valence and arousal) under incidental encoding require further investigation. The objective is to study memory accuracy and response bias for positive/negative and highly/medium arousing words in a surprise old/new recognition memory paradigm under incidental encoding.

Materials and Method: 113 volunteers (60 young, 53 older) participated. Emotional words were presented on a computer screen and participants were instructed to count vowels in the incidental encoding phase. After a 30-minute retention interval, participants' memory was assessed with a surprise old/new recognition memory task.

Results: A 2×3×2 mixed analysis of variance was conducted. Memory accuracy (using d' scores) and response bias (using criterion scores) were the dependent variables in Signal Detection Theory. Older adults had a significant bias ($p < 0.05$) responding "yes" to positive words, indicating that they had seen these words beforehand; their memory accuracy did not differ in terms of valence.

Conclusion: Older participants emphasize positive words more than negative words. When considering incidental encoding, this age-related change suggests that older participants regulate their emotion in favor of maintaining their well-being. Our study indicates the importance of disentangling age-related factors from the memory performance metrics.

Key Words: Memory; Recognition (Psychology); Aged; Emotions; Bias; Signal Detection, Psychological

ARAŞTIRMA

SÜRPRİZ BİR ESKİ/YENİ TANIMA BELLEĞİ GÖREVİNDE YAŞLI YETİŞKİNLERDE OLUMLU KELİMELER İÇİN TEPKİ YANLILIĞI DEĞİŞİMİ: BİR TESADÜFİ KODLAMA ÇALIŞMASI

Öz

Giriş: Yaşlı bireylerin özellikle olumlu kelimeleri bellekte daha iyi tuttukları bilinmesine rağmen, duygunun iki boyutunun (olumluluk ve heyecan düzeyleri) tesadüfi kodlama yapılan tanıma belleği performansı üzerindeki etkisi hâlâ netlik kazanmamıştır. Araştırmanın amacı, tesadüfi kodlanan ve olumluluk (olumlu, olumsuz ve nötr) ve heyecan düzeyleri (yüksek ve düşük) değişimlenen kelimelerin tanıma belleği puanları (bellek doğruluğu ve tepki yanlılığı) üzerindeki etkisini, sürpriz bir eski/yeni tanıma belleği göreviyle incelemektir.

Gereç ve Yöntem: Çalışmaya, 60 genç ve 53 yaşlı olmak üzere 113 gönüllü katılmıştır. İlk olarak, duygusal kelimeler bilgisayarda tek tek sunulmuş, tesadüfi kodlama yapması istenen katılımcılardan kelimelerin kaç sesli harften oluştuğunu belirtmesi istenmiştir. 30 dakikadan sonra, test aşamasına geçilmiş, çalışma aşamasına atıfta bulunarak daha önce gördükleri kelimeleri tanımaları yönünde yönerge sunulmuş, sürpriz bir eski/yeni tanıma göreviyle bellek performansı kaydedilmiştir.

Bulgular: 2×3×2 son faktörde tekrar ölçümlü deney deseni kullanılmıştır. Bağımlı değişken, tanıma belleği puanları olup, Sinyal Belirleme Kuramı temel alınarak bellek doğruluğu ve tepki yanlılığı hesaplanmıştır. Varyans analizlerine göre, yaşlıların kelimelerin olumluluk düzeyi açısından bellek doğruluğu puanları değişmemekle birlikte, özellikle olumlu kelimelere karşı istatistiksel olarak anlamlı bir tepki yanlılığı gösterdikleri bulunmuştur.

Sonuç: Yaşlılar olumsuz kelimelere nazaran olumlu kelimelere daha çok önem vermektedir. Kelimelerin çaba harcamadan, tesadüfi kodlandığı koşulda, yaşla birlikte ortaya çıkan bu farklılık, yaşlıların iyi olma hallerini korumak adına duygularını düzenlediklerini öne sürmektedir. Çalışmamız bellek performansı ölçümlerinde, yaşla ilişkili etkenlerin belirlenmesinin önemine dikkat çekmektedir.

Anahtar Sözcükler: Bellek; Tanıma (Psikoloji); Yaşlı; Duygular; Yanlılık (Epidemiyoloji); Sinyal Belirleme, Psikolojik

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Portions of the study were presented in poster form at the Annual Meeting of the Society for the Neurobiology of Language (SNL), San Diego, CA, on November 6, 2013. Besides, portions of this study were presented in oral presentation form at the Annual Meeting of the Gerontological Society of America (GSA), Washington, DC, on November 7, 2014.

