Acta Psychologica 244 (2024) 104172

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Colored valence in a lexical decision task

Alessandro Bortolotti [a,*], Caterina Padulo [b], Nadia Conte [c], Beth Fairfield [b], Riccardo Palumbo [a]

[a] *Department of Neuroscience e Imaging University of Chieti, Italy*
[b] *Department of Humanities University of Naples "Federico II", Italy*
[c] *Department of Psychological, Health and Territorial Sciences University of Chieti, Italy*

ARTICLE INFO

Keywords:
Red
Green
Information processing
Valence
Psuedowords
Words

ABSTRACT

Color influences behavior, from the simplest to the most complex, through controlled and more automatic information elaboration processes. Nonetheless, little is known about how and when these highly interconnected processes interact. This study investigates the interaction between controlled and automatic processes during the processing of color information in a lexical decision task. Participants discriminated stimuli presented in different colors (red, blue, green) as words or pseudowords. Results showed that while color did not affect the faster and more accurate recognition of words compared to pseudowords, performance was influenced when examining words and pseudowords separately. Pseudowords were recognized faster when presented in blue or red, suggesting a potential influence of evolutionary color preferences when processing is not guided by more controlled processes. With words, emotional enhancement effects were found, with a preference for green independent of valence. These results suggest that controlled and more automatic processes do interact when processing color information according to stimulus type and task.

1. Introduction

Color is an ever-present feature of psychological experience (Maule et al., 2023; Witzel & Gegenfurtner, 2018). It is a key signal for basic vision and a useful cue for object perception and cognition. Color helps distinguish objects with similar shapes and objects from backgrounds (e.g., Gegenfurtner & Rieger, 2000). It can also provide information about object properties (e.g., Bortolotti et al., 2023; Osorio & Vorobyev, 1996). For example, individuals may use color to determine whether fruit is ripe or whether meat is spoiled. The color of the sky can be used to estimate the time of day, and the color of trees may indicate the season. Color can also provide information about an individual's internal state—blushing when embarrassed, pale when in poor health (e.g., Stephen et al., 2009). Moreover, colors help describe and communicate efficiently (e.g., Conway et al., 2020) since different colors have been shown to have reliable associations with emotions (Mammarella et al., 2016) and abstract concepts (Tham et al., 2020). In this regard, there are a number of studies that have investigated the role of color and emotions in word recognition tasks (Crossfield & Damian, 2021; Kuperman et al., 2014), and the role of color in communication (e.g., red for stop, green for go) and word processing (Gerrig & Bower, 1982; Larsen et al., 2008; Sereno et al., 2015).

Several theories have been advanced to explain color preferences and clarify how color information is processed. The cone-contrast theory posits that color preferences arise from hard-wiring in early visual processing (Hurlbert & Ling, 2007; Ling et al., 2006). In line with this, studies have focused on the correct description of color as a stimulus (Bortolotti et al., 2023; Briki & Hue, 2016; Xia et al., 2016) since colors can vary widely according to characteristics such as hue, chroma, and lightness (Bortolotti et al., 2022; Wilms & Oberfeld, 2018). In addition, studies on color and selective attention suggest that red stimuli receive an attentional advantage and found that participants' visual search times were faster for desaturated red compared to other colored targets (e.g., Folk, 2015) and Sahin and Figueiro (2013) found that participants exposed to blue (relative to yellow) illumination reported greater mental alertness.

Color information may also be used as a visual cue for word segmentation (Cunillera et al., 2010; Saffran et al., 1996; Sell & Kaschak, 2009). Studies have shown how color information is effectively used to delimit words in unspaced writing systems like Chinese (Perea et al., 2015; Perea & Wang, 2017; Zhou et al., 2020), and thus to facilitate eye guidance in Chinese reading (Pan et al., 2021). In a behavioral study,

* Corresponding author at: Center for Advanced Studies and Technology (CAST), Via Luigi Polacchi, 11, 66100 Chieti, CH, Italy.
E-mail addresses: alessandro.bortolotti@unich.it (A. Bortolotti), caterina.padulo@unina.it (C. Padulo), nadia.conte@unich.it (N. Conte), beth.fairfield@unina.it (B. Fairfield), riccardo.palumbo@unich.it (R. Palumbo).

https://doi.org/10.1016/j.actpsy.2024.104172
Received 13 October 2023; Received in revised form 31 January 2024; Accepted 1 February 2024
Available online 7 February 2024
0001-6918/© 2024 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Vergara-Martínez et al. (2023) found that prime and target colors in a masked priming paradigm influences lexical decision performance when target were nonwords. Neuroimaging research has also shown advantages for congruent prime target shapes, but only when color is also congruent (Emmanouil et al., 2013), suggesting that color can influence information processing at very early stages.

The ecological valence theory (EVT; Palmer & Schloss, 2010), instead, affirms that individuals like some colors more than others due to the valence of the objects associated with those colors. Thus, color preferences result from an individual's associated liking/disliking to corresponding colored objects (Palmer & Schloss, 2010; Taylor & Franklin, 2012). Indeed, sometimes colors send an "approach" signal (e.g., bright colors to attract insects), and other, send an "avoid" signal (e.g., dark colors to deter predators). Although the colors of many things are completely arbitrary (e.g., the color of a shirt or car) and thus do not have significant signal value, deeply ingrained natural color signals (e.g., the redness of a blushing face) may be strong enough to influence color preferences (Humphrey, 2019).

