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When Green Is Positive and Red Is Negative: Aging and the Influence of Color on Emotional Memories

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Numerous studies have reported age-related differences in memory for emotional information. One explanation places emphasis on an emotion processing preference in older adults that reflects their socioemotional self-relevant goals. Here, we evaluate the degree to which this preference in memory may be modulated by color. In 2 experiments, younger and older adults were asked to study a series of affective words (Experiment 1) or affective pictures (Experiment 2) and then presented with an immediate yes/no memory recognition task. In particular, words and pictures were colored according to the following valence-color associations: positive-green, negative-red, and neutral-blue. Each study condition included both congruent (e.g., positive-green) and incongruent associations (e.g., positive-red). For both experiments, participants showed an advantage for congruent associations compared with other types of valence-color pairings that emphasized a robust joint effect of color and affective valence in memory. More specifically, older adults' memory was sensitive to positive-green stimuli only. We discussed results in line with mechanisms underlying positivity effects in memory and the effect of color on emotional memory encoding.

Keywords: emotional memory, positivity effect, color

Information derived from color perception undeniably affects many aspects of daily life since colors can have different purposes and communicate different messages. Many studies have shown how different colors have different impacts on health and cognitive processing. In fact, color therapy has a long tradition in this regard (see O'Connor, 2011, for a review on color research) showing how, for example, warm versus cold colors can be used to arouse or relax. Moreover, a recent line of studies (e.g., Gil & Le Bigot, 2014; Kuhbandner & Pekrun, 2013) suggests that color may also carry an affective connotation and/or orientate emotional reactions toward a more positive or negative pole. Consequently, colors may have implications on memory tasks as well (for a review see Dzulkifli & Mustafar, 2013; Valdez & Mehrabian, 1994) and may influence emotion processing. In this study, we focus on a recent hypothesis that assumes that color influences emotional enhancement effects and that different colors differentially affect emotional memory (Kuhbandner & Pekrun, 2013). This leads us to two fundamental questions: (a) do older adults benefit from color information and (b) does color influence the strength of valence biases in memory (e.g., positivity effects)?

To investigate these questions, we conducted two experiments that varied in terms of study material. In Experiment 1, we used affective words whereas in Experiment 2, we adopted pictures. In both experiments, the common main manipulation was color condition since we presented stimuli in three different colors (green, red, or blue) that could or could not match the affective valence of items. After studying a list of colored items, younger and older adults were asked to immediately remember whether each item, presented in black (or black-and-white for the affective pictures), was old or new.

Memory and Color

Because individuals generally remember colored items better than black-and-white ones, color seems to hold a special status in memory, the so-called *color superiority effect* (e.g., Bredart et al., 2014; Wichmann et al., 2002). A cognitive explanation for this effect claims that color enriches and specifies memory traces therefore allowing individuals to benefit from multiple cues at retrieval (Tulving & Thomson, 1973). Hence, the interaction between color and memory has been repeatedly investigated, and especially in the context of source memory where color informa-

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Preliminary data from Experiment 1 were presented at the Italian Conference on Psychology and Aging held in Pavia (Italy) in June 2015. Our dataset from Experiment 1 and 2 and the list of affective pictures are available on OpenScience Framework website project at https://osf.io/av7jx/. We thank Mara Mather and other two anonymous reviewers for their comments.

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tion represents a contextual feature that can be manipulated to test memory for item and source information (e.g., Altamura et al., 2013). In this line of research, colors are presented centrally in a unitized manner (e.g., a colored word) or peripherally in a non-unitized manner (e.g., a word surrounded by a colored frame). Unitization occurs when the different components of an association are processed to integrate them into a coherent unity. Results from these studies show how individuals generally remember colors well because they are encoded and retrieved in a relatively automatic manner (familiarity-based), while other types of contextual features, such as spatial or temporal information that require more strategic and effortful processes, often lead to more errors (e.g., recollection-based; Troyer & Craik, 2000).

More interestingly, in line with the increasing interest in emotion and memory studies (e.g., Kensinger & Corkin, 2003; Mather & Knight, 2005), memory for color has recently captured the attention of emotion researchers as well because colors also convey meaning on both a conscious and subconscious level. For example, red is commonly associated with negatively connoted situations or threat contexts (e.g., Elliot & Aarts, 2011), although there are conditions in which red is associated with positive experiences (e.g., love or romantic relationships). In addition, classical motivational studies (e.g., Knapp, 1962) have underlined interactions between motivation and meanings associated with color, showing how people with a low need of achievement prefer red, while people with high need of achievement more frequently prefer green. Educational contexts have also contributed to strengthen the association between red and negative affect because errors are typically marked in red. Finally, color-meaning associations also influence preferences for commercial products (e.g., Moore et al., 2005): red is the preferred for warning signs and information that signals imminent danger, while green indicates situations that are perceived as safe.

Furthermore, although color information is generally processed in an automatic manner and is well remembered, less is known about how color influences memory and the elaboration of affective information. Results regarding memory for colors associated with or carry meanings are complex and even contradictory. It may be that when colors are associated with meanings, they require more effortful processing and, therefore, lead to decreases in performance. For instance, Rimmele et al. (2011) found that memory for color was impaired when it framed negative scenes compared with neutral ones (see also Boywitt, 2015). Moreover, in semantic Stroop tasks (e.g., Risko et al., 2006) incongruent color associates (e.g., sky written in green compared with sky written in blue) interfere more with color identification. In addition, visual recognition studies, especially in the domain of object recognition, have repeatedly detected significant interactions between emotion and color processing. For example, a study by McMenamin et al. (2013) found that color affects attention allocation. In particular, their results showed how color information can be used as a diagnostic cue to facilitate rapid detection of emotional objects versus nonemotional objects (see also Bramão et al., 2011, for a meta-analysis about color and visual object recognition). The authors explained their results according to the motivational implications of the affective states induced by the meanings associated with colors. In fact, positive affective states are inferred to reflect approach tendencies (e.g., reward and social interactions) and negative affective states are inferred to reflect withdrawal tendencies (e.g., punishment and dangerous situations; Gable & Harmon-Jones, 2008).

Aging, Emotional Memory, and Color

Similar to studies with younger adults, color processing in aging has generally been investigated for its relevance to the study of contextual memory across the life span. Although source memory studies have shown that older adults remember color better than many other types of contextual features (e.g., Chalfonte & Johnson, 1996; Mammarella, Fairfield, & Di Domenico, 2012), another series of studies found that the precision with which individual visual features (such as color) are maintained in memory, declines with aging (e.g., Peich et al., 2013). In particular, although the ability to discriminate between slight color differences is compromised by aging, there is evidence for age-related compensatory mechanisms that enable color information processing to be, generally speaking, efficient (e.g., Cernin et al., 2003; Wuerger, 2013).