INTRODUCTION

Changes in neurological and neuropsychological status in the aging brain have begun to garner much attention (1-3). The broad consensus is that memory performance declines with increased age; more specifically, as age increases, recognition memory performance decreases. However, memory is suffused with emotion, and hence, the interaction between emotion and aging may result in differential effects in memory enhancement for emotional stimuli. Perhaps due to this, findings on the effect of age on emotional memory performance and/or the relationship between the two are contradictory. Older adults, like young adults, are more likely to detect and attend emotional information than they are to do so for non-emotional information (4,5). Some recent research (6,7) has demonstrated that negative stimuli have a tendency to be better remembered, overall. However, older adults seem to exhibit a positivity bias; in other words, they are more likely to remember positive information than negative information (8). In sum, there is substantial evidence that older adults process emotional information differently from young adults.

There is a theory called "Socioemotional Selectivity Theory" which tries to explain the positivity bias of older adults by positing that as older adults realize that they are close to the end of their lives, they begin to view time as limited. Hence, goals associated with emotional well-being become more salient and, the focus of their goals may change from exploration (or knowledge accumulation) toward emotional gratification (9,10). This kind perspective shift may cause a positivity bias: they are more likely to remember positive information than negative information. Since young adults do not view time as limited and finite, they need not regulate emotions. The "emotional regulation" goals of young and older adults seem to be very different, and this difference results in differential biases for emotional stimuli. Conscious attentional processes may offer an explanation to this finding. When older adults devote full attention towards the emotional information, they show positivity bias (11). Positivity effect may be less likely to occur when the focus of attention or thought is constrained during encoding (8). When their attention is divided or cognitive resources are limited during information via processing experimental task, older participants may not focus their attentional resources towards to positive information, and hence, the positivity bias disappears (12). Several researchers (5,13,14) have failed to find a positivity effect in the memories of older adults. In other words, the attentional effort spent during encoding might be an important variable that results in positivity effect in memory. Thus, it may be concluded that the tendency of shifting attention to positive items in older adults is a controlled and effortful process. On the other hand, Sayar and Cangöz's research (10) revealed that emotional information could be processed and recalled automatically. They observed differences in young and older adults in terms of testing interval and valence levels of words demonstrating that older participants exhibited the positivity effect while recalling the words implicitly. Thus, these findings lead us to choose incidental encoding in study session.

Neuroimaging studies provide support for such "controlled emotion processing". Medial prefrontal activity is often associated with emotion regulation. So, neuroimaging studies which focused on emotion regulation investigate the activity in medial prefrontal cortex and amygdala. In a study which investigated the activity in medial prefrontal cortex and amygdala during emotion regulation (15) for negative and positive emotion, older adults were presented emotional information, and the prefrontal cortex activation was observed to be increased for negative emotion, while amygdala activation decreased (15). Based on this result, it can be concluded that older adults intentionally and effortfully tried to control their responses to negative items (15). Another interesting neuroimaging result was that older adults showed greater medial prefrontal activity than younger adults while responding to the negative emotional images. This kind of control mechanism was absent in the brains of young adults. Moreover, in a recent study on emotional working memory, positivity effect was observed in people with Alzheimer's disease demonstrating that positively valenced stimuli enhanced memory performance through the higher activity in left ventral prefrontal cortex (3). Consistent with this result, another study conducted by Addis, Leclerc, Muscatell and Kensinger (16) also revealed that while older adults were encoding positive stimuli, their ventromedial prefrontal cortex and amygdala together affected hippocampal activity. In contrast, only thalamus had an influence on hippocampal activity when young adults were encoding these stimuli. This differing influence may be the reason that why young adults are less likely than older adults to remember positive stimuli than negative stimuli. It is also crucial to remember that during the encoding of negative stimuli, no age-related differences were detected in terms of the connectivity among the brain regions. This raises the following question: what happens if older adults encode positive and negative stimuli that have different arousal levels under incidental encoding?