Another explanation, the Color-emotion Theory, suggests that color preferences arise from the emotional content of colors (Ou et al., 2004). From a semantic point of view, color may also convey meaning, including affective content and knowledge important to surrounding contexts. For example, in western cultures red is generally associated with negativity whereas green is more often associated with positivity (Mammarella et al., 2016; Sivananthan et al., 2021) showing how color can assume an affective connotation and thereby influence information processing in line with studies on the influence of affective content on information processing (Balsamo et al., 2020; Fairfield et al., 2022) have shown how neutral and emotionally charged stimuli influence a number of cognitive processes, including lexical decision (e.g., Scott et al., 2009; Scott et al., 2014), speed of processing (e.g., Hildebrandt et al., 2012), stimulus evaluation (e.g., Manippa et al., 2018; Padulo et al., 2018), accuracy of word detection (Ortigue et al., 2004), and memory (Kuchinke et al., 2006; Mammarella et al., 2013).

Elliot and Maier (2014) proposed the Color-in-Context Theory, a broad model of color and psychological functioning. They posit color carries meaning, influences psychological functioning, and that its effects are automatic. Most importantly, color meanings and effects are context specific. For example, in achievement contexts, red seems to impair performance and assume a meaning of failure (Elliot et al., 2007) whereas in affiliation contexts, red carries a positive meaning (Elliot et al., 2010).

Nonetheless, although context effects have repeatedly been demonstrated, it is difficult to predict which salient features in the context will influence the meaning of specific concepts (Bramão et al., 2011). For example, the dimension-specificity hypothesis (Schietecat et al., 2018) predicts that cross-modal associations emerge depending on the most salient affective dimension (i.e., valence, arousal, or dominance) in a specific context. Thus, when categorizing red, green, positive, and negative related stimuli in a cognitive task, both concept pairs (i.e., red vs green, and positive vs negative) have the highest conceptual distance on the evaluation dimension and should become the salient dimension of meaning underlying color associations. Based on the salient dimension in the task, green and positive will both be assigned a positive meaning, whereas red and negative will be assigned a negative meaning. Moreover, when more than one dimension is present in a task, a weighting process will determine salience. Thus, colors may be processed differently in terms of controlled and automatic information processing.

Comparing words and pseudowords may shed light on how color affects information processing since lexical processing can be driven by both controlled and automatic processes (Garrido et al., 2019; Sulpizio et al., 2021). Controlled lexical processes stress the importance of higher mental processes such as expectations and beliefs and place demand on an individual's cognitive skills and short-term memory. Yet, even top down lexical processing becomes more automatic in time since words are stored in long-term memory can be accessed rapidly when needed. In this manner, words are generally discriminated quickly and easily. Differently, pseudowords, strings of letters conforming to a language's orthographic pattern and pronounceable but without meaning, require more cognitive resources since the ability to discriminate these items necessitates access to phonetic information and semantic memory as well.

Here we aimed to investigate how controlled and automatic processes interact when color information is present in a lexical decision task in which participants are required to discriminate between words and pseudowords. We expect words, independent of color and valence, to be recognized faster and more accurately than pseudowords (Dufau et al., 2012; Perea et al., 2002; Ratcliff et al., 2004). In addition, if color is processed principally through more automatic processes, we expect words and pseudowords presented in red to be recognized faster and more accurately than words presented in green and blue since red seems to have a basic perceptual preference in attention (Elliot & Aarts, 2011; Elliot et al., 2007; Kuniecki et al., 2015. If, instead, color is preferentially processed through controlled processes, we may find faster and increased accuracy for words presented in both red and green compared to stimuli in blue since affective information typically shows memory advantages (Mammarella et al., 2016; Mehta & Zhu, 2009). We also expect accuracy for affective words to be higher than neutral words as typically found in literature (Fairfield et al., 2013). Finally, with regards to valence/color congruency effects, if controlled processing has an overall advantage over automatic processing, we expect faster and more accurate recognition when negative words are presented in red and positive words in green compared to negative in green and positive in red.

2. Method

2.1. Participants

One hundred and twenty-three undergraduates from the University of Chieti took part in the experiment for course credit (104 Females; mean age 21.71, SD 6.93). All participants had normal or corrected-to-normal vision and were native Italian speakers. All participants reported being in good mental and physical health and without major hearing or vision problems. Participants did not self-report any color vision deficiency such as Daltonism or Achromatopsia.

2.2. Materials

We selected 180 affective words from the Italian version of the ANEW (Montefinese et al., 2014) and 180 pseudowords for the lexical decision task. 60 words were positive (M 7.70, SD 0.50), 60 were negative (M 2.10, SD 0.46), and 60 words were neutral (M 5.09, SD 0.41). Positive and negative words were more arousing than neutral words. Positive and negative words were matched in terms of arousal. Mean arousal for positive words was M 6.48 (SD 0.67), while it was M 6.55 (SD 0.6) for negative ones and M 4.9 (SD 0.43) for neutral ones. Words were comparable for length, frequency of use and familiarity. Words whose meanings frequently associated with a color (e.g., grass and green) were excluded. The 180 pseudowords were constructed following the rules of Italian grammar and starting from existing words. The pseudoword length was M 6.48 (SD 1.42). 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).

