Attentional switch to memory: An early and late stage of cognitive processing allowing efficient visual search

Chen Cai[1], Le Zhang[1], Zihan Quan[1], Xin Fang[1], Sisi Cai[1], and Jia Zhang[2]

[1]Qingdao University
[2]Yantai University

June 8, 2023

Abstract

Individuals are apt to link various characteristics of an object or event through different sensory experiences. We conducted an electrophysiological study to examine the in-depth cognitive processing mechanisms underlying the visual search process in multisensory attention. A pilot study with two questionnaires was conducted to screen experimental materials and establish the color-flavor combinations. In the experimental study, the participants were prompted with a flavor label and asked to choose the one with it from the following four beverage bottle images. The behavioral results showed that searching for a color-flavor weak association target was slower than for a strong association one in the color-flavor congruent condition, opposite to the incongruent condition. The ERP component analysis detected smaller N2 and larger P3 and LPC amplitudes for the color-flavor incongruent targets than for the congruent targets. A further time-frequency analysis elicited that the color-flavor congruent and strong association targets evoked lower parietal theta power (range: 200–800 ms, 4–8 Hz) than the incongruent and weak association targets, respectively. Overall, our research indicated that (1) the color-flavor congruency and association strength interactively impacted the visual search efficiency, (2) the attentional switch from external stimuli to internal memory is necessary for efficient visual search, and (3) the parietal region plays a critical role in attentional processing and memory retrieval. These findings shed light on the intricate cognitive processes involved in visual search and the underlying neurocognitive dynamics.

1. Introduction

People are prone to associate the properties or dimensions of a stimulus (i.e., an object or event) in different sensory modes, a phenomenon called *crossmodal correspondence* (Spence, 2011). For example, the color of food and drinks affects people's subsequent perception of taste and flavor (Wan et al., 2016). Packages design can also impinge upon the consumers' subjective perception and purchase intention of the products (Ares & Deliza, 2010). The visual components of beverage packaging, such as logos, colors, images, text, shape, and texture, strive to draw attention, enhance emotional experiences, and ultimately boost sales (Hu, 2016). Visual perception plays a pivotal role in captivating consumers' attention, shaping their perceptions, and influencing their product-related expectations. When it comes to multi-sensory product packaging design, color may be the most vital visual element that can sway customers' purchase decisions (Spence & Velasco, 2018).

Participants in a study formed color expectations based on flavor labels and were slower to find the target when the package color was incongruent with its flavor association, known as the *color-flavor incongruency effect* (Huang et al., 2019). Previous studies demonstrated that the participants may initially relied on the color and their color-flavor association from personal experiences to search for a specific flavor label on the package, and if necessary, they would switch back to the word-based search (Huang et al., 2021, 2019a, 2019b; Velasco et al., 2015). As a result, they were faster at finding the target product when the color is congruent with the flavor label word than when it is incongruent. In addition, when tasting fruit juices with flavor labels, participants rated the ones with congruent color-taste associations higher than those with incongruent associations (Garber et al., 2015; Peng et al., 2022). However, Peng and Wan (2022) proposed that participants may divert their search strategy from relying on the color association to producing the expectation that violated the association, leading to a reduced or even eliminating the color-flavor incongruency effect. A view called *attentional switch to memory*(ASM) explicated the phase that attention switched from the external environment to the internal memory (Servais et al., 2023). It may be the key mechanism underlying the application of visual search strategies and further research is needed to dig deeper into it.

Not only was visual search efficiency affected by the congruency between color and flavor, but also by the association strength between them. For example, consumers typically associate tomato flavor with red and cucumber flavor with green, whereas thinking that the association between chicken flavor and orange and barbecue flavor and burgundy is weak (Velasco et al., 2015). Huang et al. (2019) proposed that the extent of discrepancy between actual and anticipated product experiences can adjust consumers' attitudes towards the product. Low incongruency is preferred over high incongruency because it causes moderate arousal and tends to be viewed as pleasant, while the latter induces high arousal and negative feelings and experiences (Piqueras-Fiszman & Spence, 2015). When the color and flavor were incongruent, it was difficult to identify a target flavor with a strong color association than with a weak one (Huang & Wan, 2019; Velasco et al., 2015). Our study revisited this issue and further explored how the color-flavor congruency and association strength of specific flavor labels concomitantly affected individuals' visual search process. Unlike previous studies, we differentiated the color-flavor association strength within flavors, taking into account the fact that some common fruits have at least two typical colors of different degrees (e.g., lemons are typical of yellow and green, and grapes are typical of purple and green). Our study aimed to systematically manipulate the color-flavor association strength within these kinds of fruits.

Hypothesis I: The color-flavor association strength interacted with its incongruency effect during the label searching process, in which the response to color-flavor strongly associated targets would be faster than to weakly associated ones for congruent conditions.

Previous studies have demonstrated that the N2 component is a direct indicator of cognitive resource allocation, reflecting the cognitive resources invested in conflict perception and response inhibition (Heil et al., 2000; Zhang & Damian, 2009). The visually repetitive presentation of Chinese words triggers a significant increase in N2 amplitude, indicating the specific role of N2 in Chinese word recognition and identification (Du et al., 2014; Zhang et al., 2012). Meanwhile, the P3 component is another indicator of cognitive processing and attention in that greater amplitude associated with tasks that require more cognitive effort (Herrmann & Knight, 2001). P3 is also proved to correlate with the conflict resolution processes in Stroop tasks, with a greater amplitude for incongruent information than congruent information (Appelbaum et al., 2009; Liotti et al., 2000; Wang et al., 2021). Furthermore, the late positive component (LPC) is associated with conflict detection, processing, and resolution (Coderre et al., 2011; Li et al., 2013; Sun et al., 2013), as well as top-down cognitive control during working memory storage and maintenance (Che et al., 2021; Gao et al., 2011). Wang et al. (2021) provided evidence that the working memory representation affected individuals' allocation of attention, suggesting that the visual search was slower when the working memory reserves did not match the exogenous stimulus. LPC is more positive for the incongruent condition relative to the congruent condition in Stroop tasks, possibly reflecting the semantic processing of words (Liotti et al., 2000; Markela-Lerenc et al., 2004). The current study tried to scrutinize the electrophysiological mechanisms underlying the interaction between the color-flavor congruency and association strength with the EEG components mentioned above.

Hypothesis II: The color-flavor congruent stimuli evoked a more negative N2 component in the early stage owing to word recognition, and the incongruent stimuli evoked more positive P3 and LPC in the late stage based on conflict control.

Among miscellaneous methods of event-related potential (ERP) analysis, time-frequency analysis allows for the identification of oscillations contained in the EEG data that can hardly be observable through component analysis (Morales & Bowers, 2022). For instance, it can generate continuous measurements of non-phase-locked signals (Peng et al., 2022), which is useful in characterizing cognitive processes. Research has demonstrated that the theta oscillation, which is typically between 4 and 8 Hz, mainly involves attentional processing (Deiber et al., 2007; Tang & Chen, 2013; Zhou et al., 2013) and is associated with a range of cognitive processes including memory, learning, performance monitoring, and action selection (Atienza et al., 2011; Vulić et al., 2021; Wynn et al., 2019; Zhao et al., 2014). Furthermore, the enhanced frontal-central theta power is closely linked to the recruitment of cognitive control in the processing of conflict information involving cognitive resource allocation, conflict detection, and control of the response conflict (Nigbur et al., 2011; Wang et al., 2014). The parietal theta has been confirmed to be correlated with memory recognition (Jacobs et al., 2006) and selective visual attention (Demiralp & Başar, 1992; Haciahmet et al., 2021). In the present study, we aimed to justify the theta band power as an indicator of selective visual attention and conflict processing for multisensory information.

Hypothesis III: The processing of congruent information induced a decreased parietal theta power compared to incongruent stimuli, and the theta power differentiated on the interaction between the color-flavor congruency and its association strength.

2. Pilot study

2.1. Method

2.2.1. Participants

Two questionnaires were administered to participants recruited online, who voluntarily and anonymously completed the surveys from March 27 to April 4, 2022. Questionnaire 1 was completed by 219 participants (mean age = 27.54 ± 7.10 years, 72 males), while Questionnaire 2 was completed by 269 participants (mean age = 22.58 ± 5.68 years, 85 males). The study adhered to the latest guidelines and was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. To protect participants' rights and privacy, appropriate protocols were implemented. All participants were fully informed about the questionnaire's purpose, which was to gather their opinions on the color-flavor associations of beverages. They were assured that their data would be kept strictly confidential, used solely for scientific research purposes, and that there were no associated risks involved.