Color deficits can be attributed to declines in the peripheral visual system (e.g., Werner et al., 2010) and/or to significantly pronounced deficits when the association between item and color is required (for a review see Old & Naveh-Benjamin, 2008). An interesting find was that this age-related associative deficit seems to decrease when participants use encoding strategies that promote unitization (e.g., Bastin et al., 2013) or, more relevant to our work, when stimuli with higher levels of arousal are used (Nashiro & Mather, 2011).

Contrary to the well-established decline in cognitive-processing in aging, recent behavioral research suggests that emotion processing is preserved (see Mather, 2016 for a review). In particular, many studies have found age-related differences linked to the valence of affective information (Mather & Carstensen, 2005). These studies have shown how older adults remember positive information better (positivity effect) than negative information and have led many cognitive and social psychology researchers (Charles & Carstensen, 2010; Kensinger & Schacter, 2008) to focus attention on the features that characterize emotional enhancement effects in general and, in particular, positivity effects (e.g., Mammarella, Di Domenico, & Fairfield, 2016). Carstensen and colleagues (e.g., Carstensen et al., 2003) explained this emotional advantage in terms of an age-related selectivity toward the pursuit of emotional goals. These authors affirmed that the proximity of the end of an individual's life span generates a cognitive shift toward emotion processing, boosting memory processes for emotional information in general and, in particular, for positively connoted meaningful goal-orientated emotional information. Although some studies have found inconsistent evidence for the positivity effect (e.g., Gruhn et al., 2005), a large corpus of data has confirmed it (see Reed et al., 2014 for a meta-analysis; see also Kalenzaga et al., 2016), highlighting the different trajectories that emotion-cognition interactions may take across the life span. In line with the older adults' strong motivation to give processing priority to emotional positive goals (e.g., Mather & Carstensen, 2005) and with the assumption that color information per se may carry an emotional connotation, an interesting question is whether and how color information may modulate emotional memory of older adults.

In particular, theoretical models of color and cognition (e.g., Elliot, 2015 for a review) posit that color functions as an automatic prompt for the evaluation of emotional connotation. For example, Moller et al. (2009) found that participants categorized failure words presented in red faster than failure words in green and categorized success words presented in green faster than success words in red. These reaction times (RTs) data suggest that color information can convey meaningful information that may automatically activate and influence performance in evaluative contexts. If so, color may function as a perceptual facilitator of the elaborative processing carried out on stimuli. Given that age-related positivity effects result from differences in processing priorities, color may further enhance these effects in memory especially in congruent color-valence conditions, that is, when color meaning matches an individual's processing priorities. For example, red is more likely to bring a negative personal experience to mind than green or blue in younger adults leading them to exacerbate their general tendency to focus and elaborate more on negative information (see Baumeister et al., 2001; Smith et al., 2006). This may consequently lead to better memory for negative items presented in red especially in younger adults. Differently, green may be more likely to bring positive and relaxing experiences to mind in older adults leading them to show an even greater focus on positive information. This may lead to better memory for positive items presented in green especially in the older adults.

As far as we know, only one study found a significant interaction between color and affective information in memory. In this work, Kuhbandner and Pekrun (2013) asked participants to study a series of word lists in black mixed with colored critical words. Critical words were red, green, or blue. At test, participants did a free-recall task. The authors found that red strongly enhanced memory for negative words while green strongly enhanced memory for positive words, indicating that color can carry specific emotional connotations that reflect everyday meaningful use of color information. In line with this, a study by May et al. (2005, Experiment 2) used color to test source memory for perceptual versus emotional information in aging. The interesting aspect of this study was that half of the items were linked to a set of perceptual plus emotional, conceptual cues (e.g., red and dangerous), while the other half was linked with the opposite set of perceptual plus emotional, conceptual cues (e.g., green and safe). Although May et al. (2005)'s study did not test the influence of color information on source memory per se, the color manipulation may have played a role in the emotion enhancement effects of older adults.

Here, we aimed to investigate whether perceptual features modulate emotional memory. To this end, we colored affective stimuli (words in Experiment 1 and pictures in Experiment 2) red, green, and/or blue (control condition). If specific colors carry specific affective meanings that facilitate processing in evaluative contexts, we expect to replicate previous data showing a memory advantage for negative stimuli in red and positive stimuli in green. Moreover, this pattern of data may be particularly interesting in relation to positivity effects in older adults because a previous study (Hess et al., 2013) found that conditions of stimuli manipulation affected the strength of the positivity effect in aging. In particular, the authors manipulated the content of affective pictures to test memory for social versus nonsocial content and found stronger positivity effects when pictures did not contain people. This study is one of the first to show that stimulus characteristics, in this case content, can modulate positivity effects typically found in older adults. For example, positivity effects may increase when the nature of this stimulus-initiated processing match the motivated processing associated with emotional goals. That is, when color meaning is coherent with participants' processing priorities. Indeed, Beck and Kastner (2009) also showed that processing priority depends on a series of bottom-up and top-down mechanisms (e.g., stimulus features and goal-relevant information, see also Altamura et al., 2016; Di Domenico et al., 2016; Fairfield et al., 2013, 2015a, 2015b; Mammarella et al., 2013). In this study, we used color information to test this hypothesis. If color meaning is coherent with processing priorities, we expect memory benefits in older adults, especially with green positive words since color meaning should prompt their tendency to focus on positive words. Differently, younger adults should show an advantage for red negative words better. We also expect age-related positivity effects to be stronger than those shown in previous studies (see Reed et al., 2014 for a meta-analysis) because of joints effect of color meaning and emotional connotation in memory.

Experiment 1: Affective Words as Stimuli

Experiment 1 investigated whether color modulates positivity effects typically found in older adults by coloring words green during encoding. In particular, younger and older adults encoded a series of colored affective words and subsequently completed a yes/no recognition task. Both age groups encoded words presented in a congruent color-valence condition (e.g., red-negative and green-positive) or incongruent color-valence condition (e.g., red-positive and green-negative). In addition, the task included neutral words presented in blue. In line with previous studies on positivity effects in memory (e.g., Mather & Carstensen, 2005), we expected older adults to remember positive words better than negative and neutral ones. However, we expected this memory benefit to be greater when positive words were in green compared with negative words in red. We expected to observe the opposite pattern of results in younger adults, who should show greater benefits for negative words colored in red.

Method

Participants. Twenty-five younger (14 women, ages 18–25, $M = 23.36$) and 25 older adults (15 women, ages 65–80, $M = 74.36$) participated in the study. A summary of participants' demographic information appears in Table 1. Younger adults were all undergraduates from the University of Chieti who participated for course credit. Older adults were community-dwelling residents from central Italy. All older participants completed 5 years of primary school, 3 years of middle school, 4 or 5 years of secondary school, and 1 or 2 years of University education. Older adults did not receive monetary reimbursement for participation. Exclusion criteria included treatment for memory problems, head injuries resulting in hospitalization for more than 24 hr and/or medical conditions that could potentially affect cognitive functioning (e.g., Alzheimer's disease, multiple sclerosis, and Parkinson's disease). Moreover, all older participants reported being in good mental and physical health and without major hearing or vision problems. In particular, participants did not self-report any color vision deficiency such as daltonism or achromatopsia.