Words and pseudowords were randomly assigned to red, green, and blue color conditions across participants so that each participant saw each word and pseudoword once only in one color. Each participant saw a total of 360 trials (180 words and 180 pseudowords).

3. Procedure

Participants were tested online using *E*-prime go software. Participants were accommodated in a quiet room and were informed about the task. Participants gave informed consent before beginning the experimental task. Before beginning the experimental task, participants completed a practice session to familiarize with the task (8 trials). Each item (Font Size 70) was presented visually on a grey background in the center of a computer screen for 2 s with a 500 ms interstimulus interval (+). The order of word and pseudoword presentation at study was randomly intermixed. Participants were instructed to silently read each stimulus and to press one of two keys: "yes" if the stimulus was an Italian word or "no" if it was a pseudoword. The entire experiment lasted about 15 min.

4. Data analysis

Data analyses were carried out on mean RTs and on mean accuracy rates calculated as correct recognition using Statistica 8.0. Regarding mean RTs, as done in previous studies (Perea & Lupker, 2004), we excluded incorrect responses and RTs less than 250 ms or greater than 1500 ms from the analysis. We calculated mean RTs and mean accuracy rates (ACC) separately for Lexicality (i.e., words and pseudo-words) and Color (i.e., blue, green, red). For words only, we also calculated mean RTs and mean ACC for Valence (i.e., negative, neutral, positive).

We carried out 2 (Lexicality: word vs pseudo-word) x 3 (Color: blue, green, red) ANOVAs separately on RTs and ACC. For words only, we carried out 3 (Color: blue, green, red) x 3 (Valence: negative, neutral, positive) ANOVAs separately on RTs and ACC. When significant effects were found, Tukey post-hoc comparisons were applied.

5. Results

5.1. RTs

Analysis with Lexicality and Color as within subject factors, revealed a main effect of Lexicality ($F(1,122) = 208.977$, $p < .001$, $\eta p2 = 0.631$), showing faster responses for words than for pseudo-words. The two-way interaction was also significant ($F(2, 244) = 10.297$, $p < .001$, $\eta p2 = 0.087$). Post-hoc comparisons revealed that responses for words were faster than responses for pseudo-words with all colors (Fig. 1). For averages and standard deviations of both accuracy and response times see Table 1.

Moreover, while responses were faster with words presented in green compared to words in red ($p = .05$), responses were slower with pseudo-words written in green compared to pseudo-words written in red ($p = .01$).

Analyses on word items with Color and Valence as within subject factors, revealed a main effect of Color ($F(2, 244) = 4.3122$, $p = .01$, $\eta p2 = 0.034$). Responses were faster for words written in green compared to red ($p = .01$). We also found a significant main effect of Valence ($F(2, 244) = 59.691$, $p < .001$, $\eta p2 = 0.329$), showing slower responses for neutral words compared to both negative and positive words (both $p < .001$). The two-way interaction between Color and Valence was also significant ($F(4, 488) = 2.5134$, $p = .04$, $\eta p2 = 0.02$). Post-hoc comparisons revealed that when words were written in blue and green, responses were faster for affective words (i.e., negative and positive) compared to neutral (all $p < .001$), when words were depicted in red, responses were faster for negative words compared to neutral ($p < .001$) and positive ($p = .04$) (Fig. 2). For averages and standard deviations of accuracy and response times see Table 2.

5.2. Accuracy (ACC)

Analysis with Lexicality and Color as within subject factors, revealed a main effect of Lexicality ($F(1, 122) = 69.980$, $p < .001$, $\eta p2 = 0.365$), showing better accuracy for words than for pseudo-words. The two-way interaction was also significant ($F(2, 244) = 6.5569$, $p = .002$, $\eta p2 = 0.051$). Post-hoc comparisons revealed that accuracy for words was better than accuracy for pseudo-words with all colors (all $p < .001$). Moreover, while there were no differences in accuracy for colored words (all $p > .266$), accuracy was poorer for pseudo-words written in green

Table 1
RT means (SD), and Accuracy rates (SD) for lexicality and color.

	Word			Pseudoword		
	Blue	Green	Red	Blue	Green	Red
ACC	0.89 (0.09)	0.9 (0.08)	0.89 (0.08)	0.79 (0.15)	0.77 (0.17)	0.8 (0.14)
RT	643 (88.95)	636 (86.96)	646 (85.81)	768 (142.52)	777 (155.48)	766 (150.76)

