Same-Location Cost Phenomenon in Semantic Association: Inhibition of Non-Target Features and Possible Target Locations

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Abstract

Using the cueing paradigm, we established semantic associations between cues, targets, and non-target items to form a strong attentional inhibition set, thereby exploring the emergence conditions and limiting factors of the same-location cost phenomenon at the abstract conceptual level. Experiment 1 established a semantic-level attentional inhibition set based on non-target item features and, for the first time, discovered the semantic-association same-location cost phenomenon. Experiment 2 eliminated the semantic association between cues and non-target items, resulting in the disappearance of the same-location cost phenomenon. Experiment 3, serving as a baseline, examined the influence of cues semantically unrelated to target color on visuospatial attentional orienting, and the results showed that the cue validity effect was not significant under any target screen condition. Experiment 4 added cues appearing at impossible target locations, finding that cues at possible versus impossible target locations differentially modulated attentional allocation. Experiment 5 eliminated the semantic association between cues and non-target items, and the same-location cost phenomenon disappeared and was unaffected by cue location. The research findings indicate: (1) The same-location cost phenomenon can occur at the abstract semantic conceptual level and is influenced by the current attentional control set; (2) Compared with the feature-perception-associated same-location cost phenomenon, the semantic-association same-location cost phenomenon requires a stronger attentional inhibition set; (3) The semantic-association same-location cost originates from the inhibition of non-target features but is limited to possible target locations.

Full Text

The Same-Location Cost Phenomenon Based on Meaningful Contingency: Suppression Based on Nontarget Features and Possible Target Positions

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Abstract

Using a cuing paradigm, this study established meaningful associations among cues, targets, and nontarget items to form a strong attentional suppression set, exploring the conditions and constraints for the emergence of same-location cost at an abstract conceptual level. Experiment 1 established a meaning-based attentional suppression set grounded in nontarget feature characteristics and, for the first time, discovered the same-location cost phenomenon based on meaningful contingency. Experiment 2 eliminated the meaningful association between cues and nontarget items, resulting in the disappearance of the same-location cost phenomenon. Experiment 3 served as a baseline investigation of the influence of cues semantically unrelated to target color on visuospatial attentional orienting, finding no significant cue validity effects under any target display conditions. Experiment 4 added cues appearing at impossible target positions, revealing differential modulation of attentional allocation depending on whether cues appeared at possible versus impossible target positions. Experiment 5 eliminated the meaningful association between cues and nontarget items, causing the same-location cost phenomenon to disappear regardless of cue position. The findings demonstrate that: (1) the same-location cost phenomenon can occur at an abstract conceptual meaning level, influenced by current attentional control settings; (2) compared with perceptually associated same-location cost, meaning-associated same-location cost requires a stronger attentional suppression set; and (3) meaning-associated same-location cost originates from suppression of nontarget features but is limited to possible target positions.

Keywords: meaningful contingency, same-location cost, attentional control setting, attentional capture, attentional inhibition

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1. Introduction

In the real world, certain stimuli can automatically attract attention, such as items that appear abruptly accompanied by luminance changes (abrupt onset) [**?**] or items that differ on a particular dimension among homogeneous items

(singleton) [?]. The stimulus-driven selection hypothesis posits that the item with the greatest physical salience will automatically drive the first attentional shift; therefore, the most salient item must attract attention first [?, ?]. However, in some cases, salient feature singletons do not produce obvious attentional capture. For instance, in Folk et al.' s (1992) study, two items were presented sequentially in random positions; the former was called the cue and the latter the target. If responses were faster when the target appeared at the cued location (valid cue condition) than when it appeared elsewhere (invalid cue condition), the cue was considered to have captured attention. The results showed that salient stimuli did not always capture attention; rather, capture depended on whether they were associated with the target item. Specifically, abrupt onset cues only captured attention when the target was also an abrupt onset stimulus, and color cues only captured attention when the target shared the same color. Folk et al. (1992) termed this observed attentional phenomenon *contingent attentional capture*, arguing that whether an item attracts attention is not determined by its own salience but by the current attentional control setting—only items that match the attentional control setting receive attention.

Previous research has shown that contingent attentional capture can occur not only at the feature level but also at the abstract conceptual meaning level [?, ?]. For example, in Wang et al.' s (2018) study, semantic associations between items were established using a cuing paradigm to examine how such semantic associations influence spatial attentional allocation. The results revealed that objects lacking perceptual association with the target but sharing only semantic association could nevertheless modulate current spatial attentional allocation, regardless of whether the paradigm used feature cues with meaning targets or meaning cues with feature targets. These findings suggest that both physical features and meaning concepts can capture attention contingent on current task demands or attentional control settings, extending to the abstract conceptual meaning level. Related research has also found that during word search tasks, search efficiency is adjusted according to task demands, with perceptual features or semantic concepts consistent with the task being more likely to attract attention or more difficult to reject [?], a phenomenon that also occurs in real-world scenes [?].