In addition to the valence dimension of emotion (ranging from unpleasant/negative to pleasant/positive), arousal is another factor, ranging from calming to exciting. Due to its relevance to the intensity of emotional experience, arousal is critical for observing the emotional memory enhancement effect. During encoding, the amygdala is indispensable for successful retrieval of arousing items later (17). According to McGaugh's memory modulation hypothesis, as long as the emotional information (either positive or negative) is highly arousing, amygdala–hippocampal interactions guide successful encoding. Involvement of both the amygdala and hippocampus increases the strength of encoding and enhances the consolidation of emotional stimuli (18). Although the "memory modulation hypothesis" concerns only consolidation mechanisms instead of the retrieval of emotional memory, Dolcos, LaBar, and Cabeza postulate the crucial role of the amygdala during retrieval (17). Even though some studies (19,20) indicate the importance of arousal for better memory performance, studies emphasizing the interaction effect of both valence arousal dimensions of emotion are also worth mentioning within the emotional memory network.

While both valence and arousal dimensions of emotion enhances memory accuracy in different ways, it might also induce a response bias. Memory accuracy (d') is a valid measurement of memory performance, but it is not sufficient because it may be contaminated by response bias. Unless response bias is considered, drawing a firm conclusion about memory performance for emotional words is not reliable. Liberal bias, the tendency to respond in a predominantly liberal way, is a strong measure to understand the interference from the cognitive system. In recognition memory tasks, responding "yes" indicates a preference towards recognizing most of the newly presented items as seen before. Liberal bias indicates a ratio regarding responding "yes" throughout the experiment. Thapar and Rouder (21) stated that emotionally charged words produce a response bias, they do not discriminate memory performance indeed and this pattern is different for young and older participants. Although both groups have a tendency to choose emotional words over neutral ones, they differ in their bias toward positive and negative words. Older participants exhibit bias for positive words while young participants exhibit bias for negative words. It is expected that during incidental encoding, the affective aspects of a stimulus would be processed without conscious cognitive interference brought by an open question, enabling better investigation of young and older adults' natural tendencies in emotional recognition memory performance based on both memory accuracy and response bias.

In this study, we hypothesized that emotional words encoded incidentally are recognized better compared with neutral words in both age groups. Also, emotional words exhibit a response bias in different patterns for young and older participants, especially as a result of the interaction between valence and arousal. In this sense, our main objective was to observe emotional effects resulting from incidental encoding.

We also aimed to detect memory accuracy and response bias, both important measures, during recognition. As we aimed to eliminate the cognitively loaded intentional memory recognition efforts, we chose the incidental encoding.

The chosen word categories were positive and negative with respect to pleasantness and highly and medium arousing with respect to emotional intensity. Neutral words were also used as controls.

MATERIALS AND METHOD

Participants

A total of 113 volunteers participated; 60 young adults [mean age, 20.77 (range 18–24) years, 30 F, 30 M] and 53 older adults [mean age, 77.13 (range 65–91) years, 33 F, 20 M). Undergraduate students at Middle East Technical University (METU), Marmara and Istanbul University received course credits for participating in the study. The older adult participants were chosen from among the residents of Istanbul Etiler Nursing Home of Social Security Institution for Civil Servants, the Istanbul Kızılay Nursing Home, and the Izmir Narlıdere Nursing Home of Social Security Institution for Civil Servants. Older adults who were living longer than 1.5 years at a nursing home were excluded from the study. All participants were native Turkish speakers with normal or corrected-to-normal vision and had no history of a neuropsychological, psychiatric disorder, or alcoholism and no use of medication affecting the central nervous system for the last 6 months. The participants in both groups were individuals who received education for 11 or more years. Statistically, age groups did not differ significantly with respect to total years of education, ($t_{(52)}$=.46, p >.05). The demographical information of the participants is shown in Table 1. Informed consent read and signed by the participants was obtained in a way approved by the METU Ethics Committee. The participants in the healthy, older adult group were selected among those who fulfill the criteria for "healthy elderly." In order to determine whether the participants fulfilled this criterion, screening tests and/or scales were employed: the Standardized Mini-Mental State Examination (22), Geriatric Depression Scale (23), and Functional Activities Questionnaire (24). In order to choose "healthy" young participants, the Beck Depression Inventory was used (25). Table 2 presents the scores for these tests.

Table 1. The demographical information of the participants.