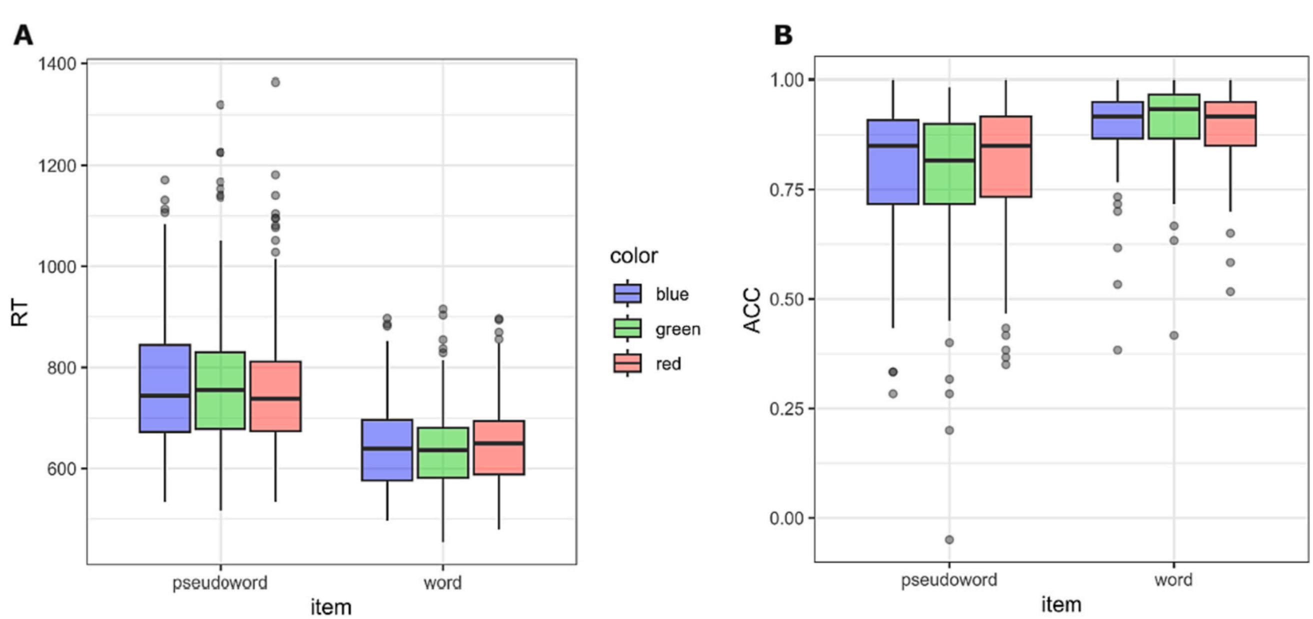

Fig. 1. RTs and Accuracy rates for lexical decision by lexicality.

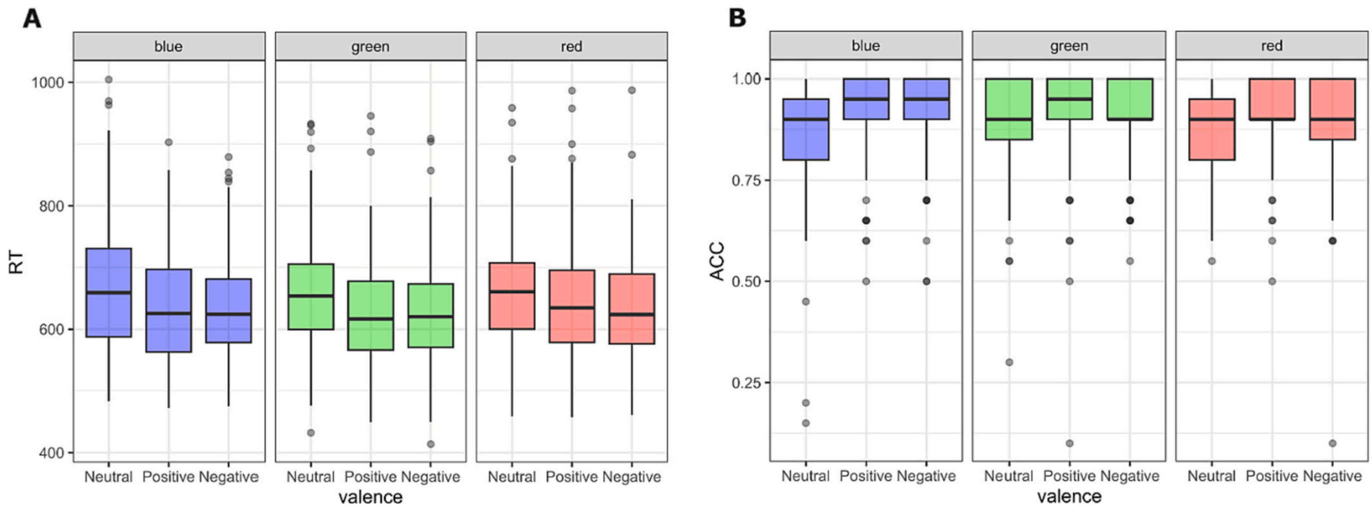

Fig. 2. RTs and Accuracy rates for words by valence x color.

Table 2
RT means (SD), and Accuracy rates (SD) for word valence and color.

	Blue			Green			Red		
	Negative	Neutral	Positive	Negative	Neutral	Positive	Negative	Neutral	Positive
ACC	0.91 (0.1)	0.85 (0.13)	0.91 (0.1)	0.91 (0.1)	0.88 (0.11)	0.91 (0.12)	0.9 (0.12)	0.87 (0,11)	0.91 (0.09)
RT	631 (85.96)	667 (105.3)	632 (91.05)	627 (89.58)	656 (94.43)	625 (93.18)	632 (83.65)	661 (91.8)	645 (100.54)

compared to pseudo-words in red ($p = .003$).