Table 1
Demographic Information for Participants in Experiment 1

Measure	Younger adults Mean (*SD*)	Older adults Mean (*SD*)	*p*
Education (years)	14.4 (2.14)	14.08 (2.12)	.59
Forward digit span	8.36 (2.12)	7.32 (1.74)	.06
Backward digit span	8.08 (1.82)	6.36 (1.31)	<.01
Panas POS	32.24 (5.76)	34.8 (4.08)	.07
Panas NEG	23.24 (6.68)	23.92 (6.14)	.71
VF	11.53 (3.31)	9.42 (3.22)	<.05
GDS	N/A	9.24 (4.04)	N/A
MMSE	N/A	27.76 (1.12)	N/A

Note. Forward and backward digit span from Mondini et al. (2011); positive (POS) and negative (NEG) Panas from Watson et al. (1988); VF = Verbal Fluency from Mondini et al., 2011; GDS = Geriatric Depression Scale (Yesavage et al., 1982); MMSE = Mini Mental State Exam (Folstein et al., 1975).

Before taking part in the experiment, participants were administered a series of cognitive and affective screening tests. In particular, we used the classical forward and backward digit span from Mondini et al. (2011) to evaluate working memory capacity. In this task, participants are required to recall a series of digit presented in lists of increasing length in their forward or backward order of presentation. The longest series of digit correctly recalled indexed capacity. In addition, we used the phonemic version from Mondini et al. (2011) to measure verbal fluency. In this task, participants list all the words that come to mind beginning with a specified letter (e.g., p) within a 1 min temporal window. Older adults were also administered the Mini Mental State Exam (MMSE; Folstein et al., 1975) to measure general cognitive functioning in terms of spatial and temporal orientation, working memory abilities, comprehension, and praxis abilities. Scores range from 0 to 30. Scores below 26 are considered an index of cognitive difficulties. Affective screening was done through the Positive and Negative Affective Scale (PANAS; Watson et al., 1988), a scale containing 20 adjectives describing different feelings (10 positive and 10 negative, e.g., interested, guilty, etc.). Participants indicated how they felt during the past week (habitual affect) in terms of positive and negative feelings on a 5-point scale (e.g., from 1 = *not at all* to 5 = *extremely*). Finally, we screened older adults in terms of negative thoughts and depression with the Geriatric Depression Scale (GDS; Yesavage et al., 1982). The GDS is a 30-item self-report assessment that asks for a "yes" or "no" response on items such as "Are you basically satisfied with your life?" The grid sets a range of 0–9 as "normal," 10–19 as "mildly depressed," and 20–30 as "severely depressed." For reliability of all screening tests, see test references.

Design. Age was the independent between-subjects variable (younger vs. older adults), and word valence (positive, negative, and neutral) and color (red, green, and blue) were the independent within-subjects variables. Recognition accuracy computed as HITs-FAs was the dependent variable.

Materials. We selected 240 affective words from the Italian version of the ANEW (Montefinese et al., 2014) for the memory task. Sixty words were positive (M = 8.1, SD = 1.20), 60 were negative (M = 2.0, SD = 1.43), and 120 words were neutral (M = 5.2, SD = 0.37). Each valenced item was randomly assigned to the study list. To reduce potential cultural-specific associations between color and word meaning, we did not include words whose meaning is frequently associated with a color (e.g., love and red). Positive and negative words were matched in terms of arousal. The mean arousal level of the positive words was 6.0 (SD = 2.5), while it was 6.2 (SD = 2.1) for negative ones. The arousal level of neutral words was M = 4.9 (SD = 1.7). In addition, each word could randomly appear in green, red, or blue across participants. Items were randomly assigned to color: red, green, and blue. The properties of the three colors were chosen according to the RGB model (red: 255, green: 0, blue: 0; green: 255, red: 0 and blue: 0; blue: 255, green: 0, red: 0).

At study, each participant encoded 120 words, 30 positive (10 colored in red, 10 colored in green, and 10 colored in blue), 30 negative (10 colored in red, 10 colored in green, and 10 colored in blue), and 60 neutral (20 presented in red, 20 in green, and 20 in blue). In addition, 24 filler words were inserted at the beginning and at the end of the study list to reduce primacy and recency effects (8 in red, 8 in green, and 8 in blue). For the yes/no recognition memory test, participants saw 240 words presented in black.

Procedure. Each item was presented visually in the center of a computer screen for 3 s with a 1 s interstimulus interval. The order of word presentation at study was randomly intermixed. Participants silently read each word and memorized it for a later memory test. Before beginning the experimental task, participants completed a practice trial to familiarize with the task. Finally, we asked participants to report any difficulty they had encountered in perceiving the color of each word.

After the encoding phase, participants took an immediate yes/no recognition task (see Appendix A for a pilot study with delayed recognition). At test, participants saw 240 black words, 120 studied words, and 120 new, never studied words. Words were randomly intermixed. Each word appeared in the center of the screen and was preceded by a 1 s fixation cross. As soon as each word appeared, participants indicated whether they had previously studied the item (old) or whether they had never seen it (new) using two keys on the computer board. Each word remained on the screen until participants responded.

Results and Discussion

Results are presented in Table 2. We computed hits minus false alarms rates for each participant using the corresponding valenced

Table 2
Mean Percentage of Hits and False Alarm Rates as a Function of Age, Valence, and Color Condition in Experiment 1 (SEs Are in Parentheses)

	Hits			
	Red	Blue	Green	FAs
Young				
Positive	43.6 (2.8)	44.1 (2.4)	72.1 (2.9)	17.4 (2.6)
Negative	76.1 (3.2)	62.8 (3.3)	64.8 (3.3)	18.1 (3.0)
Neutral	54.6 (4.1)	53.8 (3.3)	51.2 (2.9)	20.4 (2.4)
Old				
Positive	63.2 (4.7)	66.4 (5.2)	79.2 (2.5)	18.9 (3.4)
Negative	59.2 (3.9)	58.1 (2.9)	56.4 (2.7)	28.1 (3.4)
Neutral	52.8 (3.9)	53.6 (4.1)	51.6 (3.8)	22.8 (2.7)

false alarms. A 2 (age group: younger vs. older) × 3 (valence: positive, negative, and neutral) × 3 (color: red, green, and blue) mixed analysis of variance (ANOVA) on recognition accuracy scores revealed no significant effect of age, $F < 1$, since recognition accuracy was comparable across the two groups. There was a significant emotional enhancement effect, $F(2, 96) = 8.36$, $p < .001$, $\eta_p^2 = .15$. In fact, positive (43%) and negative words (40%) were remembered better than neutral words (31%; LSD Test $p < .05$). There was also a significant effect of color, $F(2, 96) = 6.48$, $p < .01$, $\eta_p^2 = .12$, because green words (42%) were remembered better than red (37%) and blue words (36%; LSD Test $p < .05$).