Age	Young	mean=20.77 sd=1.54	
	Older	mean=77.13 sd=7.01	
Years of Education	Young	mean=13.27 sd=1.04	
	Older	mean=12.96 sd=2.06	
Gender	Young	Female=30 Male=30	(50%) (50%)
	Older	Female=33 Male=20	(62%) (38%)
Marital Status	Young	Married=- Single=60 Widowed/Divorced=-	 (100%)
	Older	Married=13 Single=6 Widowed/divorced= 34	(25%) (11%) (64%)
Occupation	Young	State=- Private=- Self-employed=- Nonworking/student= 60	 (100%)
	Older	State=2 Private=4 Self-employed=1 Nonworking/retired= 46	(4%) (8%) (1%) (87%)

sd= standard deviation

Table 2. Means and standard deviations of the scores that participants got from screening tests and/or scales and the cut-off points for "healthy" young and older adults.

SMMSE (Older)	mean=27.68 sd= 1.68	Cut-off point ≥25
GDS (Older)	mean=4.28 sd= 2.86	Cut-off point ≤11
FAQ (Older)	mean=0.23 sd=0.82	60–69 years old= 2 or more activities ≤ 5 points 70 years old and above=2 or more activities ≤9 points
BDI (Young)	mean=7.62 sd=3.84	Cut-off point ≤ 17

sd= standard deviation

SMMSE=Standardized Mini Mental State Examination; GDS=Geriatric Depression Scale; FAQ=Functional Activities Questionnaire; BDI=Beck Depression Inventory.

Word stimuli

A total of 180 concrete words (30 words from each category highly arousing positive, highly arousing negative, medium arousing positive, medium arousing negative, and 60 neutral words) were selected from the Turkish Affective, Semantic and Evaluative word norm database, TÜDADEN (26). The words were controlled for word length ranging from 4-7 letters and 2 or 3 syllables. In this regard, on average, the words used in the study session (*M*=5.43; *SE*=.11) and the words added for test session (*M*=5.42; *SE*=.10) did not differ in terms of word length ($t_{(89)}$=.08, p >.05). On a scale of 1–9, the mean valence of the positive words was 7.58; the mean valence of the negative words was 2.46; the mean arousal of the highly arousing words was 6.76, and the mean arousal of the medium arousing words was 4.90.

The words were distributed to four lists such that Word List 1 and Word List 2 were used during incidental encoding and contained 45 words each, and Word List 3 and Word List 4 were used during recognition and contained 90 words each. The main difference between these lists was the arousal levels. Word Lists 1 and 3 contained medium arousing words, and Word Lists 2 and 4 contained highly arousing words. The distribution of the words is illustrated in Figure 1.