An analysis on words with Color and Valence as within subject factors, revealed a significant main effect of Valence ($F(2, 244) = 31.327$, $p < .001$, $\eta p2 = 0.204$), showing less accuracy for neutral words compared to both negative and positive words (both $p < .001$). The main effect of Color and the two-way interaction were not significant ($p = .246$ and $p = .182$, respectively).

6. Discussion

Color processing is often so subtle that its influence on affect, cognition, and behavior usually goes undetected. Research on color information processing has generally focused on either controlled or automatic processing without considering that the task and stimuli adopted may create contexts in which these two types of processing may, to different extents, coexist. Automatic processing is learned in long-term store, is triggered by appropriate inputs, and then operates independently of the subject's control. It does not require attention, though may attract attention when appropriate. In search, detection, and attention tasks, automatic detection develops when stimuli are consistently mapped to responses. In this manner, information can attract attention and initiate responses automatically, regardless of other inputs or memory load. Controlled processing, instead, requires attention and engages short-term capacity. In search, attention, and detection tasks, controlled processing usually takes the form of a serial comparison process.

Here we adopted a lexical decision task in which participants categorize stimuli presented one at a time as words or non-words, to investigate the potential interaction between bottom-up and top-down processes during color information processing. As expected, we found that words were recognized faster and more accurately than pseudowords in line with studies in literature (e.g., Antos, 1979). However, color, in general, did not affect this robust finding suggesting that automatic language processing may guide the task requests and that color may not be considered an essential cue for correctly completing the task at hand.

Interestingly, performance changed when we examined words and pseudowords independently. We found that psuedowords presented in blue or red were recognized faster and better than pseudowords presented in green suggesting that when processing is not captured by top-down processes linked to word and language processing, automatic preferences may emerge. Our results are in line with studies that have established early attentional preferences for red (Elliot et al., 2007; Kuniecki et al., 2015). An alternative explanation may be that performance with items presented in green are slower and less accurate linked to a conflict between answer and experience learned semantic associations. Indeed, the lexical decision task requires a “no” response while the color green may be linked to semantic associations learned through experience such as “go”, “right”, “up”, “positive”, “correct “(Goodhew & Kidd, 2017, 2020; Mammarella et al., 2016; Maule et al., 2022) creating a conflict indexed by increased response time and lower accuracy.

Differently, when we examined performance for words, we found typical emotional enhancement effects with positive and negative word recognition being both faster and better than neutral word recognition. Interestingly, we found an advantage for the affective words when these were presented in green independent of valence. Green may be considered a contextual cue indicating “go” in line with studies that have found associations between stimulus properties across different sensory modalities enhancing top-down processing of meaningful information (words) in a task where individuals are asked to discriminate between words and pseudowords. For example, associations between particular sounds and certain visual shapes are demonstrated in the now famous example in which people overwhelming link the sound of the verbal name “bouba” to a rounded-contour visual shape and the name “kiki” to a sharp-angled shape (Goodhew & Kidd, 2020; Maule et al., 2022; Ramachandran & Hubbard, 2001).

We did not find valence color congruency effects as found in literature (Mammarella et al., 2016). A potential explanation for this difference is that Mammarella et al. (2016) used an old/new affective word recognition task, whereas we used a lexical decision task. The lexical decision task does not necessarily require participants to deeply process the semantic meaning of the word items to correctly complete the task. Indeed, since the task requires individuals to simply discriminate between words and non-words, it may be that individuals limit language processing to superficial phonological and/or orthographic processing, just enough to be able to discriminate a word from a pseudoword.

Our study, however, is not without limits. Certainly, color is a complex type of information that contains not only hue but luminance/lightness and saturation as well and although there do seem to be some innate preferences for hue, future studies should take luminosity and saturation into consideration as well. Also, our results certainly do not allow us to completely disentangle top-down and bottom-up processing of color information. Future studies need to adopt different tasks that require different degrees of top-down control to better understand how color information is processed and to clarify how and when bottom-up and top-down processes interact during information processing. Finally, it would be interesting to investigate cross-cultural performance for stimuli in green in populations that do not semantically associate green with "go" or individual differences in the number of associations between specific objects and green.

In sum, our results seem to suggest that automatic and controlled processes do interact according to stimulus type and on-going task evidencing how different salient features in the context may influence cognitive performance. In general, as task requirements increase, controlled processes take over and more automatic color influences do not emerge. However, when discriminating responses for stimuli that do not active top-down language processing (pseudo-words), blue and red color preferences emerge. With words, instead, emotional enhancement effects are observed and the preference for green, independent of word valence, suggests a sort of cross modal effect for task-response.