Numerous studies have demonstrated that items consistent with the target gain attentional priority at both vivid perceptual feature levels and abstract conceptual meaning levels [?, ?, ?, ?, ?]. However, the influence of items inconsistent with the target on visuospatial attentional allocation requires further investigation. In fact, Lamy et al. (2004) found early on that when cue and target features were inconsistent, responses in the valid cue condition were slower than in the invalid cue condition. Relative to the benefit of attentional capture, the attentional orienting effect for feature-inconsistent cues showed a reversal—a cost. This delay in responding to targets at valid cue locations with feature inconsistency can be termed the *same-location cost*. Lamy et al. (2004) proposed that the same-location cost arises from feature-based suppression: participants suppress feature singleton items that do not match the target, causing delayed

attentional allocation to that location. Eimer et al. (2009) also found that when targets appeared at mismatched cue locations, the attentional selection component N2pc was delayed. N2pc (N2-posterior-contralateral) is a contralateral negative potential difference occurring at posterior scalp locations 180–300 ms after stimulus presentation, reflecting attentional resource allocation to an item [**?**]. The delayed N2pc for targets at mismatched cue locations indicates that perceptually salient but task-irrelevant visual events trigger location-specific suppression mechanisms, delaying subsequent target selection. Consistent with contingent attentional selection, whether items gain attention or are suppressed is influenced by top-down factors; subjective intentions or current tasks can modulate attentional shifts. When attentional control settings change or are adjusted, spatial attentional allocation is correspondingly affected.

The same-location cost phenomenon has gradually attracted attention, generating alternative explanations, the most influential being the object-file updating account. The concept of object files was proposed to explain how objects maintain perceptual continuity when changing (e.g., moving), binding different parts or features together to be perceived as a changing object rather than multiple distinct static objects [**?**]. The object-file updating theory suggests that if a cue and a target with inconsistent features appearing at the same location are viewed as an object with changing features, the delayed response to the target reflects the time cost of updating information about the changing object [**?**]. In Carmel and Lamy' s (2014) study, under continuous object conditions, the cue and target appearing at the same location might be perceived as the same object undergoing continuous change—one part of this object (the cue circle) changed color during cue presentation, while another part (the target letter) changed color during target presentation. Therefore, responding to the changed object (i.e., the target object) required updating the object' s features, resulting in prolonged response times and increased reaction times under valid cue conditions. Under discontinuous object conditions, without placeholders, the cue circle and target letter were perceived as independent objects; since there was no changing object perceptually, no updating was required, and thus reaction times remained unchanged. Based on these results, Carmel and Lamy (2014) attributed the same-location cost to the cost of updating stored information about an object as it changes over time.

Existing same-location cost studies have yielded results based on perceptual associations. To our knowledge, no same-location cost phenomenon based on meaningful contingency has been discovered; in other words, whether the same-location cost can occur at the abstract conceptual meaning level remains to be investigated. In Wang et al.' s (2018) study, when white Chinese character cues with color meaning were semantically inconsistent with color targets, there was no difference in reaction times between valid and invalid cue conditions. Does this indicate that the same-location cost cannot access the semantic conceptual level, or that previous experimental designs failed to meet the requirements for the phenomenon to emerge? In Wang et al.' s (2018) study, the target display always contained red and green objects. Therefore, under cue-target semantic

inconsistency conditions, there was always a nontarget item whose color was semantically consistent with the Chinese character cue. For example, when the cue was the character "红" (red) and the target was green, the nontarget items were red, blue, and yellow. Thus, participants likely held not only an attentional control setting for searching for the green feature but also a setting for suppressing red, blue, and yellow features. From this perspective, according to the feature suppression account, the "红" character cue, which was meaningfully associated with the red feature, should have triggered suppression. The absence of suppression could be explained in two ways: either the same-location cost cannot occur at the semantic level, or the meaning-associated suppression set was not strong enough to manifest in reaction times. This study aims to strengthen the attentional control setting for suppressing nontarget features to examine whether the same-location cost phenomenon based on meaningful contingency emerges and to identify its cause. Using the cuing paradigm, we established meaningful associations among cues, targets, and nontarget items to examine how cues semantically consistent or inconsistent with targets influence responses to subsequently presented targets. If the suppression set is sufficiently strong under conditions that adjust the suppression of nontarget features, we may discover the same-location cost phenomenon based on meaningful contingency, supporting the feature suppression account. If adjusting the suppression set for nontarget features has no effect on the same-location cost when object features remain unchanged, the object-file updating account would be supported.