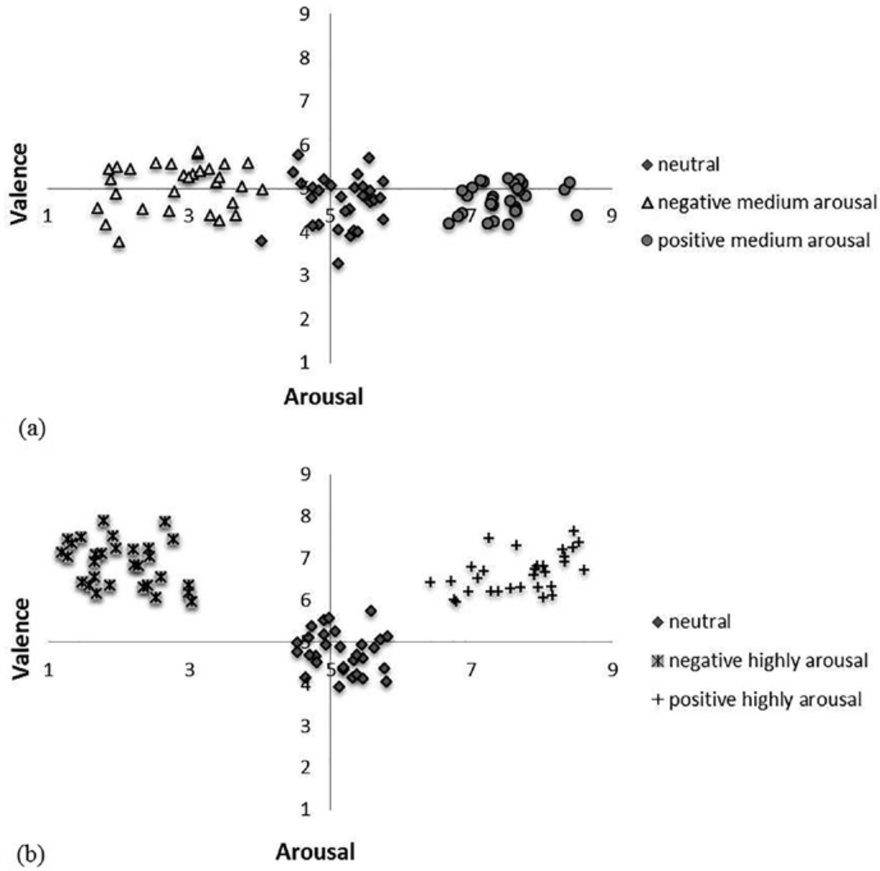

Figure 1. The distribution of words used in Word List 3 (a) and Word List 4 (b) according to the values in two dimensions of emotion (x-axis: valence and y-axis: arousal).

Procedure

The participants completed the informed consent form in which no mention was made of the forthcoming memory test. Instead, it was indicated that the aim was to examine differences among adults in terms of processing words and numbers. Before participants were recruited into the study, they were exposed to screening tests in order to ensure that all participants met the selection criteria. After the administration of the screening tests, the participants from two age groups were randomly assigned to group 1 or group 2. The variable “arousal levels of words” was designed as “between group,” which differed between these two groups. On the hand, the variable “valence levels of words” was within subject. The experiment started with incidental encoding (study session), in which the participants viewed words from either Word List 1 or Word List 2 one at a time on the computer screen for 1 second. Participants were told to simply look at the words on the computer screen and decide how many vowels each word contained by pressing the respective number button (that is, 2 or 3) within 2 seconds. Following the study session, the participants were given a 2-minute distractor task. In the distractor task, 50 simple mathematical operations requiring a decision whether the number pairs are equal or not were presented on the computer screen. Next, a 30-minute delay (27) was introduced before starting the surprise recognition memory task (test session). A classical old/new paradigm was used in the test session. During this self-paced test session, participants saw 90 words from either Word List 3 or 4. Among these words, half had been presented in the study session. For each word, participants pressed a button to indicate whether they had seen the word before. “Yes” responses were categorized as “old” and “No” responses were categorized as “new.” Stimulus presentation and response recording for each of the sessions were controlled by a 15.4 inch laptop, with E-prime v.1.2 software (Psychology Software Tools Inc., Pittsburg, PA). The words were presented on a light gray background with letters in Arial font, in black color, and all upper case. At the end, the participants were asked if they had expected a memory test. Participants who had answered negatively in the debriefing forms (113 out of 113) were included in the statistical analyses.

Data analysis

To measure memory performances of the participants, Signal Detection Theory (SDT) (28) was used. The participants’ “yes” responses to the studied words were called “hits.” “Yes” responses for non-studied words were called “false alarms.” After calculating hits and false alarm rates, memory accuracy d’ was computed as follows.

d’=z(Hit rates) – z(False alarm rates)

d’ indicates the difference between rates of correctly recognized old words in the test list and misclassified new words in the test list as study items. d’ is a normalized score because z-scores are used instead of actual hits and false alarms.

In addition, response bias, which is the calculated criterion scores using hits and false alarm rates based on SDT, was computed as follows.

Criterion=−0.5 * [z(Hit rates) + z(False alarm rates)]

Criterion scores quantify the tendency of participants to respond in a predominantly liberal way by favoring “yes” responses (more negative scores reflect a liberal pattern, which gives an opportunity to evaluate the response change towards responding as “old”).

The exclusion criterion was based on the participant’s performance in d’ scores. Participants with memory accuracy less than a threshold ($d' \leq 0$) were excluded: only one participant from young adults and five participants from older adults. Afterwards, possible outliers were scanned to get the efficient statistical results. For this reason, all scores were transformed to standardized scores (that is, z-scores) and examined. No data were needed to be excluded, so normalization was provided for further analysis.

As preliminary analyses revealed no effects for gender, it is not included as a factor in the analyses reported below. The data were analyzed in a 2 (age: young and older) × 2 (arousal: high and medium) × 3 (valence: positive, negative and neutral) mixed analysis of variance (ANOVA). The independent variables "age" and "arousal levels of words" were between groups; while the independent variable "valence levels of words" was within subjects. Participants' memory was assessed with a surprise old/new recognition memory task. In this regard, primary analyses were performed on memory accuracy and response bias using the d' scores and criterion scores as the dependent measures, respectively. For all of the analyses in this study, a .05 alpha level and $\eta\varrho^2$ to measure effect sizes were used.