2.2.2. Measures

For experimental materials, we specifically chose five commonly consumed fruit juice flavors: lemon, peach, orange, grape, and mango. These flavors were selected based on their prevalence in daily life and the fact that each flavor is associated with at least two distinct colors of varying strength. To ensure the suitability of these materials, we conducted a preliminary online survey where participants were asked to indicate the color they most strongly associated with each flavor label through two questionnaires. This initial survey yielded a total of 219 completed Questionnaire 1 (https://www.wjx.cn/vm/Pp5p7RU.aspx), which helped determine the association strength between color and flavor in congruent conditions. Subsequently, we conducted a second online survey (Questionnaire 2, https://www.wjx.cn/vm/eYGrTvw.aspx) with 269 recollected samples to establish the specific color-flavor combinations for both strong- and weak-congruent conditions.

To ensure data quality, we excluded invalid questionnaires according to the following criteria: (1) duplicated IP addresses, and (2) response times falling outside the fastest 1% (Questionnaire 1: 21.00 s; Questionnaire 2: 26.00 s) or the slowest 1% (Questionnaire 1: 290.50 s; Questionnaire 2: 490.33 s) of all participants. Participants who met any of these criteria were excluded from the following analysis. As a result, a total of fifteen questionnaires (thirteen from Questionnaire 1 and two from Questionnaire 2) were excluded from the analysis.

2.2. Results and discussion

The strong association color, representing the most commonly associated color for each fruit flavor, and the weak association color, representing the least commonly associated color, were determined based on the results from two questionnaires. The selection of color-flavor combinations followed a careful screening process. Firstly, in Questionnaire 1, pink (87.38%) and purple (94.66%) were proven to be the strong-congruent colors for peach and grape flavors, respectively. However, certain colors were common among other flavors. Specifically, yellow colors were chosen as the strong association color for lemon (95.63%), orange (88.83%), and mango (97.57%) flavors. Consequently, green was designated as the weak association color for lemon, orange, mango, and grape flavors. Therefore, we further refined the selection outputs by considering the repeatedly chosen colors through an additional survey. In Questionnaire 2, the weakly associated colors for orange and mango flavors were determined as lime green (R: 50, G: 205, B: 50; 14.98%) and green yellow (R: 173, G: 255, B: 47; 5.24%), respectively. Moreover, we observed that, among the remaining undetermined greenish colors, green (R: 0, G: 128, B: 0) was selected by the least participants for both lemon (13.11%) and grape (5.62%) flavors. The selection results of both questionnaires are illustrated in**Figure 1(A)** . To ensure distinct colors for different flavors, the classic green was assigned to the lemon flavor, while spring green (R: 0, G: 142, B: 87) was chosen for the grape flavor, separately as the weak-congruent color for each flavor. Finally, the complementary color of each fruit under the congruent condition, without overlapping with the selected colors, was reckoned as the incongruent color for both strong and weak associations. The final color-flavor combinations used as the experimental materials are depicted in **Figure 1(B)** .

[Insert Figure 1 near here]

3. Experimental study

3.1. Method

3.1.1. Participants

A priori power analysis by G. Power 3.1.9.7 (Faul et al., 2007) showed the total sample size of 36 would be enough, setting the effect size$f = 0.25$, α err prob = 0.05, power ($1 - \beta$ err prob) = 0.95. Therefore, 44 students (mean age = 19.34 ± 1.63 years; 14 males) from Qingdao University were recruited in this study. The sensitivity power analysis with this sample size exhibited the minimum effect size that could be obtained under an alpha of 0.05 (power level = 0.95) was 0.278. All participants had normal or corrected-to-normal vision without color blindness or any neurological history. Written informed consent was obtained from each participant, and the experiment was approved by the Institutional Review Board of Psychology of Qingdao University on March 21, 2022 (*IRB No. QDU202203210001*). For open sharing policies, we provided our exemplar materials and raw data on the Open Science Framework at https://osf.io/3mvr7/.

3.1.2. Apparatus and materials

In the present experiment, we used E-Prime 3.0 to present visual stimuli and record the behavioral data, and Adobe Photoshop CS 6 to create and polish the images of the beverage bottle against a black background. The flavor label comprised three Chinese characters (boldface, 52 point) and subtended 5.72° horizontally and 1.34° vertically. Four images of the beverage bottle were displayed simultaneously in the four quadrants of the screen, each measuring 5.91° horizontally and 9.72° vertically. The resolution of the images was 80 $\times$ 150 pixels, and they were presented on a 23.8-inch monitor with a resolution of 1600 $\times$ 900 pixels and a refresh rate of 60 Hz. The viewing distance was approximately 60 cm.

3.1.3. Design

A 2 (color-flavor congruency: congruent, incongruent) $\times$ 2 (color-flavor association: strong, weak) within-subject design was implemented in the present study, resulting in four experimental groups: color-flavor congruent label with strong association (CS), color-flavor congruent label with weak association (CW), color-flavor incongruent label with strong association (IS), and color-flavor incongruent label with weak association (IW). The sample illustrations of four experimental conditions are shown in **Figure 2** .

[Insert Figure 2 near here]

3.1.4. Procedure

Each trial started with a 1000 ms red cross in the center of the screen, then a flavor label (composed of three Chinese characters) presented for 1000 ms. After this, there was a blank screen for 500 ms, followed by four images of beverage bottles (with distinct flavor labels) randomly displayed in the four quadrants of the screen for 3000 ms. The participants were instructed to identify the bottle with the former flavor label by pressing "S", "F", "J", or "L" keys on the keyboard with their left middle, left index, right index, or right middle finger when the target was presented in the upper left, lower left, upper right, and lower right quadrant, respectively. The practice block contained 20 trials, with five trials for each experimental condition, and the formal experiment consisted of 400 trials, evenly divided into four blocks.

3.1.5. Electrophysiological (EEG) data recording and preprocessing

The EEG signals were recorded from 64 Ag/AgCl active electrode elements embedded in a conductive cap (actiCHamp, Brain Products, Gilching, Germany) conforming to the 10–20 international electrode system. The electrode impedances were kept below 5 KΩ, with electrooculogram (EOG) signals recorded with Fp1 and Fp2 and Cz serving as the online reference. The signals were digitized at a 1000 Hz sampling rate, amplified by a Brain Product actiCHamp amplifier system with a band-pass filter of 0.01 to 100 Hz, recorded by the Brain Vision Recorder 2.1, and analyzed offline by Brain Vision Analyzer 2.1 (Brain Products, Gilching, Germany). We re-referenced all channels to an average of bilateral mastoids and applied spherical spline interpolation to estimate the signal of noisy channels based on the weighted signal of surrounding four electrodes. The raw data was filtered using Butterworth infinite-impulse-response (IIR) filter (24 dB/Oct) with a range of a 0.5 to 30 Hz and an independent component analysis (ICA) was used to eliminate artifacts from eye blinks. Trials contaminated by positive and negative deflections exceeding $\pm$ 200μV were excluded, leading to the exclusion of EEG data from four participants from subsequent analysis. Epochs were generated between -200 ms pre-stimulus onset and 1400 ms post-stimulus onset, with -200 to 0 ms interval serving as a baseline. Only the ERPs with correct responses were analyzed and averaged under each experimental condition. After removing epochs with artifacts and incorrect responses, approximately 94.56% of the data remained for final analysis.

3.1.6. ERP Data analysis

In light of previous studies (Liu et al., 2019; Pires et al., 2014) and the grand average waveforms on each electrode, the mean amplitudes of the N2, P3, and LPC were examined in the time windows of 220 to 280 ms, 350 to 450 ms, and 500 to 700 ms, respectively. Moreover, three brain regions were targeted at: frontal region (F3, Fz, F4), central region (C3, Cz, C4), and parietal region (P3, Pz, P4). A 2 (color-flavor congruency: congruent, incongruent) $\times$ 2 (color-flavor association strength: strong, weak) $\times$ 3 (brain region: frontal, central, and parietal) repeated-measure analysis of variance (ANOVA) was performed in each time window. The p -values for ANOVAs were reported after the Greenhouse-Geisser correction when the sphericity test was not assumed.

3.1.7. Time-frequency analysis on the EEG data

We used the Letswave 7.0 toolbox (https://letswave.cn) installed in the MATLAB software (Mathworks, Natick, MA, USA) to perform the event-related oscillation analysis. Time-frequency representations were computed using the approach of the continuous wavelet transform. Single trial spectral amplitudes were then averaged across trials, which was used to determine real-time event-related spectral perturbation, with -750 to -250 ms serving as a baseline. Frequencies that were presented ranged from 1 to 30 Hz in steps of 5 Hz.