2. Experiment 1: Meaning-Associated Same-Location Cost Based on Nontarget Feature Suppression

Using a cuing paradigm, we employed white Chinese characters "红" (red) or "绿" (green) with color meaning as cues and red and green colors as targets. To maximize the strength of the attentional suppression set, the target display contained only red and green colors: when the target color was red, the nontarget color was green, and vice versa. Thus, under cue-target semantic inconsistency conditions, the cue was meaningfully associated and semantically consistent with the nontarget feature. Participants held not only an attentional control setting for searching for the target feature but also a setting for suppressing the nontarget feature. Compared with Wang et al.' s (2018) study, where the cue was only meaningfully associated with one of three nontarget features, the suppression of the single nontarget feature associated with the cue in this experiment would be stronger. Since the target could appear in two possible positions, cues also appeared in two positions to maintain the same randomness as targets. If the same-location cost phenomenon emerged in this experiment, it would indicate that this phenomenon can occur at the abstract semantic conceptual level. If not, it would suggest that the phenomenon may not occur at the abstract semantic conceptual level or that meaning-associated attentional suppression was not significant enough to manifest in reaction times.

The target effect size was set at a minimum of 0.07, yielding an Effect size f

of 0.27. With Type I error probability α set at 0.05 and statistical power (1-β) at 0.80, the calculated sample size was 29. To ensure adequate experimental power, all experiments in this study included at least 30 participants. Thirty undergraduate and graduate students (13 male, 17 female) participated in Experiment 1, aged 18–24 years (21.0 ± 1.5 years). Two were left-handed, and the rest were right-handed. All participants were native Chinese speakers with normal or corrected-to-normal vision and no color blindness.

2.1.2 Apparatus and Materials

Stimuli were presented on a 22-inch color monitor with a resolution of $1680\$\times 1050 and a refresh rate of 85 Hz. The experimental program was compiled using E-Prime. There were three basic stimulus displays : fixation display, cue display, and target display (see Figure 1[Fi see original paper]). The fixation display presented a central fixation cross (0.48°×0.48°) with two boxes (1.53°×\$1. on the left and right sides, each centered 4.4° from the screen center. The central fixation cross was white, the peripheral boxes were gray (RGB: 128 128 128), and the background was black. In the cue display, a white Chinese character randomly appeared in one of the peripheral boxes, either "红" or "绿" . The target display modified the fixation display by changing the colors of the peripheral boxes to red and green, with the positions of the two colors randomized. Simultaneously, a gap appeared on the left or right side of each colored box, with gap positions randomized. Based on cue-target combinations, there were four conditions: when the target was a red box, the "红" character was a semantically consistent cue and the "绿" character was a semantically inconsistent cue; when the target was a green box, the "红" character was a semantically inconsistent cue and the "绿" character was a semantically consistent cue.

2.1.3 Procedure and Design

Participants were presented with instructions to ensure they understood the experimental procedure and task. Participants viewed the display from a distance of 74 cm. As shown in Figure 1, the fixation display (including the central fixation cross and two peripheral boxes) was presented for 500 ms, followed by the cue display for 100 ms. After an interstimulus interval (ISI) of 100 ms, the target display was presented for 500 ms. Participants could respond within 1500 ms after the target display disappeared. A random intertrial interval (ITI) of 1.4–1.6 s of blank screen separated trials. Since cue and target positions were random, the target had a 50% probability of appearing at the cued location (valid cue) and a 50% probability of appearing elsewhere (invalid cue).

Based on cue-target combinations, there were two tasks and four conditions, with each task including two conditions: in the red target task, presenting the "红" character was the semantically consistent condition, while presenting the "绿" character was the semantically inconsistent condition; in the green target task, presenting the "红" character was the semantically inconsistent condition, while presenting the "绿" character was the semantically consistent condition. The

experiment used a block design, with the order of the two tasks randomized and the order of the two experimental conditions within each task randomized. The combination of cue and target only varied between blocks; within each block, the cue character and target color were fixed, and participants only responded to a specific color. Before the experiment, participants were informed about the arrangement of cue displays but were instructed to ignore task-irrelevant cues during the experiment.

Participants' task was to judge the gap location in the specified color box for the current block as quickly and accurately as possible. If the gap was on the left, they pressed the "Z" key with their left index finger; if on the right, they pressed the "M" key with their right index finger. If no response occurred within 2000 ms after target onset, the trial was considered an error.