We found a significant two-way interaction between age and emotional valence, $F(2, 96) = 17.03$, $p < .001$, $\eta_p^2 = .26$. In fact, we detected a negativity bias in younger adults since they remembered negative words (50%) better than positive (36%) and neutral words (33%) (LSD Test $p < .05$). Differently, older adults showed a positivity effect, since they remembered positive words (51%) better than negative (30%) and neutral words (30%; LSD Test $p < .001$). There was also a two-way interaction between valence and color because memory was better in congruent valence-color conditions, $F(4, 192) = 20.19$, $p < .001$, $\eta_p^2 = .30$. Positive words in green (57%) were remembered better than positive words in red (35%) and blue (37%; LSD Test $p < .001$), whereas negative words in red (45%) were remembered better than negative words in blue (37%) and green (38%; LSD Test $p < .05$). The two-way interaction between age and color was not significant, $F(2, 96) = 1.84$ $p = .16$ because of similar effects of color information among the two groups when valence was not included.

More important, these main effects were qualified by a significant three-way interaction between age, valence, and color, $F(4, 192) = 2.54$, $p < .05$, $\eta_p^2 = .05$ (see Figure 1) that remained significant $F(4, 184) = 3.01$, $p < .05$, $\eta_p^2 = .06$ after controlling for participants' cognitive abilities in terms of backward digit span and verbal fluency.

To better clarify this interaction, we computed ANOVAs for younger and older adults. We found a significant main effect of emotional valence in the younger adults, $F(2, 48) = 9.61$, $p < .001$, $\eta_p^2 = .29$ since negative words (50%) were remembered better than positive (36%) and neutral words (33%; LSD Test $p < .01$). We also found a significant main effect of color, $F(2, 48) = 6.67$, $p < .01$, $\eta_p^2 = .22$ since words in green (42%) were remembered better than words in red (37%) and blue (36%; LSD Test $p < .05$) irrespective of valence. Finally, the two-way interaction between emotional valence and color was significant, $F(4, 96) = 19.74$, $p < .001$, $\eta_p^2 = .45$. Positive words in green (55%) were remembered better than positive words in red (26%) and blue (27%; LSD Test $p < .001$). Differently, negative words in red (58%) were remembered better than negative words in blue (45%) and in green (47%; LSD Test $p < .01$). In addition, negative words in blue and green were remembered better than positive words in red and blue (LSD Test $p < .01$). These data underlined strong congruency effects since memory for words in younger adults improved when valence and color information were congruent compared with noncongruent conditions.

In older adults, we found a significant effect of valence, $F(2, 48) = 15.58$, $p < .001$, $\eta_p^2 = .39$ since positive words (51%) were remembered better than negative (30%) and neutral words (30%; LSD Test $p < .001$). The effect of color was not significant, $F(2, 48) = 1.49$ $p = .23$ because of the fact that positive words showed a supremacy in memory independent of color. Finally, we found a two-way interaction between valence and color, $F(4, 96) = 4.11$, $p < .01$, $\eta_p^2 = .15$. Positive words in green (60%) were remembered better than positive words in red (44%) or blue (47%; LSD Test $p < .001$).

We also performed an analysis on differential scores between congruent word valence/color conditions (positive/green and negative/red) and neutral words colored in green or in red in both younger and older adults to isolate valence effects and better assess the influence of color on emotional memory. Effect size was reduced ($\eta_p^2 = .19$) for the age by valence interaction compared with the one obtained in our primary analyses (.26), showing how color information boosted valence effects in memory.

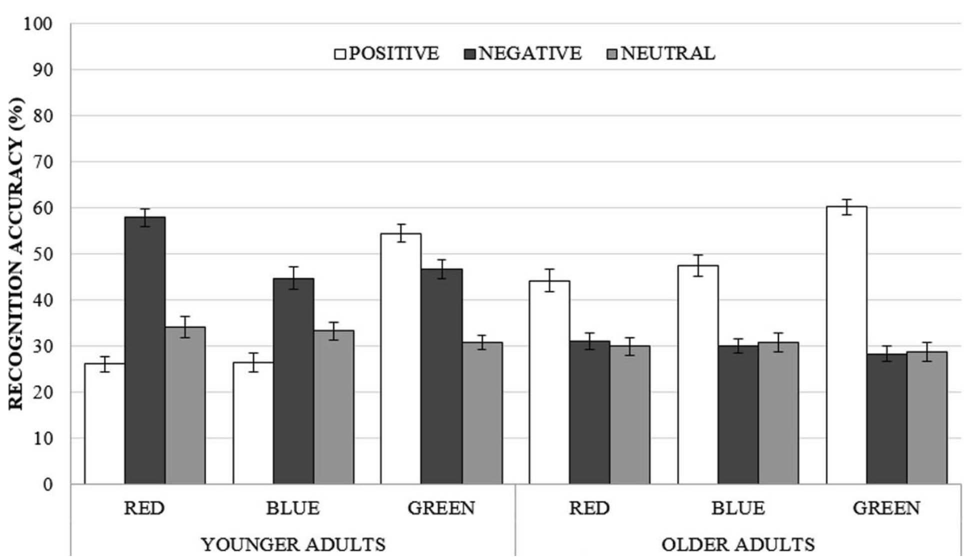

Figure 1. Mean percentage of hits minus false alarms (recognition accuracy) as a function of age, valence, and color condition in Experiment 1 (error bars represent the *SEM*s).

Finally, recognition memory generally increased in all participants but especially in congruent valence/color conditions. Indeed, older adults benefited only when positive words were presented in green, in line with the hypothesis that the affective meaning linked to a color can influence affective memories in older adults.

Experiment 2: Affective Pictures as Stimuli

In this experiment, we aimed to clarify whether results reported in Experiment 1 for verbal stimuli extended to pictorial stimuli as well. To this end, we tested memory for affective pictures shaded in red, green and blue in younger and older adults. Younger and older adults studied a series of pictures in valence-color congruent or incongruent conditions and then tested with a yes/no recognition memory task. If color influences the positivity effect typically found in older adults with pictorial stimuli as well, we expect positivity effects in memory to increase with positive pictures shaded green.