According to previous research (Atienza et al., 2011; Vulić et al., 2021; Wynn et al., 2019; Zhao et al., 2014) and the time-frequency diagrams obtained from this experiment, we analyzed the theta oscillation (4 to 8 Hz) in post-stimulus 200 to 800 ms and selected electrodes located at the parietal region for statistical analysis. The obtained power data were then subjected to a 2 (color-flavor congruency: congruent, incongruent) $\times$ 2 (color-flavor association strength: strong, weak) $\times$ 3 (electrodes: P3, Pz, P4) repeated-measure ANOVA.

3.2. Results

3.2.1. Behavioral results

To examine the potential moderating effect of gender on the relationship between color-flavor congruency and reaction times (RTs) or accuracies (ACCs), as well as between color-flavor association strength and RTs or ACCs, we conducted a univariate analysis. The results showed that there was no significant interaction effect of gender × color-flavor congruency or gender × color-flavor association strength on RTs or ACCs, F (1, 84) = 0.013 ˜ 0.623 , p = 0.432 ˜ 0.911, η = 0.000 ˜ 0.007. However, gender did have a significant main effect on RTs, in that female undergraduates responded faster than male ones (color-flavor congruency: F (1, 84) = 5.330, p = 0.023, η = 0.060, 95% CI [-156.714, -11.669]; color-flavor association strength: F (1, 84) = 5.388, p = 0.023, η = 0.060, 95% CI [-156.322, -12.061]), but not on ACCs (color-flavor congruency: F (1, 84) = 2.354, p = 0.129, η = 0.027; color-flavor association strength: F (1, 84) = 2.387, p = 0.126, η = 0.028). To spare the influence of gender on the results, subsequent data analysis on RTs was carried out by assigning weights by gender.

Only correct trials (95.02%) were included in the following analysis. Moreover, we excluded RTs that fell below 200 ms or exceeded three standard deviations from the group mean (2685 ms) from the data, resulting in the removal of additional 0.68% of the raw data. Then, mean RTs and ACCs for each condition were analyzed, as presented in **Table 1** .

[Insert Table 2 near here]

A 2 (color-flavor congruency: congruent, incongruent) × 2 (color-flavor association strength: strong, weak) repeated-measure ANOVA was employed on the behavioral data. Firstly, no significant main effects or interactions were detected on ACCs, F (1, 43) = 0.062 ˜ 1.095, p s = 0.301 ˜ 0.804, η = 0001 ˜ 0.025. As for RTs, although the main effect of flavor label color-flavor congruency was not significant, F (1, 57) = 2.279, p = 0.137, η = 0.038, 95% CI [-3.964, 28.258]; the main effect of color-flavor association strength was significant, F (1, 57) = 4.721, p = 0.034, η = 0.076, 95% CI [1.185, 29.047]. That is to say, the responses to color-flavor weakly associated targets were much slower than to strongly associated targets. Moreover, the color-flavor congruency × association strength interaction was significant, F (1, 57) = 30.068, $p < 0.001$, η = 0.345. The simple effect analysis showed that the participants responded more slowly to the CW stimuli than the CS stimuli, $p < 0.001$, 95% CI [23.874, 66.231], but faster to the IW stimuli than the IS stimuli, p = 0.030, 95% CI [-28.186, -1.453]. The mean RTs for each condition are delineated in **Figure 3** .

[Insert Figure 3 near here]

3.2.2. ERP results

3.2.2.1. Component analysis.

There was a significant main effect of color-flavor congruency on the N2 component, F (1, 39) = 15.346, $p < 0.001$, η = 0.282, 95% CI [-0.691, -0.221], resulting in a larger amplitude in the color-flavor congruent condition than the incongruent condition (see **Figure 4A**). The main effect of color-flavor association was also significant, F (1, 39) = 4.202, p = 0.047, η = 0.097, 95% CI [-0.510, -0.003], with a larger amplitude in the color-flavor weak association than the strong association condition. Furthermore, we found a significant main effect of the brain region, F (1.077, 41.990) = 15.986, $p < 0.001$, η = 0.291. The post hoc tests revealed that the mean amplitudes of the frontal region and central region were larger than the parietal region, respectively (frontal vs. parietal: $p < 0.001$, 95% CI [-3.607, -1.121]; central vs. parietal: $p < 0.001$, 95% CI [-2.847, -1.156]), but the rest pairwise comparison was unnoticeably different (frontal vs. central: p = 0.133, 95% CI [-0.842, 0.116]).

Moreover, the multivariate general linear model exhibited a significant color-flavor congruency × association strength interaction, F (1, 39) = 5.407, p = 0.025, η = 0.122. As shown in **Figure 4B** , the N2 amplitude was larger in the IW condition than in the IS condition (p = 0.010, 95% CI [-0.896, -0.132]), but the same trend did not maintain in the congruent conditions (p = 0.998, 95% CI [-0.288, 0.288]). Furthermore, we also found a significant color-flavor congruency × brain region interaction, F (1.398, 54.533) = 24.253, $p < 0.001$, η = 0.383. After stratification by brain regions, significant differences existed between color-flavor congruent and incongruent conditions particularly in the frontal and central regions. For the frontal region, the N2 amplitude in the congruent condition was more negative than the incongruent condition, $p < 0.001$, 95% CI

[-1.066, -0.467], which was also true for the central region ($p < 0.001$, 95% CI [-0.805, -0.283]). While no such significant difference was found in the parietal region, $p = 0.612$, 95% CI [-0.288, 0.172]. Furthermore, no other significant interactions were found, $F = 1.439$ ~ 1.832, p s = 0.176 ~ 0.242, $\eta = 0.036$ ~ 0.045.

As for the P3 component, a significant main effect of color-flavor congruency was spotted, F (1, 39) = 6.237, p = 0.017, $\eta = 0.138$, eliciting that the incongruent condition had a larger mean amplitude than the congruent condition, 95% CI [0.052, 0.493] (see**Figure 4A**). There was also a main effect of the brain region,F (1.137, 44.352) = 20.822, $p < 0.001$, $\eta = 0.348$. The post hoc tests demonstrated that the P3 amplitude was more positive in the parietal region than the central region ($p < 0.001$, 95% CI [0.740, 1.863]), in the central region than the frontal region ($p = 0.001$, 95% CI [0.342, 1.182]), as well as in the parietal region than the frontal region ($p < 0.001$, 95% CI [1.174, 2.953]). No other significant main effects or interactions were found, F = 0.012 ~ 1.255,p s = 0.279 ~ 0.912, $\eta = 0.000$ ~ 0.031.

Regarding the LPC component, we found a main effect of color-flavor congruency, F (1, 39) = 10.082, p = 0.003, $\eta = 0.205$. Particularly, the color-flavor incongruent condition exhibited a larger mean amplitude than the congruent condition, 95% CI [0.105, 0.474] (see **Figure 4A**). Other than that, no more significant results were detected, $F = 0.081$ ~ 1.456, p s = 0.238 ~ 0.833, $\eta = 0.002$ ~ 0.036.

[Insert Figure 4 near here]

3.2.2.2. Time-frequency analysis.

The multivariate general linear model manifested a significant main effect of color-flavor congruency, F (1, 39) = 13.782, $p = 0.001$, $\eta = 0.261$, with a significantly lower theta power for the color-flavor congruent condition than for the color-flavor incongruent condition, 95% CI [-0.700, -0.206]. The main effect of color-flavor association strength was significant too, F (1, 39) = 4.126,$p = 0.049$, $\eta = 0.096$, which demonstrated that the theta power of color-flavor strong association was lower than that of color-flavor weak association, 95% CI [-0.455, -0.001]. And the main effect of electrodes was also significant, F (2, 78) = 3.210, $p = 0.046$, $\eta = 0.076$. Only P3 collected a lower theta power than Pz ($p = 0.006$, 95% CI [-0.583, -0.104]), while the theta power collected by P4 was insignificantly different from P3 or Pz, respectively (P4 vs. P3: $p = 0.530$, 95% CI [-0.191, 0.366]; P4 vs. Pz: $p = 0.124$, 95% CI [-0.587, 0.074]).