The experiment employed a 2 (cue validity: invalid, valid) × 2 (cue-target semantic consistency: consistent, inconsistent) within-subjects design. Each task included 12 practice trials, and each experimental condition included 96 formal trials, with a break after every 32 formal trials (break duration self-paced). The experiment comprised 408 trials total, with each block containing 96 trials, lasting approximately 30 minutes.

2.2 Results and Analysis

Trials with incorrect responses or reaction times exceeding three standard deviations from the mean were excluded, accounting for 6.6% of the data. A repeated-measures ANOVA on reaction times revealed a significant main effect of cue validity, $F(1, 29) = 4.73$, $p = 0.04$, $\mathrm{p}^2 = 0.14$, with responses to targets at non-cued locations (487.7 ms) overall slower than those at cued locations (480.2 ms). The 95% confidence interval for the difference was 0–15 ms. The main effect of cue-target semantic consistency was not significant, $F(1, 29) = 1.40$, $p = 0.25$, $\mathrm{p}^2 = 0.05$. Critically, the interaction between the two factors was significant, $F(1, 29) = 72.25$, $p < 0.001$, $\mathrm{p}^2 = 0.71$. Simple effects analysis showed that when cue-target semantic consistency was present, responses were slower for invalid cues (494 ms) than for valid cues (470 ms), $F(1, 29) = 31.84$, $p < 0.001$, $\mathrm{p}^2 = 0.52$, 95% CI = 16–33 ms, indicating a capture effect. When cue-target semantic consistency was absent, responses were faster for invalid cues (481 ms) than for valid cues (491 ms), $F(1, 29) = 6.78$, $p = 0.014$, $\mathrm{p}^2 = 0.19$, 95% CI = -17 to -2 ms, indicating a suppression effect (see Figure 2 [Figure 2: see original paper]). Additionally, we examined interactions between target position, target color, and experimental variables, finding none significant, Fs ≤ 2.74, ps ≥ 0.11. The priming of target display color features across trials also showed no significant interaction with experimental variables, Fs ≤ 3.94, ps ≥ 0.06.

A repeated-measures ANOVA on accuracy revealed no significant main effect of cue validity, $F(1, 29) = 1.12$, $p = 0.32$, $\mathrm{p}^2 = 0.03$, or cue-target semantic consistency, $F(1, 29) = 1.29$, $p = 0.27$, $\mathrm{p}^2 = 0.04$. However, the interaction

was significant, $F(1, 29) = 18.37$, $p < 0.001$, $p^2 = 0.39$. Simple effects analysis showed that when cue-target semantic consistency was present, accuracy was lower for invalid cues (91.5%) than for valid cues (94.8%), $F(1, 29) = 14.41$, $p = 0.001$, $p^2 = 0.33$, 95% CI = -5.1% to -1.5%. When cue-target semantic consistency was absent, accuracy was higher for invalid cues (94.9%) than for valid cues (92.6%), $F(1, 29) = 8.55$, $p = 0.007$, $p^2 = 0.23$, 95% CI = 0.7% to 3.9% (see Figure 2). Calculated statistical power for significant results exceeded 0.95.

Experiment 1 manipulated cue validity and cue-target semantic consistency, establishing meaningful associations among cues, targets, and nontarget items while reducing the number of items in the target display to examine whether the same-location cost phenomenon would emerge under a strong attentional suppression set. The results showed that when cue-target semantic consistency was present, a capture effect emerged, consistent with previous research [**?**, **?**], demonstrating that items lacking target-related features but consistent with the target at an abstract conceptual level can attract attention. Importantly, when cue-target semantic consistency was absent, a same-location cost phenomenon emerged, with slower responses for valid than invalid cues. This represents, to our knowledge, the first discovery of a meaning-associated same-location cost phenomenon. Because the cue was meaningfully associated with the sole nontarget item, participants held not only an attentional control setting for searching for the target feature but also a clear setting for suppressing the nontarget feature. Compared with Wang et al.' s (2018) study, where the cue was only meaningfully associated with one of three nontarget items, the present experiment produced stronger suppression of the nontarget-related cue, sufficient to manifest in reaction times. This experiment suggests that the same-location cost results from attentional suppression of target-irrelevant items based on current attentional control settings, and that this suppression can occur at an abstract semantic conceptual level, manifesting as a meaning-associated same-location cost phenomenon. Moreover, the same-location cost found in this experiment should not have originated from object-file updating, as the cue and target forms used here were identical to those in Wang et al. (2018). Object-file updating is not influenced by participants'subjective intentions, and since Wang et al. (2018) did not find a same-location cost phenomenon, it should not have appeared in this experiment either. In fact, under semantic consistency conditions, the cue and target differed in identity and features; if the same-location cost in this experiment had originated from object-file updating, it should have also appeared under semantic consistency conditions, which was clearly not the case.