In fact, previous studies (e.g., Wichmann et al., 2002) have found a specific color effect in memory, independent of other types of controlled physical features (such as contrast). These data indicate that color effects on memory may be more conceptually driven and less dependent on age-related sensory deficits. Another interesting aspect, instead, may be related to picture presentation per se. With colored pictures, participants may experience greater incongruency effects (e.g., a green sky) than those experienced with colored words because of the visual nature of stimuli. This, in turn, may increase attention and should generate better recognition memory for incongruent stimuli. However, if the joint benefit deriving from color is less perceptually driven and relies more on general visual scenes knowledge, we expect positivity effects to increase in older adults only when pictures are shaded in green. This would again highlight a beneficial effect of color only when there is a match between stimulus perceptual features and motivational goals.

Lastly, although recognition memory was tested immediately in Experiment 1, participants, and especially older adults, showed some fatigue effects. In fact, recognition performance was not very high. To overcome these methodological pitfalls, we reduced the number of items per conditions in Experiment 2.

Method

Participants. Twenty-five younger adults (12 women, ages 18–25, M = 22.04) and 25 older adults (16 women, ages 65–80, M = 72.28) participated in the study. None of them had participated in Experiment 1. A summary of participants' demographic information appears in Table 3. The younger adults were undergraduates at the University of Chieti who participated in exchange for course credit. Older adults were community-dwelling residents from central Italy. The education level of older adults was comparable with the older adults in Experiment 1. Older adults did not receive monetary reimbursement for their participation. Exclusion criteria included treatment for memory problems, head injuries resulting in hospitalization for more than 24 hr and/or medical conditions that could potentially affect cognitive functioning (e.g., Alzheimer's disease, multiple sclerosis, and Parkinson's disease). Moreover, all older participants reported being in good mental and physical health and having no major hearing or vision problems. In particular, participants did not self-report any color vision deficiency such as daltonism or achromatopsia. Finally, participants' cognitive and affective abilities were screened as in Experiment 1.

Table 3
Demographic Information for Participants in Experiment 2

Measure	Young adults Mean (*SD*)	Older adults Mean (*SD*)	*p*
Education (years)	14,12 (1,94)	13,96 (2,35)	.79
Forward digit span	8,48 (2,16)	7,64 (1,38)	.11
Backward digit span	7,96 (1,79)	6,52 (1,08)	<.01
Panas POS	31,56 (6,01)	32,88 (4,56)	.38
Panas NEG	22,56 (3,61)	23,04 (5,45)	.71
VF	12,22 (2,67)	8,92 (2,79)	<.01
GDS	N/A	9,44 (3,22)	N/A
MMSE	N/A	28,12 (1,16)	N/A

Note. Forward and backward digit span from Mondini et al. (2011); positive (POS) and negative (NEG) Panas from Watson et al. (1988); VF = Verbal Fluency from Mondini et al., 2011; GDS = Geriatric Depression Scale (Yesavage et al., 1982); MMSE = Mini Mental State Exam (Folstein et al., 1975).

Design. Age was the independent between-subjects variable (younger vs. older adults), and picture valence (positive, negative, and neutral) and color (red, green, and blue) were the independent within-subjects variables. Recognition accuracy computed as HITs-FAs was the dependent variable.

Materials. We selected 96 affective pictures from the International Affective Picture System (IAPS) database (Lang et al., 2008) for the memory task. Twenty-four pictures were positive (M = 7.9, SD = 0.27), 24 were negative (M = 2.4, SD = 0.51), and 48 pictures were neutral (M = 5.2, SD = 0.28). Positive and negative pictures matched in terms of arousal. The mean level of arousal for positive pictures was 4.8 (SD = 0.90) while it was 5.0 (SD = 0.71) for negative ones. The mean level of arousal for neutral pictures was 3.4 (SD = 0.62. Valenced items were randomly assigned to the study list and color shade. In particular, shading was performed via PowerPoint manipulating color saturation according to the RGB model (red: 255, green: 107, blue: 107; green: 255, red: 107 and blue: 107; blue: 255, green: 107, red: 107).

Participants viewed 48 items at study, 12 positive pictures (4 presented in red, 4 in green, and 4 in blue), 12 negative pictures (4 in red, 4 in green, and 4 in blue), and 24 neutral pictures (8 in red, 8 in green, and 8 in blue). In addition, we inserted 12 fillers (4 pictures presented in red, 4 in green, and 4 in blue) at the beginning and at the end of the study list to reduce primacy and recency effects. For the yes/no recognition memory test, participants viewed 96 black and white pictures.

Procedure. Each item was presented visually in the center of a computer screen for 3 s with a 1 s interstimulus interval. The order of picture presentation at study was randomly intermixed. Participants silently studied each picture and tried to memorize it for a later memory test. Before beginning the experimental task, participants completed a practice trial to familiarize with the task. Finally, we asked participants to report any difficulty they had encountered in perceiving the color of each picture.

Participants took a yes/no recognition memory task immediately after the encoding phase (see Appendix A for a pilot testing with delayed recognition). At test, participants saw 96 black and white pictures, 48 studied items, and 48 never studied items. The order of pictures was randomly intermixed. Each picture appeared in the center of the screen and was preceded by a 1 s fixation cross. As soon as each picture appeared, participants indicated whether they had previously studied the item (old) or whether they had never seen it (new) using two keys on the computer board. Pictures remained on the screen until participants responded.

Results and Discussion

Results are presented in Table 4. We computed hits minus false alarms rates for each participant using the corresponding valenced false alarms. A 2 (age group: young vs. old) × 3 (valence: positive, negative, and neutral) × 3 (color: red, green, and blue) mixed ANOVA on recognition accuracy scores revealed a significant main effect of age, $F(1, 48) = 5.00$ $p < .05$, $\eta_p^2 = .09$, since younger adults (61%) performed better than older adults (52%). There was a significant emotional enhancement effect, $F(2, 96) = 6.64$, $p < .01$, $\eta_p^2 = .12$. In fact, positive (61%) and negative pictures (59%) were remembered better than neutral pictures (48%; LSD Tests $p < .01$). There was also a significant effect of color, $F(2, 96) = 12.52$, $p < .001$, $\eta_p^2 = .21$, because pictures shaded in green (63%) were remembered better than red (55%) and blue pictures (51%; LSD Tests $p < .05$).

We found a significant two-way interaction between age and valence, $F(2, 96) = 32.67$, $p < .001$, partial $\eta_p^2 = .40$. In fact, we detected a negativity bias in the younger adults who remembered negative pictures (78%) better than positive (49%) and neutral pictures (56%) (LSD Tests $p < .001$). Differently, older adults showed a positivity effect since they remembered positive pictures (73%) better than negative (41%) and neutral pictures (42%; LSD Tests $p < .001$). We also found a two-way interaction between valence and color showing how memory was better in congruent valence/color conditions, $F(4, 192) = 14.71$, $p < .001$, $\eta_p^2 = .23$. Participants remembered positive pictures shaded in green (83%) better than positive pictures shaded in red (49%) and blue (51%; LSD Test $p < .001$). They also remembered negative pictures shaded in red (65%) better than negative pictures shaded in green (57%) and blue (56%; LSD Test $p < .05$). The two-way interaction between age and color was not significant, $F < 1$ because of similar effects of color information among the two groups when valence was not taken into consideration.