As for the interaction effects, the color-flavor congruency $\times$ association strength interaction was significant on theta power,F (1, 39) = 4.256, $p = 0.046$, $\eta = 0.098$. Stratified by color-flavor congruency, the theta power was exclusively lower in the IS condition than in the IW condition, $p = 0.005$, 95% CI [-0.740, -1.133] (see **Figure 5**), while no such effect was discovered in the color-flavor congruent condition. Apart from that, a significant interaction between color-flavor congruency and electrodes was also unveiled, F (2, 78) = 4.754, p = 0.011, $\eta = 0.109$. The simple effect analysis presented a significant difference between different electrodes exclusively in the incongruent condition. That is to say, a significantly lower theta power spotted at P3 than Pz,$p < 0.001$, 95% CI [-0.729, -0.250], but no such difference was found in the congruent condition. However, other interactions were insignificant, $F = 1.106$ ~ 1.636, p s = 0.201 ~ 0.326, $\eta = 0.028$ ~ 0.040.

[Insert Figure 5 near here]

3.3. Discussion

3.3.1. Color-flavor congruency intertwined with its association strength on visual search efficiency

The behavioral results indicated that there was no significant effect of the color-flavor congruency on the RTs or ACCs, which is inconsistent with previous studies that observed a *color-flavor incongruency effect* on behavior (Huang et al., 2021, 2019b; Piqueras-Fiszman & Spence, 2011; Velasco et al., 2015). The paradigm utilized in our experiment was more comparable to the Stroop task, wherein the word recognition process was interpreted as a manifestation of the speed of visual search, while the color naming process was conceived as a combination of the speed of working memory and visual search (Nicosia & Balota, 2020). The participants probably mainly focused on the flavor labels with a bottom-up visual search strategy and conducted the word recognition rather than the color naming, which was incongruent half the time, to find the target.

Switching from a top-down search strategy based on the associative color with a specific flavor label to a bottom-up visual search resulting from experiencing some color-expectation violations would ultimately lead to a reduced *color-flavor incongruency effect* (Guo et al., 2023; Wan et al., 2022). Interestingly, however, the responses to the targets with strong associations were significantly faster in comparison to those with weak associations. Due to frequent co-occurrences with certain colors in the environment, some flavors have a greater color identification (Velasco et al., 2015, 2014). Specifically, for a particular flavor with two colors, the color-flavor with a stronger association, which is more familiar in our daily life, is comparatively easier to identify than one with a weaker association.

More importantly, the color-flavor congruency × association strength interaction analysis presented that the participants responded faster to the CS stimuli relative to the CW stimuli. This is primarily because the colors used in the CS condition are more accessible and characteristic in our daily life, which are more commonly associated with the respective flavors (Liu et al., 2012; Zhou et al., 2021). Previous studies have proved that the priming flavor label could trigger attentional bias toward the associated color, inducing selective attention toward specific information (Huang et al., 2021; Peng & Wan, 2022). In the color-flavor congruent condition, compared with colors in weak association, which may endure mild expectation conflict in lack of prevalence, the participants preferred to associate the priming flavor labels with colors in strong association and generated a specific color expectation based on their life experience, which then could guide the focus of their visual attention. In other words, a specific flavor label can activate related color representation which may exert a top-down influence on the visual search efficiency for the targets (Spence et al., 2010; Velasco et al., 2015).

By contrast, the participants exhibited an opposite trend in their task performance in the strong- and weak-incongruent conditions, that is, they tended to take a shorter time to locate the target in the IW condition compared to the IS condition. This discrepancy can be attributed to the greater cognitive conflict resolution effort invested in the IW condition. Consistent with this finding, the EEG evidence suggested that the IW condition elicited a larger N2 amplitude relative to the IS condition, illustrating that the IW condition entailed more attentional resources to the top-down conflict inhibition of distractor stimuli (i.e., colors), which resulted in faster target detection. The larger N2 amplitude observed over frontal and central regions indicated the important role of the frontocentral brain region in conflict control (Kang et al., 2018), and it also forecasted the top-down attentional control (Kehrer et al., 2009; Wei et al., 2021). Overall, our results revealed that visual search is a process influenced by both bottom-up as well as top-down control.

3.3.2. Orthographic processing and word recognition in the early stage of cognitive processing

Our EEG findings showed a more negative N2 amplitude elicited by color-flavor congruent stimuli than incongruent stimuli, and the color-flavor congruency × association strength interaction further suggested a larger N2 amplitude exclusively occurred in the CS condition than the IS condition, both indicating that the stimuli, especially with a strong association, that matched the contents of working memory automatically captured attention in the early stage of information processing (Hu & Zhang, 2016). Previous studies have demonstrated that orthographic processing also strokes at the early stage involving rather generalized and advanced visual processing for Chinese word recognition (Du et al., 2014; Zhang et al., 2012). We presumed that, as mentioned earlier, the participants might switch their search strategy from a top-down passageway based on the color expectation to a bottom-up visual search based on orthographic processing. That is to say, the attention was initially oriented to external information for comparing beverage labels with the priming label, which is considered to be in the external focus of attention (Hautekiet et al., 2023; Servais et al., 2023). Consequently, the color-flavor congruent information consistent with the prime words in orthography would capture more focused attention.

Furthermore, we observed a significant decrease in parietal theta power for the color-flavor congruent trials compared to the incongruent trials. Previous research has revealed that theta rhythms in V1 and V4 are reduced when the visual stimulus is attended to (Spyropoulos et al., 2018). Some studies have found that occipital theta is associated with attention - the attention focused more, the stimulus-evoked theta power decreased more, the vibration pattern of which is quite opposite to frontal theta (Han et al., 2019; Spyropoulos et al., 2018). As in the results of the ERP component analysis, we observed a more negative N2 amplitude triggered by color-flavor congruent trials relative to incongruent ones, suggesting that more focused attention based on the early orthographic processing was allocated to the congruent targets than to the incongruent ones (Grossi & Coch, 2005; Zhang et al., 2012). Together with the behavioral results indicating a bottom-up visual search, our findings suggested that selectively attend to the word orthography, especially the congruent ones, to search for the targets reduced the theta rhythms over the parietal brain region.

3.3.3. Semantic interpretation and conflict control in the late stage of cognitive processing

The EEG results revealed that the P3 amplitude evoked by color-flavor incongruent stimuli was significantly more positive compared to congruent stimuli, suggesting a potentially heightened retrieval process for word meaning (Wang et al., 2021). Additionally, a notably larger LPC elicited by incongruent stimuli was found predominantly over the left posterior superior scalp, converged with multiple studies on the linkage between LPC and word meaning processing (Appelbaum et al., 2009; Atienza et al., 2011; Bechtold et al., 2023; Li et al., 2013; Qiu et al., 2006; Sun et al., 2013). According to Liotti et al. (2000), the activation of the left posterior cortex implies a critical phase of semantic processing involved in the color-meaning interference effect in the Stroop task. As earlier, we postulated that participants initially engage in a label searching process by prioritizing orthographic features, which gradually transitions to the flavor-relevant memory retrieval, encompassing probably both episodic and semantic memory (e.g., the fruit representations and semantic interpretations). These assumptions align with the ASM model, which suggests that successful task completion necessitates a shift in attention towards memory retrieval when internal information processing requires more attentional resources (Servais et al., 2023). More importantly, our study extends its implications by highlighting that attention can be switched not only towards episodic memory retrieval, but also towards semantic memory retrieval within the context of visual search.

Furthermore, some studies conclude that the enhanced P3 is associated with cognitive control processes (Carbine et al., 2018; Huster et al., 2013; Wang et al., 2021), while the LPC is linked to the conflict resolution processes (Coderre et al., 2011; Lu et al., 2014; Vo et al., 2021). In line with these findings, our study observed larger P3 and LPC amplitudes in the incongruent condition compared to the congruent condition, indicating that the color-flavor conflicts required more cognitive resources to process (Gao et al., 2011; Tang et al., 2021). According to the ASM model, the participants need to shift their attention toward the internally associated constructs when they dive into the long-term memory of flavor labels. Unlike congruent targets requiring relatively fewer attentional resources to simultaneously process internal and external information, incongruent targets would introduce conflicts between internal and external processing, necessitating disengagement from the external environment. Storing information of a priming word in working memory can activate its associated semantic long-term memory representation at the same time (D'Esposito & Postle, 2015; Vo et al., 2021). Thus, the color-flavor incongruency would trigger conflicts between perceptual stimuli and internal conceptual representations. Akin to the Stroop effect, which involves the color-meaning interference during the later stages of cognitive processing (Liotti et al., 2000; Liu et al., 2012; Markela-Lerenc et al., 2004), the incongruent stimuli impose greater demands on cognitive resources associated with semantic processing and conflict control processing.