RESULTS

Analyses of d' scores

Results indicated main effects of age ($F_{(1, 109)}$=38.53, *p* =.000, $\eta\varrho^2$=.26), arousal ($F_{(1, 109)}$=8.35, *p* =.005, $\eta\varrho^2$=.07) and valence ($F_{(2, 218)}$=3.63, $p < .05$, $\eta\varrho^2$=.03) on d' scores. There was also a significant age × valence interaction ($F_{(2, 218)}$=2.93, p=.05, $\eta\varrho^2$=.03) (Figure 2). Results for age × valence × arousal mixed ANOVA indicated a significant three-way interaction effect ($F_{(2, 218)}$=7.07, p=.001, $\eta\varrho^2$=.06) (Figure 3).

In a more detailed post-hoc analysis, paired samples t-tests were conducted in order to isolate the differences. Significance levels for each group were determined by Holm's Sequential Bonferroni correction method. In order to be significant at the .05 level under Bonferroni, .05 was divided by the number of pairwise comparisons.

Since there are lots of comparisons and the three-way interaction effect was found significant, only the three-way interaction analysis is further indicated in this paper as summarized in Figure 3.

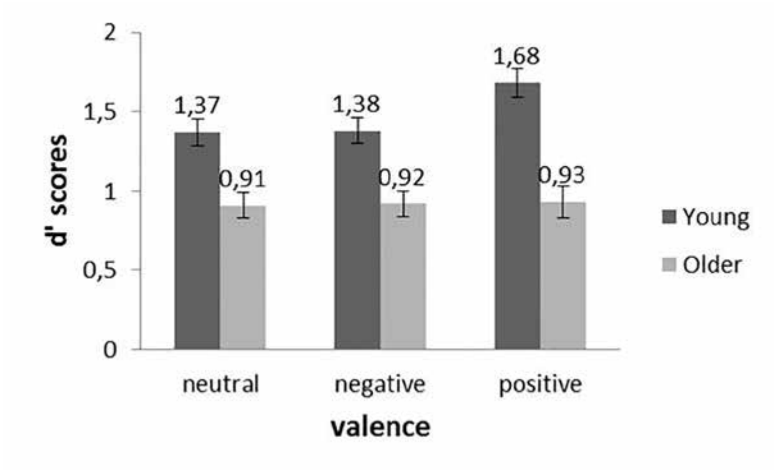

Figure 2. Age × Valence on d' scores. Error bars represent standard error.

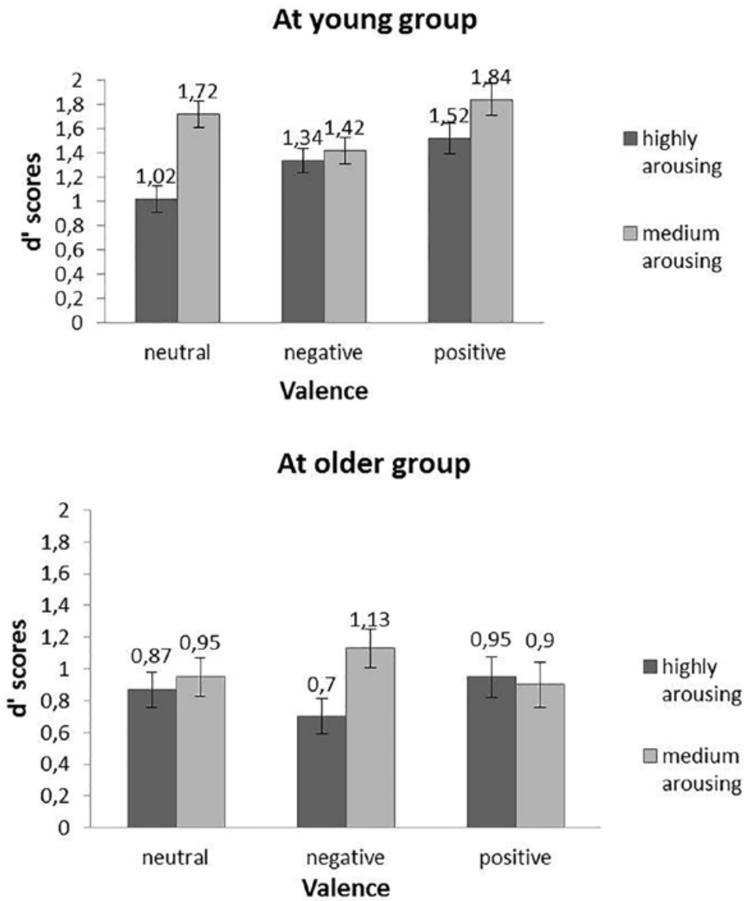

Figure 3. Age × Valence × Arousal on d' scores. Error bars represent standard error.