Ethics approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Alessandro Bortolotti: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Caterina Padulo:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Nadia Conte:** Writing – review & editing, Writing – original draft, Data curation. **Beth Fairfield:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Riccardo Palumbo:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

Antos, S. J. (1979). Processing facilitation in a lexical decision task. *Journal of Experimental Psychology: Human Perception and Performance, 5*(3), 527. https://doi.org/10.1037/0096-1523.5.3.527

Balsamo, M., Carlucci, L., Padulo, C., Perfetti, B., & Fairfield, B. (2020). A bottom-up validation of the IAPS, GAPED, and NAPS affective picture databases: Differential effects on behavioral performance. *Frontiers in Psychology, 11*, 2187. https://doi.org/10.3389/fpsyg.2020.02187

Bortolotti, A., Cannito, L., Anzani, S., & Palumbo, R. (2023). The promise of color in marketing: Use, applications, tips and neuromarketing. *Cultura e Scienza del Colore-Color Culture and Science, 15*(01), 76–85. https://doi.org/10.23738/CCSJ.150110

Bortolotti, A., Cannito, L., Anzani, S., Rossi, M., & Palumbo, R. (2022). About the influence of color perceived lightness on psychological functions. *Cultura e Scienza del Colore - Color Culture and Science, 14*(01), 112–122. https://doi.org/10.23738/CCSJ.140114

Bramão, I., Reis, A., Petersson, K. M., & Faísca, L. (2011). The role of color information on object recognition: A review and meta-analysis. *Acta Psychologica, 138*(1), 244–253. https://doi.org/10.1016/j.actpsy.2011.06.010

Briki, W., & Hue, O. (2016). How red, blue, and green are affectively judged. *Applied Cognitive Psychology, 30*(2), 301–304. https://doi.org/10.1002/acp.3206

Conway, B. R., Ratnasingam, S., Jara-Ettinger, J., Futrell, R., & Gibson, E. (2020). Communication efficiency of color naming across languages provides a new framework for the evolution of color terms. *Cognition, 195*, Article 104086. https://doi.org/10.1016/j.cognition.2019.104086

Crossfield, E., & Damian, M. F. (2021). The role of valence in word processing: Evidence from lexical decision and emotional Stroop tasks. *Acta Psychologica, 218*, Article 103359. https://doi.org/10.1016/j.actpsy.2021.103359

Cunillera, T., Camara, E., Laine, M., & Rodríguez-Fornells, A. (2010). Speech segmentation is facilitated by visual cues. *Quarterly Journal of Experimental Psychology, 63*(2), 260–274. https://doi.org/10.1080/17470210902888809

Dufau, S., Grainger, J., & Ziegler, J. C. (2012). How to say "no" to a nonword: A leaky competing accumulator model of lexical decision. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*(4), 1117. https://doi.org/10.1037/a0026948

Elliot, A. J., & Aarts, H. (2011). Perception of the color red enhances the force and velocity of motor output. *Emotion, 11*, 445–449. https://doi.org/10.1037/a0022599

Elliot, A. J., Kayser, D. N., Greitemeyer, T., Lichtenfeld, S., Gramzow, R. H., Maier, M. A., et al. (2010). Red, rank and romance in women viewing men. *Journal of Experimental Psychology. General, 139*, 399–417. https://doi.org/10.1037/a0019689

Elliot, A. J., & Maier, M. A. (2014). Color psychology: Effects of perceiving color on psychological functioning in humans. *Annual Review of Psychology, 65*, 95–120. https://doi.org/10.1146/annurev-psych-010213-115035

Elliot, A. J., Maier, M. A., Moller, A. C., Friedman, R., & Meinhardt, J. (2007). Color and psychological functioning: The effect of red on performance attainment. *Journal of Experimental Psychology: General, 136*(1), 154–168. https://doi.org/10.1037/0096-3445.136.1.154

Emmanouil, T. A., Burton, P., & Ro, T. (2013). Unconscious processing of unattended features in human visual cortex. *Journal of Cognitive Neuroscience, 25*(3), 329–337. https://doi.org/10.1162/jocn_a_00320

Fairfield, B., Mammarella, N., & Domenico, A. D. (2013). Centenarians' "holy" memory: Is being positive enough? *The Journal of Genetic Psychology, 174*(1), 42–50. https://doi.org/10.1080/00221325.2011.636399

Fairfield, B., Padulo, C., Bortolotti, A., Perfetti, B., Mammarella, N., & Balsamo, M. (2022). Do older and younger adults prefer the positive or avoid the negative? *Brain Sciences, 12*(3), 393. https://doi.org/10.3390/brainsci12030393

Folk, C. L. (2015). The role of color in the voluntary and involuntary guidance of selective attention. In A. J. Elliot, M. D. Fairchild, & A. Franklin (Eds.), *Handbook of color psychology* (pp. 481–501). Cambridge University Press. https://doi.org/10.1017/CBO9781107337930.024.

Garrido, M. V., Prada, M., Simão, C., & Semin, G. R. (2019). The impact of stimuli color in lexical decision and semantic word categorization tasks. *Cognitive Science, 43*(8), Article e12781. https://doi.org/10.1111/cogs.12781

Gegenfurtner, K. R., & Rieger, J. (2000). Sensory and cognitive contributions of color to the recognition of natural scenes. *Current Biology, 10*(13), 805–808. https://doi.org/10.1016/S0960-9822(00)00563-7

Gerrig, R. J., & Bower, G. H. (1982). Emotional influences on word recognition. *Bulletin of the Psychonomic Society, 19*(4), 197–200. https://doi.org/10.3758/BF03330231

Goodhew, S. C., & Kidd, E. (2017). Language use statistics and prototypical grapheme colours predict synaesthetes' and non-synaesthetes' word-colour associations. *Acta Psychologica, 173*, 73–86. https://doi.org/10.1016/j.actpsy.2016.12.008

Goodhew, S. C., & Kidd, E. (2020). Bliss is blue and bleak is grey: Abstract word-colour associations influence objective performance even when not task relevant. *Acta Psychologica, 206*, Article 103067. https://doi.org/10.1016/j.actpsy.2020.103067

Hildebrandt, A., Schacht, A., Sommer, W., & Wilhelm, O. (2012). Measuring the speed of recognising facially expressed emotions. *Cognition & Emotion, 26*(4), 650–666. https://doi.org/10.1080/02699931.2011.602046

Humphrey, N. (2019). The colour currency of nature. In *Colour for architecture today* (pp. 9–12). Taylor & Francis.