Table 4

Mean Percentage of Hits and False Alarm Rates as a Function of Age, Valence, and Color Condition in Experiment 2 (SEs Are in Parentheses)

	Hits			
	Red	Blue	Green	FA
Young				
Positive	45.5 (4.6)	46.5 (5.4)	90.1 (2.5)	11.1 (2.6)
Negative	96.1 (1.9)	81.5 (4.6)	79.5 (5.0)	7.7 (1.9)
Neutral	67.5 (4.5)	65.5 (4.1)	65.1 (5.1)	10.1 (1.8)
Old				
Positive	70.1 (5.2)	72.1 (4.9)	93.1 (2.3)	5.1 (1.4)
Negative	61.1 (4.3)	57.1 (5.1)	60.1 (6.9)	17.6 (3.9)
Neutral	50.1 (5.9)	47.5 (5.1)	51.5 (6.0)	7.7 (1.2)

More important, these main effects were qualified by a significant three-way interaction between age, valence, and color, $F(4, 192) = 2.74$, $p < .05$, $\eta_p^2 = .05$ (see Figure 2). As in Experiment 1, this interaction remained significant, $F(4, 184) = 2.47$, $p < .05$, $\eta_p^2 = .05$ after controlling for participants' cognitive abilities in terms of backward digit span and verbal fluency.

To better clarify this interaction, we computed separate ANOVAs for younger and older adults. In younger adults, we found a significant main effect of valence, $F(2, 48) = 17.94$, $p < .001$, $\eta_p^2 = .43$. Negative pictures (78%) were remembered better than positive (49%) and neutral pictures (55%; LSD Test $p < .001$). We found a significant main effect of color, $F(2, 48) = 11.03$, $p < .001$, $\eta_p^2 = .31$. Participants remembered pictures shaded in green (69%) better than pictures shaded in red (60%) and blue (55%; LSD Test $p < .001$), irrespective of valence. Finally, there was a two-way interaction between valence and color, $F(4, 96) = 18.77$, $p < .001$, $\eta_p^2 = .44$. Positive pictures shaded in green (79%) were remembered better than positive pictures shaded in red (34%) and blue (35%; LSD Test $p < .001$). Differently, negative pictures shaded in red (88%) were remembered better than negative pictures shaded in green (72%) or in blue (74%; LSD Test $p < .05$). In addition, negative pictures shaded in blue and green were remembered better than positive pictures shaded in red and blue (LSD Test $p < .001$). As in Experiment 1, these data evidenced strong congruency effects since memory in younger adults improved when valence and color were congruent compared with noncongruent conditions.

In the older adults, we found a significant effect of valence, $F(2, 48) = 21.01$, $p < .001$, $\eta_p^2 = .47$ since they remembered positive pictures (73%) better than negative (41%) and neutral pictures (42%; LSD Test $p < .001$). The effect of color was significant, $F(2, 48) = 3.65$ $p < .05$ $\eta_p^2 = .13$, since green shaded pictures were (58%) recognized better than red (50%) and blue ones (48%; LSD Test $p < .05$). Finally, the two-way interaction between valence and color tended to significance, $F(4, 96) = 2.04$, $p = .09$, $\eta_p^2 = .08$. Older adults remembered positive pictures shaded in green (88%) better than positive pictures shaded in red (65%) or blue (67%) (LSD Test $p < .001$) showing how green strongly amplified positivity effects in older adults while color did not differentially affect memory for negative and neutral pictures.

As in Experiment 1, we again performed an analysis on differential scores between congruent picture valence/color conditions (positive/green and negative/red) and neutral pictures shaded in green or in red in younger and older adults to isolate valence effects and better assess the influence of color on emotional memory with pictorial stimuli. Effect size was reduced ($\eta_p^2 = .27$) for the age by valence interaction compared with the one obtained in our primary analyses (.40), indicating that color information influenced the strength of emotional memory biases with pictorial information as well.

Again, it is noteworthy that recognition memory in general increased especially in congruent valence/color conditions. More important, the positivity effect in older adults was boosted only when pictures were shaded in green. In Experiment 2 we also observed better recognition performance across both groups compared with Experiment 1 confirming that the lower number of items assigned to each valence and color condition and the nature of stimuli positively influenced memory performance in both groups.

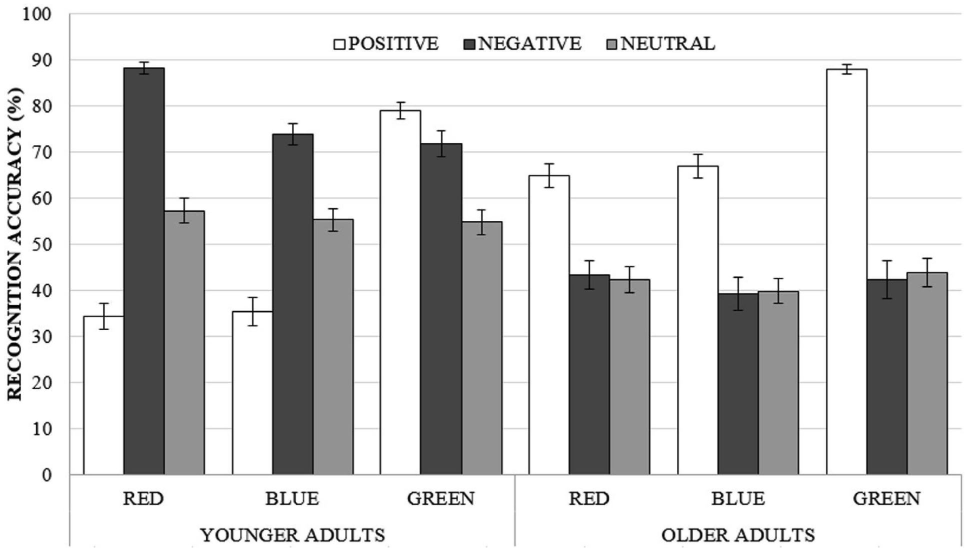

Figure 2. Mean percentage of hits minus false alarms (recognition accuracy) as a function of age, valence, and color type condition in Experiment 2 (error bars represent the *SEM*s).

General Discussion

This study assessed a potential perceptual modulator of the positivity effect in memory in older adults, that is, color. In line with previous studies (e.g., Kuhbandner & Pekrun, 2013) that showed joint effects of color and emotion on memory, we hypothesized an increase in the positivity effect in aging only when color matched the motivational goals of older adults. More specifically, we assumed that if positive information were green, this congruent valence/color association would lead to better memory. Differently, we expected a decrease in memory performance under incongruent valence/color conditions.