3. Experiment 2: Elimination of Meaning-Associated Same-Location Cost Based on Nontarget Feature Suppression

We propose that the same-location cost phenomenon discovered in Experiment 1 originated from suppression of items meaningfully associated with nontarget fea-

tures. Therefore, when the meaningful association between cues and nontarget items is eliminated, participants no longer have a subjective basis for suppressing meaning-associated cues, and the same-location cost phenomenon should disappear. If the same-location cost phenomenon in Experiment 1 originated from object-file updating, then even after eliminating the meaningful association between cues and nontarget items, the same results should be replicated as long as cue and target forms remain unchanged.

Experiment 2 modified the color of nontarget items in the target display from Experiment 1: regardless of whether the target color was red or green, the nontarget item was always blue. Thus, whether the cue was "红" or "绿", it no longer had a consistent meaningful association with this nontarget item. If a same-location cost phenomenon emerged in Experiment 2, it would suggest that the same-location cost phenomena in Experiments 1 and 2 might have originated from object-file updating. If no same-location cost phenomenon appeared in Experiment 2, it would indicate that the same-location cost phenomenon in Experiment 1 originated from suppression based on nontarget item features.

3.1.1 Participants

Thirty-two undergraduate and graduate students (9 male, 23 female) participated in Experiment 2, aged 17–27 years (18.8 ± 2.2 years). Three were left-handed, and the rest were right-handed. All participants were native Chinese speakers with normal or corrected-to-normal vision and no color blindness.

3.1.2 Apparatus, Materials, Procedure, and Design

The only difference from Experiment 1 was that when the target was a red or green box, the nontarget box was blue (RGB: 0 0 255), meaning red and green never appeared simultaneously in the target display. All other aspects were identical to Experiment 1.

3.2 Results and Analysis

Trials with incorrect responses or reaction times exceeding three standard deviations from the mean were excluded, accounting for 6.6% of the data. A repeated-measures ANOVA on reaction times revealed a significant main effect of cue validity, $F(1, 31) = 18.68$, $p < 0.001$, $\mathrm{p}^2 = 0.38$, with responses to targets at non-cued locations (477 ms) overall slower than those at cued locations (462 ms), 95% CI = 8–22 ms. The main effect of cue-target semantic consistency was not significant, $F(1, 31) = 0.50$, $p = 0.49$, $\mathrm{p}^2 = 0.02$. Critically, the interaction between the two factors was significant, $F(1, 31) = 72.18$, $p < 0.001$, $\mathrm{p}^2 = 0.70$. Simple effects analysis showed that when cue-target semantic consistency was present, responses were slower for invalid cues (485 ms) than for valid cues (455 ms), $F(1, 31) = 53.53$, $p < 0.001$, $\mathrm{p}^2 = 0.63$, 95% CI = 22–39 ms, indicating a capture effect. When cue-target semantic consistency was absent, there was no difference between invalid (468 ms) and valid cues (469 ms), $F(1, 31) = 0.02$, p

= 0.88, p^2 = 0.001 (see Figure 3 [Figure 3: see original paper]). Additionally, we examined interactions between target position, target color, and experimental variables, finding none significant, Fs ≤ 3.50, ps ≥ 0.07. The priming of target display color features across trials also showed no significant interaction with experimental variables, Fs ≤ 3.55, ps ≥ 0.07.

A repeated-measures ANOVA on accuracy revealed no significant main effect of cue validity, $F(1, 31) = 1.93$, $p = 0.18$, $p^2 = 0.06$, or cue-target semantic consistency, $F(1, 31) = 1.42$, $p = 0.24$, $p^2 = 0.04$. However, the interaction was significant, $F(1, 31) = 26.74$, $p < 0.001$, $p^2 = 0.46$. Simple effects analysis showed that when cue-target semantic consistency was present, accuracy was lower for invalid cues (93.0%) than for valid cues (95.3%), $F(1, 31) = 12.09$, $p = 0.002$, $p^2 = 0.28$, 95% CI = -3.7% to -1.0%. When cue-target semantic consistency was absent, there was no difference in accuracy between invalid (93.2%) and valid cues (92.5%), $F(1, 31) = 0.99$, $p = 0.33$, $p^2 = 0.03$ (see Figure 3). Calculated statistical power for significant results exceeded 0.95.