Moreover, the results of our time-frequency analysis exhibited a higher theta power over the parietal region in the IW condition compared to than the IS condition. This implied that more cognitive resources were allocated to dealing with task-relevant information (i.e., flavor labels) for the IW stimuli, as opposed to those with strong associations (Karakas, 2020). Previous research by Pastotter and Frings (2018) has also proved that increased theta power over the parietal region is associated with attentional processing of conflict. Therefore, our EEG results support the notion that the heightened activation in the parietal region may serve as an indicator of the ASM model, indicating the allocation of attentional resources during strategic retrieval. This finding reconfirmed the critical role of the parietal region in attentional processes and memory retrieval, which simultaneously corroborated the *attention to memory* (AtoM) hypothesis (Ciaramelli et al., 2008). In addition, we observed a more negative N2 amplitude in the IW condition compared to the IS condition, demonstrating greater allocation of attentional resources to inhibit task-irrelevant information

(Awh et al., 2003; Kehrer et al., 2009). Taken together, these findings provide further evidence that the attentional enhancement of target stimuli and suppression of distractor stimuli are two distinct processing strategies involved in conflict resolution for cognitive control regulation (Couperus & Mangun, 2010; Focker et al., 2023; Forschack et al., 2022; Li et al., 2018).

3.3.4. Limitations and prospects

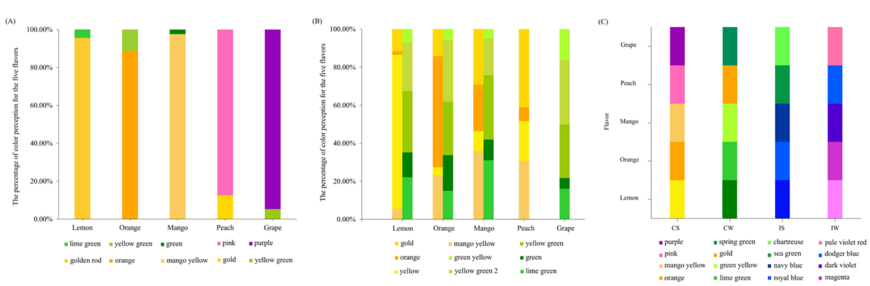
There are several limitations that should be further addressed in future research. Firstly, the limited discrimination between certain colors used in our study is due to the inherent characteristics of the fruits' colors. To enhance the realism of participant experience, future research could consider utilizing virtual reality (VR) technologies to simulate a more authentic environment. This would allow for a better understanding of the color-flavor associations in a simulated real-world context. Secondly, our research primarily focused on the influence of flavor labels on attentional bias through orthographic processing and the subsequent formation of color expectations. However, it is important to acknowledge that reference pictures are indispensable elements in beverage packaging and significantly contribute to the visual search of products. Therefore, it would be desirable to investigate whether the cognitive processes involved in linking flavor labels and reference pictures on the packages are distinct and independent or if they are intertwined. Exploring the cognitive pathways underlying flavor labels and reference pictures would provide valuable insights into the comprehensive understanding of how consumers perceive and choose products.

3.4. Conclusion

This research highlighted the importance of color-flavor congruency and association strength in the process of visual search and illuminated the underlying neurocognitive mechanisms involved in multisensory information processing and crossmodal cognition. By integrating the behavioral and EEG results, we demonstrated that various attentional strategies, ranging from external to internal focus of attention, contribute to more effective visual search. Furthermore, our research extended the ASM model to encompass semantic memory retrieval and revealed the vital role of the parietal region in cognitive processing. Overall, the findings of this research indicate that there is an attentional switch to memory in Chinese visual search, in which orthographic processing and word recognition are engaged in the early stage of visual processing, while semantic interpretation and conflict control come into play in the late stage of visual search. These findings contribute to our understanding of the intricate processes involved in visual search as well as its underlying cognitive dynamics.

Figure 1

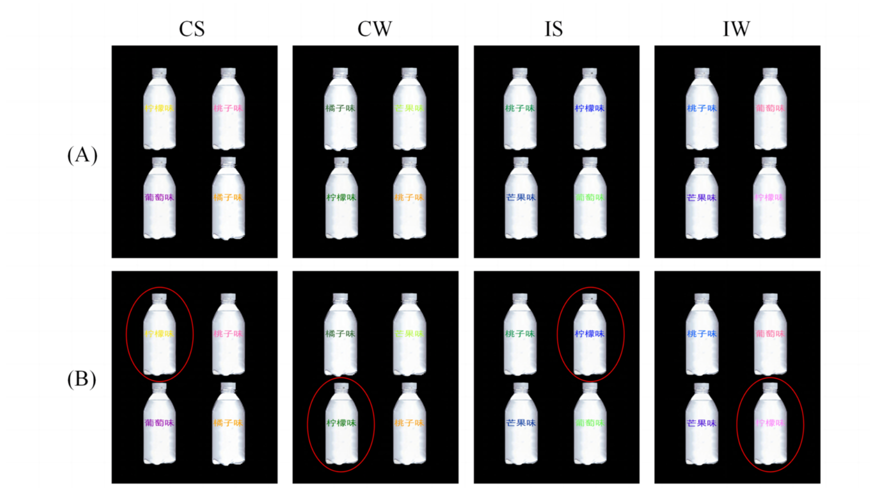
The percentage chosen for each color-flavor combination



Note: (A) The percentage of color perception for the five flavors in Questionnaire 1. (B) The percentage of color perception for the five flavors in Questionnaire 2. (C) The final color-flavor combinations, which were synthesized from Questionnaires 1 & 2, used in the four conditions of the experimental study. The legends for each column from top to bottom correspond to colors for each column from top to bottom illustrated in the bar charts, respectively. CS = color-flavor congruent label with strong association, CW = color-flavor congruent label with weak association, IS = color-flavor incongruent label with strong association, and IW = color-flavor incongruent label with weak association.

Figure 2

Sample illustrations of four experimental conditions



Note: Take “柠檬味” (lemon flavor) as an illustration of the target flavor label under four conditions. (A) From left to right: CS = color-flavor congruent label with strong association, CW = color-flavor congruent label with weak association, IS = color-flavor incongruent label with strong association, and IW = color-flavor incongruent label with weak association. (B) The images in the red circles were the targets that participants should select under each condition.

Table 1

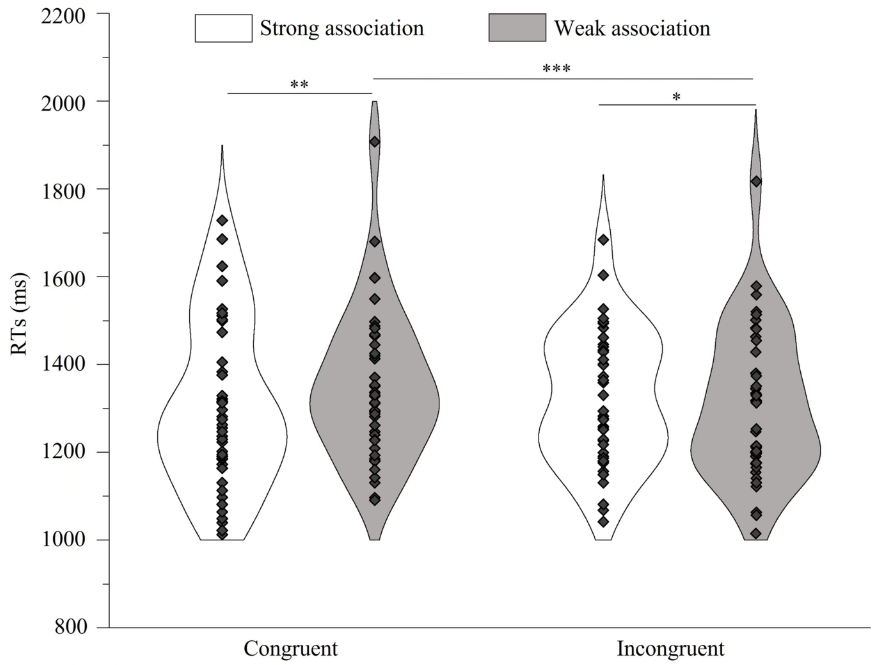
Means and standard deviations at RTs (ms) and ACCs under four conditions

Association Strength	Congruency	RT	ACC
Strong Strong	Congruent	1308.36 ± 189.49	0.94± 0.06
	Incongruent	1326.15 ± 152.21	0.95 ± 0.04
Weak Weak	Congruent	1353.41 ± 173.12	0.95 ± 0.06
	Incongruent	1311.33 ± 172.58	0.95 ± 0.05

Note: RT, response time; ACC, accuracy.