Age-Related Color Effects in Memory

We found a main effect of color in both Experiment 1 and 2. Moreover, we found a “green supremacy effect” in both experiments. That is, both younger and older adults showed better memory performance when stimuli were green compared with red or blue. When looking at recognition performance across the two groups separately in both experiments, we found that green boosted memory compared with red and blue conditions in the younger group too because even younger adults benefited from green in congruent valence/color conditions. Older adults showed a more diversified pattern of performance. In Experiment 1, color was not significant in the older adults’ group, while it was in Experiment 2. One explanation may be in the nature of study material and the fewer items assigned to experimental conditions. In fact, the green effect was magnified in the older adults when we used pictorial material. Most noteworthy, this effect was strictly dependent on the positive-green association as in Experiment 1. Altogether, our findings indicated that color may be used as a diagnostic cue for stimulus encoding and retrieval and that older adults are able to use color to sustain memory performance.

Age-Related Valence Effects in Memory

In both experiments, we replicated typical emotion enhancement effects found in memory studies. That is, we found better memory for emotionally charged items compared with neutral items (e.g., Kensinger & Corkin, 2003). In addition, we found the typical valence by age interaction generally found in emotional memory and aging studies (e.g., Mather & Knight, 2005), because younger adults remembered negative items better, while older adults remembered positive items better. This so-called positivity effect occurred with both affective words and affective pictures. Our findings are in line with a series of studies showing the robustness of the positivity effect in memory in older adults (e.g., Di Domenico et al., 2014, 2015; Kalenzaga et al., 2016; Reed et al., 2014) and evidenced the role of socioemotional self-relevant goals in shaping memory performance (e.g., Mather & Carstensen, 2005). In particular, as stated in the Introduction, healthy older adults show a preference toward positively charged events in their cognitive processing and away from negative stimuli. The opposite pattern, instead, occurred in the younger adults. The main assumption is that the frequency and intensity of negative events is typically higher during youth and decreases as we age (e.g., Tsai et al., 2000). In addition, socioemotional diversified goals among younger and older adults shape their cognitive processing (e.g., Mather & Carstensen, 2005).

Age-Related Joints Effects of Valence and Color in Memory

This study demonstrated that color modulates emotional enhancement effects in memory in younger and older adults. In line with the hypothesis that color and affective connotation may interact in memory processes (e.g., Kuhbandner & Pekrun, 2013), we found additive effects of color and affective connotation on memory. In general, these effects mirrored the classical age by valence interaction, suggesting that motivational goals may influence the perceptual quality of the affective information to be learned and subsequently remembered. In particular, color modulated the strength of valence biases by strengthening the underlying motivational implications (e.g., reflecting negative affect in the younger group and positive affect in the older adult group). In fact, we found that green stimuli selectively enhanced memory for positive pictures in the older group, while red stimuli led to better memory for negative information in the younger group. Compared with previous studies as reported by Reed et al. (2014), we obtained an even larger effect size in terms of the positivity effect. We believe that this may be because of the following reasons. First, we used an immediate recognition memory task while other recognition memory studies included a retention interval of at least 10 min or even longer (e.g., Emery & Hess, 2008; Kensinger, 2008; Thomas & Hasher, 2006 to cite only few). This may have increased the effect of color information on immediate retrieval and consequently given rise to a stronger age by valence interaction. Second, the increase in effect sizes may be linked to the color manipulation per se. Color boosted performance in general and especially in congruent conditions, toward the positive or negative pole according to age differences. Thus, larger effect sizes may be because of additive effects of color and emotion in recognition memory as shown by the complementary analysis on differential scores. This analysis in fact revealed that the contribution of valence to recognition memory for both Experiment 1 and 2 tends to be weaker and more in line with the literature on positivity effects (between .05 and .15).

This pattern of data is coherent with previous studies (e.g., Fairfield et al., 2015a; Mather & Knight, 2005) showing that positivity effects rely on conceptually driven processes oriented toward positive information processing in older adults. In fact, only congruent conditions boosted older adults' memory for positive information, indicating that older adults encoded color, in this case green, with particular reference to their general knowledge about the emotional meaning that the color can carry. Differently, when there was a mismatch between motivational goals and common meaning of color, the positivity effect was less evident. This finding supported the idea that the effect of color information in memory in older adults depends less on perceptually driven processes and more on conceptual elaboration of stimulus features. More important, color did not influence memory performance in older adults when color was unitized with negative or neutral information. This finding highlighted the cognitive effort that older adults make to focus more on positive information and less on negative information. Differently, younger adults benefited when color was congruently associated with the valence of items, both for positive and negative items.

Altogether, these results are particularly interesting when considering the nature of the studied material. In fact, positivity effects in aging have been shown to occur more frequently with pictorial material (e.g., Fernandes et al., 2008) because of the richness of perceptual features that accompany encoding and retrieval of valenced information. Consequently, any manipulation that could influence this effect may be informative about mechanisms involved. In our case, we found that conditions that captured attention (i.e., incongruent valence/color conditions) and, consequently, led to better memory, did not strongly affect the occurrence of positivity effects. This data again highlights the contribution of more conceptually driven processes in the generation of positivity effects in older adults.

In line with previous studies investigating whether stimulus features affect emotional memories (e.g., Hess et al., 2013), we found that perceptual features such as color may also be considered as a cue that attributes emotional meaning to stimuli and consequently leads to differences in valence processing. Previous studies in the object recognition domain (e.g., Bramão et al., 2011) repeatedly found that color information underlies faster detection of objects in a scene and influence attention allocation. Our study thus extends these findings to memory as well. In particular, it is worth nothing that we used a recognition memory task while the study by Kuhbandner and Pekrun (2013) asked participants to recall. Typically, recall is more sensitive to contextual information while recognition memory tasks rely more on item-specific information (Hunt & McDaniel, 1993). However, previous studies (e.g., D'Argembeau & Van der Linden, 2004; Doerksen & Shimamura, 2001; MacKenzie et al., 2015) found that color (e.g., yellow or blue) is remembered better with affective words than neutral words, suggesting that memory for color information is typically better for affective than neutral words independent of memory tasks. Our data replicated this finding and extended it to memory in older adults. A complementary motivational-based explanation of our recognition memory data (e.g., Stein et al., 1997) is that people are often motivated to understand emotional situations by searching for cues that can explain reactions and emotional connotation attribution processes. This, in turn, leads to better memory for contextual details as well. In our case, color information was a cue that strengthened the valence of study items.

Noteworthy, in our study learning occurred intentionally because participants knew about the subsequent memory task. Intentional learning therefore, may have played an important role in fostering conceptually driven processing and in rendering recognition memory tasks less sensitive to study-test perceptual mismatch (colored items vs. black items). This is particularly true for older adults, whose recognition memory seems to be driven more by the positivity effect than any color manipulation. To this end, incidental learning, that typically occurs when participants are unexpectedly presented with a memory task, would also be an interesting manipulation. In fact, incidental learning may be more sensitive to perceptual manipulations (e.g., Blaxton, 1989). The comparison between intentional and incidental learning may thus add evidence about the degree of perceptual-versus conceptual-driven processing in driving the color effect found in our study.