Experiment 2 modified the nontarget item color from Experiment 1 to eliminate any possible meaningful association between cues and nontarget items. The results showed that when cue-target semantic consistency was present, attentional capture occurred, but when semantic consistency was absent, no same-location cost phenomenon emerged. The cue and target forms in Experiment 2 were identical to those in Experiment 1. If the same-location cost phenomenon in Experiment 1 had originated from object-file updating, Experiment 2 should have replicated Experiment 1' s results. However, the absence of a same-location cost phenomenon in Experiment 2 occurred because the cue no longer had a meaningful association with the nontarget item, eliminating suppression based on nontarget features. Consequently, the same-location cost phenomenon observed in Experiment 1 disappeared. These results support the feature suppression account influenced by subjective intentions and indicate that cue-target semantic inconsistency is not a sufficient condition for the emergence of meaning-associated same-location cost; rather, the phenomenon only emerges when there is a meaningful association between the cue and nontarget item and when suppression is sufficiently strong.

Like Experiment 1, Experiment 2 showed attentional capture when cue-target semantic consistency was present, with comparable capture magnitude, $t(60) = 1.06$, $p = 0.29$, consistent with the meaning-associated attentional capture effect found in Wang et al. (2018) (approximately 25 ms), supporting the meaning-associated attentional capture account.

4. Experiment 3: Baseline Experiment with Cues Semantically Unrelated to Target Features

To ensure that the attentional orienting effects observed in Experiments 1 and 2 resulted from manipulation of the experimental variables rather than interference from other irrelevant factors, Experiment 3 served as a baseline investiga-

tion of the influence of white "黄" (yellow) characters semantically unrelated to target color on visuospatial attentional orienting. The target displays from Experiments 1 and 2 were retained. If cues semantically unrelated to target features produce some degree of attentional orienting effect, then the effects found in Experiments 1 and 2 should contain some baseline component. If no significant attentional orienting effect is found in Experiment 3, then the attentional orienting effects in Experiments 1 and 2 should entirely result from experimental manipulation, unaffected by cues unrelated to the target.

4.1.1 Participants

Thirty undergraduate students (13 male, 17 female) participated in Experiment 3, aged 19-20 years (19.3 ± 0.5 years). One was left-handed, and the rest were right-handed. All participants were native Chinese speakers with normal or corrected-to-normal vision and no color blindness.

4.1.2 Apparatus, Materials, Procedure, and Design

The cue in Experiment 3 was a white "黄" character. The target display included all forms from Experiments 1 and 2. The order of the two color tasks (red task and green task) was randomized, as was the order of the two target display conditions (Experiment 1 target display condition and Experiment 2 target display condition) within each task. For each target display condition, a one-factor two-level within-subjects design was used, with cue validity (invalid, valid) as the independent variable. All other aspects were identical to Experiments 1 and 2.

4.2 Results and Analysis

Trials with incorrect responses or reaction times exceeding three standard deviations from the mean were excluded, accounting for 5.3% of the data. Table 1 presents mean reaction times and accuracy rates for each cue validity level under the two target display conditions. Paired-samples *t*-tests showed that for reaction times, cue validity effects were not significant under either target display condition: for the Experiment 1 target display condition, $t(29) = -1.32$, $p = 0.20$; for the Experiment 2 target display condition, $t(29) = 0.36$, $p = 0.73$. Additionally, we examined interactions between target position, target color, and experimental variables under each target display condition, finding none significant, Fs ≤ 2.02, ps ≥ 0.17. The priming of target display color features across trials also showed no significant interaction with experimental variables, Fs ≤ 3.05, ps ≥ 0.09.

For accuracy, paired-samples *t*-tests showed that cue validity effects were not significant under either target display condition: for the Experiment 1 target display condition, $t(29) = 1.16$, $p = 0.26$; for the Experiment 2 target display condition, $t(29) = 0.55$, $p = 0.59$.

Table 1 Mean Reaction Times and Accuracy Rates for Each Cue Validity Level Under Two Target Display Conditions in Experiment 3 (M±SD)

Target Display Condition	Cue Validity	Reaction Time (ms)	Accuracy (%)
Experiment 1 condition	Invalid	463$±53|95.5±7.2|||*Valid*|458±50|94.7±7.3||*Experiment2conditi*	

Experiment 3 found that cue validity effects were not significant under either target display condition. This indicates that when cues are semantically unrelated to targets, they do not cause attentional enhancement or suppression. The attentional orienting effects found in Experiments 1 and 2 resulted from manipulation of the independent variables, unaffected by cues unrelated to targets. Although the cue was an abrupt onset stimulus with potential for automatic attentional capture [**?**], it failed to capture attention when the target was a color feature, consistent with Folk et al.' s (1992) results and supporting the contingent attentional orienting hypothesis.