Figure 3

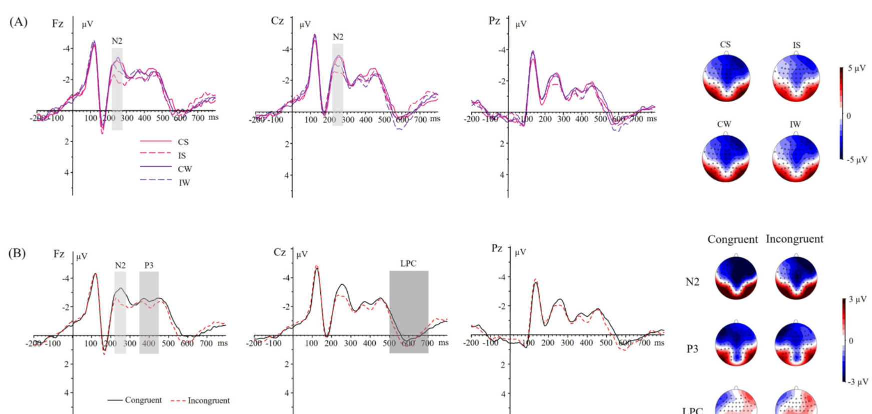
Mean RTs (ms) for four conditions



Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 4

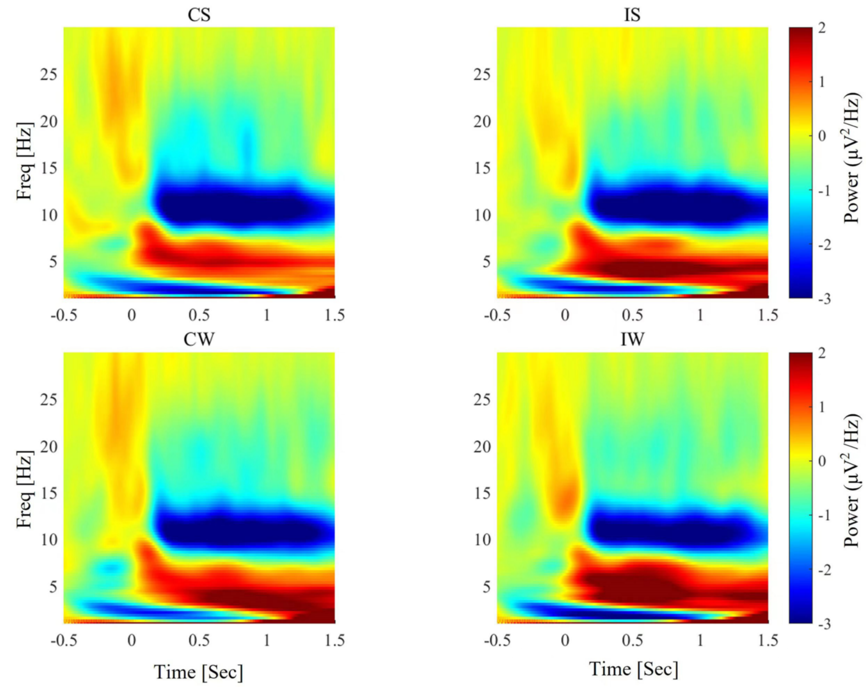
Grand-averaged waveforms and the topographic maps elicited in different conditions



Note:Grand-averaged waveforms and the topographic maps of ERP components in electrodes Fz, Cz, and Pz. (A) N2 (220 to 280 ms), P3 (350 to 450 ms), and LPC (500 to 700 ms) depicted in color-flavor congruent and incongruent conditions. (B) N2 (220 to 280 ms) depicted in four experimental conditions. CS = color-flavor congruent label with strong association, CW = color-flavor congruent label with weak association, IS = color-flavor incongruent label with strong association, and IW = color-flavor incongruent label with weak association.

Figure 5

Time-frequency representations of grand-averaged oscillations power at Pz electrode in four conditions



*Note***:** The grand-averaged oscillations power collected at Pz electrode ranges from -500 to 1500 ms with a frequency band from 1 to 30 Hz. CS = color-flavor congruent label with strong association, CW = color-flavor congruent label with weak association, IS = color-flavor incongruent label with strong association, and IW = color-flavor incongruent label with weak association.

References

Appelbaum, L. G., Meyerhoff, K. L., & Woldorff, M. G. (2009). Priming and backward influences in the human brain: processing interactions during the stroop interference effect. *Cereb Cortex* ,*19* (11), 2508–2521. https://doi.org/10.1093/cercor/bhp036

Ares, G., & Deliza, R. (2010). Studying the influence of package shape and colour on consumer expectations of milk desserts using word association and conjoint analysis. *Food Quality and Preference* ,*21* (8), 930–937. https://doi.org/10.1016/j.foodqual.2010.03. 006

Atienza, M., Crespo-Garcia, M., & Cantero, J. L. (2011). Semantic Congruence Enhances Memory of Episodic Associations: Role of Theta Oscillations. *Journal of Cognitive Neuroscience* , *23* (1), 75–90. https://doi.org/10.1162/jocn.2009.21358

Awh, E., Matsukura, M., & Serences, J. T. (2003). Top-down control over biased competition during covert spatial orienting. *J Exp Psychol Hum Percept Perform* , *29* (1), 52–63. https://doi.org/10.1037//0096-1523.29.1.52

Bechtold, L., Bellebaum, C., & Ghio, M. (2023). When a Sunny Day Gives You Butterflies: An Electrophysiological Investigation of Concreteness and Context Effects in Semantic Word Processing. *J Cogn Neurosci* ,*35* (2), 241–258. https://doi.org/10.1162/jocn_a_ 01942

Carbine, K. A., Rodeback, R., Modersitzki, E., Miner, M., LeCheminant, J. D., & Larson, M. J. (2018). The utility of event-related potentials (ERPs) in understanding food-related cognition: A systematic review and recommendations. *Appetite* , *128* , 58–78. https://doi. org/10.1016/j.appet.2018.05.135

Che, X., Xu, H., Wang, K., Zhang, Q., & Li, S. (2021). Precision requirement of working memory representations influences attentional guidance. *Acta Psychologica Sinica* , *53* (7), 694–713. https://doi.org/10.3724/sp.J.1041.2021.00694

Ciaramelli, E., Grady, C. L., & Moscovitch, M. (2008). Top-down and bottom-up attention to memory: A hypothesis (AtoM) on the role of the posterior parietal cortex in memory retrieval. *Neuropsychologia* ,*46* (7), 1828–1851. https://doi.org/10.1016/j.neuropsych ologia.2008.03.022

Coderre, E., Conklin, K., & van Heuven, W. J. (2011). Electrophysiological measures of conflict detection and resolution in the Stroop task. *Brain Research* , *1413* , 51–59. https://doi.org/10.1016/j.brainres.2011.07.017

Couperus, J. W., & Mangun, G. R. (2010). Signal enhancement and suppression during visual-spatial selective attention. *Brain Research* , *1359* , 155–177. https://doi.org/10.1016/j. brainres.2010.08.076

D'Esposito, M., & Postle, B. R. (2015). The cognitive neuroscience of working memory. *Annual Review of Psychology* , *66* , 115–142. https://doi.org/10.1146/annurev-psych-010814-015031

Deiber, M. P., Missonnier, P., Bertrand, O., Gold, G., Fazio-Costa, L., Ibañez, V., & Giannakopoulos, P. (2007). Distinction between Perceptual and Attentional Processing in Working Memory Tasks: A Study of Phase-locked and Induced Oscillatory Brain Dynamics. *Journal of Cognitive Neuroscience* , *19* (1), 158–172. https://doi.org/10.1162/ jocn.2007.19.1.158

Demiralp, T., & Başar, E. (1992). Theta rhythmicities following expected visual and auditory targets. *International Journal of Psychophysiology* , *13* (2), 147–160. https://doi.org/10. 1016/0167-8760(92)90054-F

Du, Y., Zhang, Q., & Zhang, J. X. (2014). Does N200 reflect semantic processing?–An ERP study on Chinese visual word recognition.*PLoS One* , *9* (3), e90794. https://doi.org/10. 1371/journal.pone.0090794

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods* ,*39* (2), 175–191. https://doi.org/10.3758/BF03193146