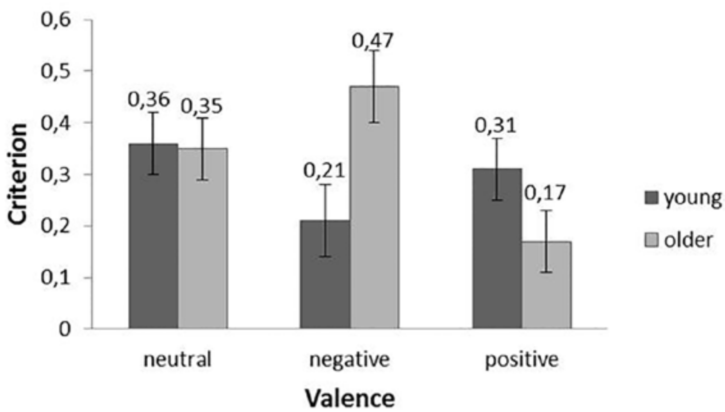

Figure 4. Age × Valence on criterion values. Error bars represent standard error.

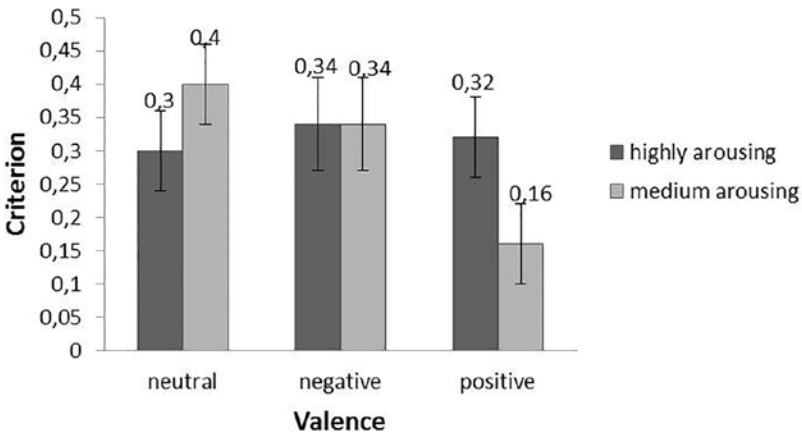

Figure 5. Valence × Arousal on criterion values. Error bars represent standard error.

Accordingly, young adults recognized highly arousing positive words (M=1.52) more accurately than neutral words used in the highly arousing verbal material list (M=1.02), $t_{(30)}$=3.13, p=.004. Young adults also recognized highly arousing negative words (M=1.34) more accurately than neutral words used in the highly arousing verbal material list (M=1.02), $t_{(30)}$=2.50, p =.018. When considering the medium arousing word list, young adults recognized medium arousing positive words (M=1.84) more accurately than medium arousing negative words (M=1.42), $t_{(28)}$=3.67, p=.001. Young adults also recognized neutral words (M=1.72) more accurately than medium arousing negative words (M=1.42), $t_{(28)}$=2.20, p=.036. Furthermore, young adult participants recognized neutral words used in the medium arousing verbal material list (M=1.72) more accurately than they did neutral words used in the highly arousing verbal material list (M=1.02), $t_{(28)}$=4.09, p=.000. For the older participant sample, medium arousing negative words (M=1.13) were recognized more accurately than highly arousing negative words (M =.70), $t_{(23)}$=3.71, p=.001.

Analyses of criterion scores

Results indicated a main effect of valence ($F_{(2, 218)}$=6.91, p=.001, $\eta\varrho^2$=.06) on criterion scores. There was no main effect of age and arousal. There was also a significant age × valence interaction ($F_{(2, 218)}$=18.53, p=.000, $\eta\varrho^2$=.15) (Figure 4). Results for arousal × valence mixed ANOVA indicated a significant 2-way interaction effect ($F_{(2, 218)}$=7.65, p=.001, $\eta\varrho^2$=.07) (Figure 5). The age × arousal × valence three-way interaction on criterion scores did not reach conventional levels of significance.