5. Experiment 4: Meaning-Associated Same-Location Cost Based on Suppression of Possible Target Positions

The same-location cost is a location-specific spatial attention phenomenon; the positional relationship between cues and targets influences subsequent spatial attentional allocation [**?**]. To examine this location-based visual spatial attention phenomenon in greater detail, Experiment 4 added possible cue locations to investigate how cue appearance at possible target positions (where targets could appear) versus impossible target positions (where targets could not appear) influences attentional selection. We hypothesized that if suppression of target-inconsistent cues is constrained by cue location, its influence on attentional allocation would differ when appearing at possible versus impossible target positions.

5.1.1 Participants

Thirty-one undergraduate and graduate students (15 male, 16 female) participated in Experiment 4, aged 17–25 years (18.3 ± 1.3 years). One was left-handed, and the rest were right-handed. All participants were native Chinese speakers with normal or corrected-to-normal vision and no color blindness.

5.1.2 Apparatus, Materials, Procedure, and Design

In this experiment, four boxes were presented around the central fixation cross (above, below, left, and right). The Chinese character cue randomly appeared in one of the four boxes. In the target display, the left and right boxes still changed to red and green, while the upper and lower boxes remained unchanged. All other aspects were identical to Experiment 1.

The experiment employed a 3 (cue validity: invalid-possible target position, invalid-impossible target position, valid) × 2 (cue-target semantic consistency: consistent, inconsistent) within-subjects design.

5.2 Results and Analysis

Trials with incorrect responses or reaction times exceeding three standard deviations from the mean were excluded, accounting for 10.2% of the data. A repeated-measures ANOVA on reaction times revealed a significant main effect of cue validity, $F(2, 60) = 5.05$, $p = 0.009$, $\eta_p^2 = 0.14$. Multiple comparisons showed that responses when cues appeared at impossible target positions and were invalid (480 ms) were overall slower than when cues were valid (472 ms), $p = 0.001$; other condition differences were not significant, $ps \geq 0.13$. The main effect of cue-target semantic consistency was not significant, $F(1, 30) = 0.30$, $p = 0.59$, $\eta_p^2 = 0.01$. Critically, the interaction between the two factors was significant, $F(2, 60) = 28.11$, $p < 0.001$, $\eta_p^2 = 0.48$. Simple effects analysis showed that when cue-target semantic consistency was present, the three cue validity levels differed significantly, $F(2, 60) = 21.39$, $p < 0.001$, $\eta_p^2 = 0.60$. Specifically, responses for invalid cues did not differ whether cues appeared at possible target positions (483 ms) or impossible target positions (486 ms), $p = 0.28$, and both were slower than for valid cues (462 ms), $ps < 0.001$. When cue-target semantic consistency was absent, the three cue validity levels also differed significantly, $F(2, 60) = 10.87$, $p < 0.001$, $\eta_p^2 = 0.27$. Specifically, responses for invalid cues at impossible target positions (478 ms) did not differ from valid cues (481 ms), $p = 0.19$, but both were slower than invalid cues at possible target positions (467 ms), $ps \leq 0.001$ (see Figure 5 [Figure 5: see original paper]). Additionally, we examined interactions between target position, target color, and experimental variables, finding none significant, $Fs \leq 2.93$, $ps \geq 0.08$. The priming of target display color features across trials also showed no significant interaction with experimental variables, $Fs \leq 3.74$, $ps \geq 0.06$.

A repeated-measures ANOVA on accuracy revealed no significant main effect of cue validity, $F(2, 60) = 3.74$, $p = 0.06$, $\eta_p^2 = 0.11$. The main effect of cue-target semantic consistency was significant, $F(1, 30) = 7.66$, $p = 0.001$, $\eta_p^2 = 0.20$, with overall higher accuracy for semantically consistent (92.8%) than inconsistent conditions (86.9%), 95% CI = 1.6–10.4%. The interaction was not significant, $F(2, 60) = 4.05$, $p = 0.053$, $\eta_p^2 = 0.12$. Calculated statistical power for significant results exceeded 0.95.

Experiment 4 results showed that cue location influenced attentional selection differently when cues appeared at possible versus impossible target positions. When cue-target semantic consistency was present, cues at all locations produced equivalent attentional capture. When semantic consistency was absent, same-location cost only occurred when cues appeared at possible target positions; no cue effect occurred at impossible target positions. Thus, attentional capture is not limited by cue location—cues attract attention as long as they share consistent meaning with the target—whereas same-location cost is limited to possible target positions. Even when cues match an attentional control setting for suppressing certain features, they remain constrained by location-based limitations. This suggests that both attentional capture and same-location cost are influenced by top-down attentional control settings but differ in their spatial

position requirements.