Focker, J., Beer, A. L., & Bavelier, D. (2023). Evidence of target enhancement and distractor suppression in early visual areas.*Attention, Perception, & Psychophysics* , *85* (3), 734–748. https://doi.org/10.3758/s13414-023-02673-w

Forschack, N., Gundlach, C., Hillyard, S., & Müller, M. M. (2022). Dynamics of attentional allocation to targets and distractors during visual search. *Neuroimage* , *264* . https://doi.org/10.1016/j.neuroimage.2022.119759

Gao, Z., Xu, X., Chen, Z., Yin, J., Shen, M., & Shui, R. (2011). Contralateral delay activity tracks object identity information in visual short term memory. *Brain Res* , *1406* , 30–42. https://doi.org/10.1016/j.brainres.2011.06.049

Garber, L. L., Hyatt, E. M., & Starr, R. G. (2015). The Effects of Food Color on Perceived Flavor. *Journal of Marketing Theory and Practice* , *8* (4), 59–72. https://doi.org/10. 1080/10696679.2000.11501880

Grossi, G., & Coch, D. (2005). Automatic word form processing in masked priming: an ERP study. *Psychophysiology* , *42* (3), 343–355. https://doi.org/10.1111/j.1469-8986.2005. 00286.x

Guo, X., Jiang, J., Li, H., & Huang, J. (2023). Expectation-driven and experience-driven attention interactively influence product searching: the moderating role of working memory capacity. https://doi.org/10.31234/osf.io/u6nj8

Haciahmet, C. C., Frings, C., & Pastotter, B. (2021). Target Amplification and Distractor Inhibition: Theta Oscillatory Dynamics of Selective Attention in a Flanker Task. *Cogn Affect Behav Neurosci* , *21* (2), 355–371. https://doi.org/10.3758/s13415-021-00876-y

Han, H. B., Lee, K. E., & Choi, J. H. (2019). Functional Dissociation of ϑ Oscillations in the Frontal and Visual Cortices and Their Long-Range Network during Sustained Attention. *Cognition and Behavior* , *6* (6), 1–12. https://doi.org/10.1523/eneuro.0248-19.2019

Hautekiet, C., Verschooren, S., Langerock, N., & Vergauwe, E. (2023). Attentional switching between perception and memory: Examining asymmetrical switch costs. *Atten Percept Psychophys* . https://doi.org/10.3758/s13414-023-02665-w

Heil, M., Osman, A., Wiegelmann, J., Rolke, B., & Hennighausen, E. (2000). N200 in the Eriksen-task: Inhibitory executive process?*Journal of Psychophysiology* , *14* (4), 218–225. https://doi.org/10.1027/0269-8803.14.4.218

Herrmann, C. S., & Knight, R. T. (2001). Mechanisms of human attention: event-related potentials and oscillations. *Neuroscience & Biobehavioral Reviews* , *25* (6), 465–476. https://doi.org/10.1016/S0149-7634(01)00027-6

Hu, Y., & Zhang, M. (2016). Electrophysiological evidence for memory-based attentional capture and memory-based attentional rejection effects. *Acta Psychologica Sinica* , *48* (1). https://doi.org/10.3724/sp.J.1041.2016.00012

Hu, Z. (2016). *The Study on Artistic Synaesthesia in Beverage Packaging Design* [Master, China Academy of Art].

Huang, J., Peng, Y., & Wan, X. (2021). The color-flavor incongruency effect in visual search for food labels: An eye-tracking study.*Food Quality and Preference* , *88* . https://doi.org/ 10.1016/j.foodqual.2020.104078

Huang, J., & Wan, X. (2019a). The color-flavor incongruency effect in product evaluation and brand perception. *Journal of Consumer Behaviour* , *18* (6), 484–495. https://doi.org/ 10.1002/cb.1787

Huang, J., Wang, F., Sui, J., & Wan, X. (2019b). Functional and structural basis of the color-flavor incongruency effect in visual search. *Neuropsychologia* , *127* , 66–74. https://doi.org/10.1016/j.neuropsychologia.2019.02.013

Huster, R. J., Enriquez-Geppert, S., Lavallee, C. F., Falkenstein, M., & Herrmann, C. S. (2013). Electroencephalography of response inhibition tasks: functional networks and cognitive contributions. *Int J Psychophysiol* , *87* (3), 217–233. https://doi.org/10.1016/j.ijpsycho. 2012.08.001

Jacobs, J., Hwang, G., Curran, T., & Kahana, M. J. (2006). EEG oscillations and recognition memory: theta correlates of memory retrieval and decision making. *Neuroimage* , *32* (2), 978–987. https://doi.org/10.1016/j.neuroimage.2006.02.018

Kang, G., Chang, W., Wang, L., Wei, P., & Zhou, X. (2018). Reward enhances cross-modal conflict control in object categorization: Electrophysiological evidence. *Psychophysiology* , *55* (11), e13214. https://doi.org/10.1111/psyp.13214

Karakas, S. (2020). A review of theta oscillation and its functional correlates. *Int J Psychophysiol* , *157* , 82–99. https://doi.org/10.1016/j.ijpsycho.2020.04.008

Kehrer, S., Kraft, A., Irlbacher, K., Koch, S. P., Hagendorf, H., Kathmann, N., & Brandt, S. A. (2009). Electrophysiological evidence for cognitive control during conflict processing in visual spatial attention. *Psychol Res* , *73* (6), 751–761. https://doi.org/10.1007/ s00426-008-0194-y

Li, G., Wang, S., Duan, Y., & Zhu, Z. (2013). Perceptual conflict-induced late positive complex in a modified Stroop task.*Neurosci Lett* , *542* , 76–80. https://doi.org/10.1016/j.neulet. 2013.01.056

Li, Z., Yang, G., Nan, W., Li, Q., & Liu, X. (2018). Attentional regulation mechanisms of cognitive control in conflict resolution.*Advances in Psychological Science* , *26* (6), 966–974. https://doi.org/10.3724/sp.J.1042.2018.00966

Liotti, M., Woldorff, M. G., Perez, R., & Mayberg, H. S. (2000). An ERP study of the temporal course of the Stroop color-word interference effect. *Neuropsychologia* , *38* (5), 701–711. https://doi.org/10.1016/S0028-3932(99)00106-2.

Liu, H., Chen, J., & Xiao, S. (2012). The Effect of Material Type and Color Typicality on Color-Object Stroop Effect. *Journal of Psychological Science* , *35* (3), 619–623. http://www.psysci.org/CN/Y2012/V35/I3/619

Liu, Y., Quan, H., Song, S., Zhang, X., Yang, C., & Chen, H. (2019). Decreased Conflict Control in Overweight Chinese Females: Behavioral and Event-Related Potentials Evidence. *Nutrients* , *11* (7), 1450–1461. https://doi.org/10.3390/nu11071450

Lu, A., Yang, L., Yu, Y., Zhang, M., Shao, Y., & Zhang, H. (2014). Event-related potentials reveal linguistic suppression effect but not enhancement effect on categorical perception of color. *Scand J Psychol* , *55* (4), 287–295. https://doi.org/10.1111/sjop. 12122

Markela-Lerenc, J., Ille, N., Kaiser, S., Fiedler, P., Mundt, C., & Weisbrod, M. (2004). Prefrontal-cingulate activation during executive control: which comes first? *Brain Res Cogn Brain Res* ,*18* (3), 278–287. https://doi.org/10.1016/j.cogbrainres.2003.10.013

Morales, S., & Bowers, M. E. (2022). Time-frequency analysis methods and their application in developmental EEG data. *Developmental Cognitive Neuroscience* , *54* , 1–13. https://doi.org/10.1016/j.dcn.2022.101067

Nicosia, J., & Balota, D. (2020). The consequences of processing goal-irrelevant information during the Stroop task. *Psychology and Aging* , *35* (5), 663–675. https://doi.org/10.1037/ pag0000371

Nigbur, R., Ivanova, G., & Sturmer, B. (2011). Theta power as a marker for cognitive interference. *Clinical Neurophysiology* ,*122* (11), 2185–2194. https://doi.org/10.1016/ j.clinph.2011.03.030

Pastotter, B., & Frings, C. (2018). It's the Other Way Around! Early Modulation of Sensory Distractor Processing Induced by Late Response Conflict. *J Cogn Neurosci* , *30* (7), 985–998. https://doi.org/10.1162/jocn_a_01267

Peng, Y., Sun, Y., & Wan, X. (2022). Influence of the crossmodal congruency between color and flavor on product evaluations: Evidence from behavioral and oscillatory brain responses. *Food Quality and Preference* , *97* . https://doi.org/10.1016/j.foodqual.2021. 104480