Limitations and Issues for Future Research

Our study has several limitations. One is that we did not use a color manipulation check so we do not know whether green and red oriented participants toward a more positive or negative mood. In line with the study by Kuhbandner and Pekrun (2013) and with previous RTs data (e.g., Moller et al., 2009), our study points in this direction. A useful future condition should include a session that experimentally primes participants with green/positive and red/negative associations and later investigates memory performance. We are currently running a RT experiment in which valenced target words are preceded by a colored screen to examine different priming effects in younger and older adults as a function of valence and color.

A further consideration is the fact that current baseline mood may also modulate memory processes and underlying valence effects. Here, in both experiments younger and older adults showed higher scores on the positive section of the PANAS. Consequently, positive mood may have influenced younger adults who also benefited from green-positive stimuli associations and may explain the greater attentional focus of older adults on positive stimuli independently of color. In addition, the presentation of affective items per se may function as a mood induction technique and trigger different emotional states that may interact with color. Although valence was intermixed at study, this may occur especially for pictorial stimuli that are often used to induce affective states (Ferrer et al., 2015).

In the context of associative memory studies (e.g., Old & Naveh-Benjamin, 2008), these findings indicate adequate processing of central component stimuli (i.e., each color and each stimulus already unitized). Both experiments in fact, provided converging support to the hypothesis that older adults were able to process already unitized stimuli. Although not directly tested, an interesting question for future studies would be to test memory for stimuli under central unitized (a colored word) versus peripheral nonunitized conditions (a black word encased in a colored frame). This may better clarify how older adults use color information while encoding affective information. In this regard, valence biases could be also indexed by the percentage of gaze fixation on color. Eye-tracking studies (e.g., Isaacowitz et al., 2006), in fact, may help disentangling the contribution of perceptually versus conceptually driven processes by allowing a continual measurement of attentional fixation and help refine data regarding the influence of color on emotional memory.

Another avenue that future studies need to consider is the robustness of this effect with different recognition memory tasks. As shown by Kensinger and Schacter (2007), in fact, memories are retrieved with different amounts of visual detail and valence can influence the likelihood that visual detail is remembered. An interesting paradigm would be to ask participants to distinguish between "same" items (e.g., colored words identical to previously presented words) from "similar" (same word but different color) and new (never seen word). This would allow us to investigate the degree to which emotion influences visual specificity in memory in older adults. Within the context of recognition tasks, it would also be interesting to investigate whether color alone is sufficient to modulate the positivity effect independent of the color used. That is, it would be important to show whether the positivity effect is stronger under any type of color condition with respect to a no color condition (e.g., comparing, for instance, a positive word colored in green with a positive word colored in blue or in black). This comparison would allow us to investigate whether color, independent from its conveyed meaning, somehow primes the emotional evaluation of stimuli.

A future concern regarding the hypothesis of mixed emotions may also be informative. In fact, mixed emotions refer to conditions that contemplate both pleasant and unpleasant aspects, that is, feeling happy and sad at the same time. Numerous studies (Ersner-Hershfield et al., 2008; Schneider & Stone, 2015) have shown that older adults experience mixed emotions more frequently than younger adults did. Thus, older adults' memory may be more sensitive to ambivalent situations than their younger counterparts. In fact, when focusing on positivity effects when positive information is colored red and blue, older adults still showed better memory for positive information over other types of ambivalent conditions. Differently, when looking at negative information, younger adults were not particularly influenced by ambivalence. According to Carstensen and colleagues (e.g., Ersner-Hershfield et al., 2008), mixed emotion typically increases when people are under time constrains, that is, when they perceive time as limited. Thus, to provide further and more direct evidence about color effects in ambivalence, future research could manipulate time perception or recruit older participants with different age ranges. We expect that inducing participants to perceive time left as limited, should increase memory for ambivalent items, especially in old-old adults compared with young–old adults.

Finally, a growing number of studies on cultural cognition have reported differences in color processing between individuals from East Asian and Western cultures (e.g., Roberson et al., 2005; Smet et al., 2014) and culture has been found to modulate positivity effects as well (e.g., Chung et al., 2012; Wang et al., 2015). In this study, we recruited only Italian participants, while Kuhbandner and Pekrun (2013) tested a group of German University students. Our findings are thus novel in the context of culture and memory studies and demonstrate that emotional biases may be dependent upon color meaning culturally congruent with the to-be-remembered item. We expect future studies in this direction.

Summary

In summary, the primary goal of the present study was to investigate conditions that influence positivity effects in aging. We investigated whether manipulating color at encoding has implications on the strength of valence biases typically shown by older adults in memory tasks. The most significant finding was that when stimulus color somehow reflected underlying motivational goals, positivity effects increased. On the contrary, when stimulus color did not evoke motivational implications of the valence bias, the effect was reduced. The possibility that color processing itself may become more conceptually driven as we age warrants further research. Such research may help better explain age-related emotional memory changes by exploring perception-emotion interactions across the life span. Our findings are ultimately coherent with the Mather and Knight (2005)'s model of top-down processes involvement in older adults' emotional memories and invite researchers to rethink the role of perceptually driven processes in the generation of positivity effects.

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Appendix

Pilot Studies

Methods and Results From Small-Scale Pilot Studies

We elected to always present the recognition test immediately after the study phase because pilot testing indicated that when the recognition memory phase occurred after 10 min, the effect of color was not significant. In particular, we piloted two small samples ($N = 12$ each) of older adults who performed the recognition memory test after 10 min. We found that although older adults show a tendency to remembered positive items better than negative and neutral items, color did not affect performance. We also noticed some fatigue effects and participants reported their difficulties in remembering items. We reasoned that a 10-min retention interval coupled with the complexity of the design may have depleted older adults' cognitive resources and, consequently, affect the processing of color information.

Participants

Twelve older adults completed a pilot study with words and 12 older adults completed a pilot study with pictures. Older adults were screened for their cognitive abilities as done in Experiments 1 and 2.

Procedure

Twelve participants completed the word version of the task, the remaining 12 completed the picture version. After presentation of items, a retention interval of 10 min followed during which participants were invited to read a newspaper. Subsequently, they were invited to remember whether each item was presented or not.

Results

Affective Words

The main effect of valence tended to significance, $F(2, 22) = 3.34$ $p = .054$, while the main effect of color was not significant, $F < 1$.

Affective Pictures

The main effect of valence show a tendency to approach significance, $F(2, 22) = 2.26$ $p = .12$, while the main effect of color was not significant, $F < 1$.

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