Hurlbert, A. C., & Ling, Y. (2007). Biological components of sex differences in color preference. *Current Biology, 17*(16), 623–625. https://doi.org/10.1016/j.cub.2007.06.022

Kuchinke, L., Jacobs, A. M., Võ, M. L. H., Conrad, M., Grubich, C., & Herrmann, M. (2006). Modulation of prefrontal cortex activation by emotional words in recognition memory. *Neuroreport, 17*(10), 1037–1041. https://doi.org/10.1097/01.wnr.0000221838.27879.fe

Kuniecki, M., Pilarczyk, J., & Wichary, S. (2015). The color red attracts attention in an emotional context. An ERP study. *Frontiers in Human Neuroscience, 9*, 212. https://doi.org/10.3389/fnhum.2015.00212

Kuperman, V., Estes, Z., Brysbaert, M., & Warriner, A. B. (2014). Emotion and language: Valence and arousal affect word recognition. *Journal of Experimental Psychology: General, 143*(3), 1065. https://doi.org/10.1037/a0035669

Larsen, R. J., Mercer, K. A., Balota, D. A., & Strube, M. J. (2008). *Not all negative words slow down lexical decision and naming speed: Importance of word arousal.*. https://doi.org/10.1037/1528-3542.8.4.445

Ling, Y., Hurlbert, A., & Robinson, L. (2006). Sex differences in colour preference. *Progress in Colour Studies, 2*, 173–188. https://doi.org/10.1075/z.pics2.15lin

Mammarella, N., Borella, E., Carretti, B., Leonardi, G., & Fairfield, B. (2013). Examining an emotion enhancement effect in working memory: Evidence from age-related differences. *Neuropsychological Rehabilitation, 23*(3), 416–428. https://doi.org/10.1080/09602011.2013.775065

Mammarella, N., Di Domenico, A., Palumbo, R., & Fairfield, B. (2016). When green is positive and red is negative: Aging and the influence of color on emotional memories. *Psychology and Aging, 31*(8), 914. https://doi.org/10.1037/pag0000122

Manippa, V., Padulo, C., & Brancucci, A. (2018). Emotional faces influence evaluation of natural and transformed food. *Psychological Research, 82*, 675–683. https://doi.org/10.1007/s00426-017-0857-7

Maule, J., Skelton, A. E., & Franklin, A. (2022). The development of color perception and cognition. *Annual Review of Psychology, 74*. https://doi.org/10.1146/annurev-psych-032720-040512

Mehta, R., & Zhu, R. (2009). Blue or red? Exploring the effect of color on cognitive task performances. *Science, 323*(5918), 1226–1229. https://doi.org/10.3389/fpsyg.2016.00784

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

Ortigue, S., Michel, C. M., Murray, M. M., Mohr, C., Carbonnel, S., & Landis, T. (2004). Electrical neuroimaging reveals early generator modulation to emotional words. *Neuroimage, 21*(4), 1242–1251. https://doi.org/10.1016/j.neuroimage.2003.11.007

Osorio, D., & Vorobyev, M. (1996). Colour vision as an adaptation to frugivory in primates. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 263* (1370), 593–599. https://doi.org/10.1098/rspb.1996.0089

Ou, L. C., Luo, M. R., Woodcock, A., & Wright, A. (2004). A study of colour emotion and colour preference. Part I: Colour emotions for single colours. *Color Research & Application, 29*(3), 232–240. https://doi.org/10.1002/col.20010

Padulo, C., Carlucci, L., Marzoli, D., Manippa, V., Tommasi, L., Saggino, A., … Brancucci, A. (2018). Affective evaluation of food images according to stimulus and subject characteristics. *Journal of Human Nutrition and Dietetics, 31*(6), 715–724. https://doi.org/10.1111/jhn.12558

Palmer, S. E., & Schloss, K. B. (2010). An ecological valence theory of human color preference. *Proceedings of the National Academy of Sciences, 107*(19), 8877–8882. https://doi.org/10.1073/pnas.0906172107

Pan, J., Liu, M., Li, H., & Yan, M. (2021). Chinese children benefit from alternating-color words in sentence reading. *Reading and Writing, 34*, 355–369. https://doi.org/10.1007/s11145-020-10067-9

Perea, M., & Lupker, S. J. (2004). Can CANISO activate CASINO? Transposed-letter similarity effects with nonadjacent letter positions. *Journal of Memory and Language, 51*(2), 231–246. https://doi.org/10.1016/j.jml.2004.05.005