Peng, Y., & Wan, X. (2022). Flavors bias attention toward associated colors in visual search. *Acta Psychologica Sinica* , *54* (7), 736–747. https://doi.org/10.3724/sp.J.1041.2022. 00736

Piqueras-Fiszman, B., & Spence, C. (2011). Crossmodal correspondences in product packaging. Assessing color-flavor correspondences for potato chips (crisps). *Appetite* , *57* (3), 753–757. https://doi.org/10.1016/j.appet.2011.07.012

Piqueras-Fiszman, B., & Spence, C. (2015). Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts. *Food Quality and Preference* , *40* , 165–179. https://doi.org/10.1016/j. foodqual.2014.09.013

Pires, L., Leitão, J., Guerrini, C., & Simões, M. R. (2014). Event-Related Brain Potentials in the Study of Inhibition: Cognitive Control, Source Localization and Age-Related Modulations.*Neuropsychology Review* , *24* (4), 461–490. https://doi.org/10.1007/ s11065-014-9275-4

Qiu, J., Luo, Y., Wang, Q., Zhang, F., & Zhang, Q. (2006). Brain mechanism of Stroop interference effect in Chinese characters.*Brain Res* , *1072* (1), 186–193. https://doi.org/ 10.1016/j.brainres.2005.12.029

Servais, A., Hurter, C., & Barbeau, E. J. (2023). Attentional switch to memory: An early and critical phase of the cognitive cascade allowing autobiographical memory retrieval. *Psychon Bull Rev* . https://doi.org/10.3758/s13423-023-02270-w

Spence, C. (2011). Crossmodal correspondences: A tutorial review. *Attention, Perception, & Psychophysics* , *73* (4), 971–995. https://doi.org/10.3758/s13414-010-0073-7

Spence, C., Levitan, C. A., Shankar, M. U., & Zampini, M. (2010). Does Food Color Influence Taste and Flavor Perception in Humans? *Chemosensory Perception* , *3* (1), 68–84. https://doi.org/10.1007/s12078-010-9067-z

Spence, C., & Velasco, C. (2018). On the multiple effects of packaging colour on consumer behaviour and product experience in the 'food and beverage' and 'home and personal care' categories. *Food Quality and Preference* , *68* , 226–237. https://doi.org/10.1016/j. foodqual.2018.03.008

Spyropoulos, G., Bosman, C. A., & Fries, P. (2018). A theta rhythm in macaque visual cortex and its attentional modulation. *Proceedings of the National Academy of Sciences* , *115* (24), E5614–E5623. https://doi.org/10.1073/pnas.1719433115

Sun, J., Sun, B., Zhang, L., Luo, Q., & Gong, H. (2013). Correlation between hemodynamic and electrophysiological signals dissociates neural correlates of conflict detection and resolution in a Stroop task: a simultaneous near-infrared spectroscopy and event-related potential study. *Journal of Biomedical Optics* , *18* (9). https://doi.org/10.1117/1.JBO. 18.9.096014

Tang, D., & Chen, A. (2013). Neural Oscillation Mechanisms of Conflict Adaptation. *SCIENTIA SINICA Vitae* , *43* (11), 992–1002. https://doi.org/10.1360/052013-44

Tang, D., Gao, X., Luo, N., Li, W., Zhu, H., & Yang, Q. (2021). The Neural Mechanisms of Stimulus and Response Conflicts in the Letter Flanker Task. *Journal of Southwest University (Natural Science Edition)* , *43* (4), 146–156. https://doi.org/10.13718/j.cnki. xdzk.2021.04.018

Velasco, C., Wan, X., Knoeferle, K., Zhou, X., Salgado-Montejo, A., & Spence, C. (2015). Searching for flavor labels in food products: the influence of color-flavor congruence and association strength. *Frontiers in Psychology* , *6* . https://doi.org/10.3389/fpsyg. 2015.00301

Velasco, C., Wan, X., Salgado-Montejo, A., Woods, A., Oñate, G. A., Mu, B., & Spence, C. (2014). The context of colour-flavour associations in crisps packaging: A cross-cultural study comparing Chinese, Colombian, and British consumers. *Food Quality and Preference* , *38* , 49–57. https://doi.org/10.1016/j.foodqual.2014.05.011

Vo, K. D., Siqi-Liu, A., Chaire, A., Li, S., Demeter, E., Egner, T., & Woldorff, M. G. (2021). Neural Dynamics of Conflict Control in Working Memory. *Journal of Cognitive Neuroscience* , *33* (10), 2079–2092. https://doi.org/10.1162/jocn_a_01744

Vulić, K., Bjekić, J., Paunović, D., Jovanović, M., Milanović, S., & Filipović, S. R. (2021). Theta-modulated oscillatory transcranial direct current stimulation over posterior parietal cortex improves associative memory. *Scientific Reports* , *11* (1). https://doi.org/ 10.1038/s41598-021-82577-7

Wan, X., Woods, A. T., Jacquot, M., Knoeferle, K., Kikutani, M., & Spence, C. (2016). The Effects of Receptacle on the Expected Flavor of a Colored Beverage: Cross-Cultural Comparison Among French, Japanese, and Norwegian Consumers. *Journal of Sensory Studies* , *31* (3), 233–244. https://doi.org/10.1111/joss.12206

Wan, X., Xu, J., & Huang, J. (2022). Influence of associative learning on consumer behavior: From the perspective of product search experience. *Advances in Psychological Science* , *30* (11), 2414–2423. https://doi.org/10.3724/sp.J.1042.2022.02414

Wang, K., Li, Q., Zheng, Y., Wang, H., & Liu, X. (2014). Temporal and spectral profiles of stimulus-stimulus and stimulus-response conflict processing. *Neuroimage* , *89* , 280–288. https://doi.org/10.1016/j.neuroimage.2013.11.045

Wang, W., Qi, M., & Gao, H. (2021). An ERP investigation of the working memory stroop effect. *Neuropsychologia* , *152* , 107752. https://doi.org/10.1016/j.neuropsychologia. 2021.107752

Wei, H., Beuckelaer, A. D., & Zhou, R. (2021). Enhanced or impoverished recruitment of top-down attentional control of inhibition in test anxiety. *Biological Psychology* , *161* , 108070. https://doi.org/10.1016/j.biopsycho.2021.108070

Wynn, S. C., Kessels, R. P. C., & Schutter, D. J. L. (2019). Effects of parietal exogenous oscillatory field potentials on subjectively perceived memory confidence. *Neurobiology of Learning and Memory* ,*168* . https://doi.org/10.1016/j.nlm.2019.107140

Zhang, J. X., Fang, Z., Du, Y., Kong, L., Zhang, Q., & Xing, Q. (2012). Centro-parietal N200: An event-related potential component specific to Chinese visual word recognition. *Chinese Science Bulletin* ,*57* (13), 1516–1532. https://doi.org/10.1007/s11434-011-4932-y

Zhang, Q., & Damian, M. F. (2009). The time course of semantic and orthographic encoding in Chinese word production: An event-related potential study. *Brain Research* , *1273* , 92–105. https://doi.org/10.1016/j.brainres.2009.03.049

Zhao, Y., Tang, D., Hu, L., Zhang, L., Hitchman, G., Wang, L., & Chen, A. (2014). Concurrent working memory task decreases the Stroop interference effect as indexed by the decreased theta oscillations.*Neuroscience* , *262* , 92–106. https://doi.org/10.1016/j.neuroscience.2013.12.052

Zhou, A., Li, S., Shi, Z., Liu, P., Xia, R., Xu, K., Zhu, J., & Ren, D. (2013). Searching the Self: Encoding Self-relevant Possessive Pronoun and Theta Activity. *Acta Psychologica Sinica* , *45* (7), 790–796. https://doi.org/10.3724/SP.J.1041.2013.00790

Zhou, W., Deng, L., & Ding, J. (2021). Neural mechanism underlying the effects of object color on episodic memory. *Acta Psychologica Sinica* , *53* (3), 229–243. https://doi.org/10.3724/SP.J.1041.2021.00229

Hosted file

`List of Figure.rar` available at https://authorea.com/users/627103/articles/648169-attentional-switch-to-memory-an-early-and-late-stage-of-cognitive-processing-allowing-efficient-visual-search

Hosted file

`Table 1.docx` available at https://authorea.com/users/627103/articles/648169-attentional-switch-to-memory-an-early-and-late-stage-of-cognitive-processing-allowing-efficient-visual-search