In a more detailed analyses of paired samples t-tests for age × valence interaction (Figure 4), young participants were more willing to classify negative words (M=.21) as old than neutral words (M=.36), $t_{(59)}$=2.89, p=.005. Moreover, young participants were more willing to classify negative words (M=.21) as old than positive words (M=.31), $t_{(59)}$=2.09, p=.041. However, older participants were more willing to classify positive words (M=.17) as old than they were to classify both neutral words (M=.35) and negative words (M=.47), $t_{(52)}$=3.88, p=.000, t(52)=6.34, p=.000, respectively. Moreover, criterion values for neutral (M=.35) and negative words (M=.47) did significantly differ from each other, $t_{(52)}$=2.63, p=.011, reflecting greater liberal bias for neutral words in the older group. In addition, young participants (M=.21) were more willing to classify negative words as old than older adults were (M=.47), $t_{(52)}$=3.15, p=.003.

DISCUSSION

The present study was designed to examine the effects of the arousal and valence axes of emotion on incidentally encoded recognition memory for emotional words in young and older adults. The main effect of age was replicated in the d' scores. More specifically, older adults were postulated to be impaired in their ability to incidentally encode the emotional words and then intentionally recollect them. As age-related losses are substantial in recognition memory tasks (1), the reduction in d' scores with aging was an expected result. Furthermore, the present finding revealed an overall significant valence main effect in d' scores favoring recognition of positive words. However, the recognition accuracies of positive, negative, and neutral words for older adults did not differ significantly. At this point, considering the contribution of a bias factor through criterion scores becomes plausible because regardless of the recognition memory accuracy (d'), the participants exhibited a liberal response bias. A moderate "positivity bias" demonstrated its strength on these scores. "Liberal criterion" analysis emphasized that older adults showed a more liberal tendency than young adults towards positive words.

As mentioned earlier, according to Socioemotional Selectivity Theory, older adults are highly motivated to daily seek meaningful and positive emotional experiences. They are more attracted to positive information and avoid negative information (10,15). Older participants seem to "expect" more positive words during the test session. In the test session, while older participants ignored negative words, they indicated more liberally that the positive words were present in the study session. Hence, we observed an age-related "positivity effect" for older adults. This is a replication of the findings of the study by Fernandes, Ross, Wiegand, and Schryer (29), in which they used three types of materials (autobiographical memories, pictures, and words) to examine the effect of the valence component of emotion on memory performance. The results of false alarm rates for words showed that older adults had higher false alarm rates for positive words than they did for negative and neutral words. Therefore, we can conclude that the older participants preferentially recognized positive words in our study.

However, in young adults, negative words produced higher liberal response bias than did positive and neutral words. These results are in agreement with Thapar and Rouder (21). In their study, recognition memory was tested by an unspecified memory task, which involved intentional learning. Thapar and Rouder (21) concluded that the valence component of emotion influenced the young and older participants' memory performance through response bias, with older participants exhibiting a greater response bias for positive words and young participants exhibiting a more liberal response bias for negative words.

The limitation of the present study includes the stimulus presentation. In this study, the words were presented visually on the computer screen. During the study session, the words stayed on the screen for 1 second and the participants made their vowel number decisions within 2 seconds. Especially for older participants, the suitability of the 2-second time period for decision making is not justified. This time period could have been longer, and possibly decided after a pilot study in the older population.

In conclusion, it is important to note that most of the existing studies have been conducted under intentional encoding. In the present study, a further question not addressed in the literature to date has been raised: Does the nature of bias differ under incidental encoding? In a verbal incidental encoding task, followed by a surprise recognition memory task, we observed unintentional emotional effects during encoding and response biases during surprise recognition. Both young and older adults were more willing to recognize emotional words over non-emotional ones, but they differed in their response bias toward positive and negative words. Our results indicated that increasing age was associated with a more liberal bias for positive words. It seems that the emotional enhancement effect reported in the literature for the older age group was due to this bias for positive words. To sum up, older participants had a tendency to respond in such a bias way that recognizing emotional words was might base on response bias, not memory accuracy. Out of this work, a future research direction emerges for investigating biases in eyewitness phenomenon.

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