Perea, M., Rosa, E., & Gómez, C. (2002). Is the go/no-go lexical decision task an alternative to the yes/no lexical decision task? *Memory & Cognition, 30*(1), 34–45. https://doi.org/10.3758/BF03195263

Perea, M., Tejero, P., & Winskel, H. (2015). Can colours be used to segment words when reading? *Acta Psychologica, 159*, 8–13. https://doi.org/10.1016/j.actpsy.2015.05.005

Perea, M., & Wang, X. (2017). Do alternating-color words facilitate reading aloud text in Chinese? Evidence with developing and adult readers. *Memory & Cognition, 45*, 1160–1170. https://doi.org/10.3758/s13421-017-0717-0

Ramachandran, V. S., & Hubbard, E. M. (2001). Synaesthesia a window into perception, thought and language. *Journal of Consciousness Studies, 8*(12), 3–34.

Ratcliff, R., Gomez, P., & McKoon, G. (2004). A diffusion model account of the lexical decision task. *Psychological Review, 111*(1), 159. https://doi.org/10.1037/0033-295X.111.1.159

Saffran, J. R., Newport, E. L., & Aslin, R. N. (1996). Word segmentation: The role of distributional cues. *Journal of Memory and Language, 35*(4), 606–621. https://doi.org/10.1006/jmla.1996.0032

Sahin, L., & Figueiro, M. G. (2013). Alerting effects of short-wavelength (blue) and long-wavelength (red) lights in the afternoon. *Physiology & Behavior, 116*, 1–7. https://doi.org/10.1016/j.physbeh.2013.03.014

Schietecat, A. C., Lakens, D., & IJsselsteijn, W. A., & de Kort, Y. A.. (2018). Predicting context-dependent cross-modal associations with dimension-specific polarity attributions part 1–brightness and aggression. *Collabra: Psychology, 4*(1). https://doi.org/10.1525/collabra.110

Scott, G. G., O'Donnell, P. J., Leuthold, H., & Sereno, S. C. (2009). Early emotion word processing: Evidence from event-related potentials. *Biological Psychology, 80*(1), 95–104. https://doi.org/10.1016/j.biopsycho.2008.03.010

Scott, G. G., O'Donnell, P. J., & Sereno, S. C. (2014). Emotion words and categories: Evidence from lexical decision. *Cognitive Processing, 15*(2), 209–215. https://doi.org/10.1007/s10339-013-0589-6

Sell, A. J., & Kaschak, M. P. (2009). Does visual speech information affect word segmentation? *Memory & Cognition, 37*(6), 889–894. https://doi.org/10.3758/MC.37.6.889

Sereno, S. C., Scott, G. G., Yao, B., Thaden, E. J., & O'Donnell, P. J. (2015). Emotion word processing: Does mood make a difference? *Frontiers in Psychology, 6*, 1191. https://doi.org/10.3389/fpsyg.2015.01191

Sivananthan, T., de Lissa, P., & Curby, K. M. (2021). Colour context effects on speeded valence categorization of facial expressions. *Visual Cognition, 29*(6), 348–365. https://doi.org/10.1080/13506285.2021.1915901

Stephen, I. D., Law Smith, M. J., Stirrat, M. R., & Perrett, D. I. (2009). Facial skin coloration affects perceived health of human faces. *International Journal of Primatology, 30*, 845–857. https://doi.org/10.1007/s10764-009-9380-z

Sulpizio, S., Pennucci, E., & Job, R. (2021). The impact of emotional content on pseudoword recognition. *Psychological Research, 85*, 2980–2996. https://doi.org/10.1007/s00426-020-01454-6

Taylor, C., & Franklin, A. (2012). The relationship between color–object associations and color preference: Further investigation of ecological valence theory. *Psychonomic Bulletin & Review, 19*, 190–197.

Tham, D. S. Y., Sowden, P. T., Grandison, A., Franklin, A., Lee, A. K. W., Ng, M., … Zhao, J. (2020). A systematic investigation of conceptual color associations. *Journal of Experimental Psychology: General, 149*(7), 1311. https://doi.org/10.1037/xge0000703

Vergara-Martínez, M., Fernández-López, M., & Perea, M. (2023). Perceptual contiguity does not modulate matched-case identity-priming effects in lexical decision. *Brain Sciences, 13*(2), 336. https://doi.org/10.3390/brainsci13020336

Wilms, L., & Oberfeld, D. (2018). Color and emotion: Effects of hue, saturation, and brightness. *Psychological Research, 82*(5), 896–914. https://doi.org/10.1007/s00426-017-0880-8

Witzel, C., & Gegenfurtner, K. R. (2018). Color perception: Objects, constancy, and categories. *Annual Review of Vision Science, 4*, 475–499. https://doi.org/10.1146/annurev-vision-091517-034231

Xia, T., Song, L., Wang, T. T., Tan, L., & Mo, L. (2016). Exploring the effect of red and blue on cognitive task performances. *Frontiers in Psychology, 7*, 784. https://doi.org/10.3389/fpsyg.2016.00784

Zhou, W., Ye, W., & Yan, M. (2020). Alternating-color words facilitate reading and eye movements among second-language learners of Chinese. *Applied PsychoLinguistics, 41* (3), 685–699. https://doi.org/10.1017/S0142716420000211