Additionally, when cue-target semantic consistency was absent, responses for invalid cues at impossible target positions did not differ from valid cues. Since valid cue responses are prolonged due to associated suppression, responses for invalid cues at impossible target positions were also prolonged. This indicates that cues at impossible target positions were not suppressed, because if a location were suppressed, its invalid cue responses should not be lengthened. A possible explanation is that under cue-target semantic inconsistency conditions, possible target positions maintain an initial inhibitory state. When a cue does not appear at a possible target position, all possible target positions retain this inhibitory state; when a cue appears at a possible target position, only that position receives suppression while the other possible target position is released from inhibition.

6. Experiment 5: Elimination of Meaning-Associated Same-Location Cost Based on Suppression of Possible Target Positions

Compared with Experiment 4, Experiment 5 eliminated the meaningful association between cues and nontarget items while maintaining the possibility of cues appearing at impossible target positions. We hypothesized that if suppression of target-inconsistent cues is based on nontarget features, this experiment should show no same-location cost phenomenon and no location-based differences.

6.1.1 Participants

Thirty-four undergraduate and graduate students (11 male, 23 female) participated in Experiment 5, aged 18–26 years (20.5 $\pm$ 2.3 years). Four were left-handed, and the rest were right-handed. All participants were native Chinese speakers with normal or corrected-to-normal vision and no color blindness.

6.1.2 Apparatus, Materials, Procedure, and Design

The only difference from Experiment 4 was that when the target was a red or green box, the nontarget box was blue, meaning red and green never appeared simultaneously in the target display. All other aspects were identical to Experiment 4.

6.2 Results and Analysis

Trials with incorrect responses or reaction times exceeding three standard deviations from the mean were excluded, accounting for 3.7% of the data. A repeated-measures ANOVA on reaction times revealed a significant main effect of cue validity, $F(2, 66) = 22.12$, $p < 0.001$, $\mathrm{p}^2 = 0.40$. Multiple comparisons showed that responses for invalid cues did not differ whether cues appeared at possible target positions (462 ms) or impossible target positions (460 ms), $p =$

0.29, and both were slower than for valid cues (449 ms), ps < 0.001. The main effect of cue-target semantic consistency was not significant, $F(1, 33) = 0.20$, $p = 0.66$, $\eta_p^2 = 0.01$. Critically, the interaction between the two factors was significant, $F(2, 66) = 29.38$, $p < 0.001$, $\eta_p^2 = 0.47$. Simple effects analysis showed that when cue-target semantic consistency was present, the three cue validity levels differed significantly, $F(2, 66) = 35.42$, $p < 0.001$, $\eta_p^2 = 0.52$. Specifically, responses for invalid cues did not differ whether cues appeared at possible target positions (463 ms) or impossible target positions (465 ms), $p = 0.57$, and both were slower than for valid cues (441 ms), ps < 0.001. When cue-target semantic consistency was absent, the three cue validity levels did not differ, $F(2, 66) = 2.81$, $p = 0.07$, $\eta_p^2 = 0.08$ (see Figure 6 [Figure 6: see original paper]). Additionally, we examined interactions between target position, target color, and experimental variables, finding none significant, Fs ≤ 1.58, ps ≥ 0.21. The priming of target display color features across trials also showed no significant interaction with experimental variables, Fs ≤ 1.16, ps ≥ 0.29.

A repeated-measures ANOVA on accuracy revealed a significant main effect of cue validity, $F(2, 66) = 6.13$, $p = 0.02$, $\eta_p^2 = 0.16$, with higher accuracy for invalid cues when they appeared at impossible target positions, ps ≤ 0.005. The main effect of cue-target semantic consistency was not significant, $F(1, 33) = 3.83$, $p = 0.06$, $\eta_p^2 = 0.10$. The interaction was not significant, $F(2, 66) = 3.22$, $p = 0.08$, $\eta_p^2 = 0.09$. Calculated statistical power for significant results exceeded 0.95.

After eliminating the meaningful contingency between cues and nontarget items, Experiment 5 found that when cue-target semantic consistency was present, cues at all locations produced equivalent attentional capture. When semantic consistency was absent, cues at any location produced no effect. This demonstrates that eliminating the meaningful association between cues and nontarget items causes the same-location cost phenomenon to disappear, and cue location no longer influences attentional selection. Thus, attentional capture remains unaffected by cue location—cues attract attention as long as they share consistent meaning with the target—whereas when cues are no longer suppressed, their location shows no differential effect, and cues at any location no longer influence attentional selection.

7. General Discussion

Through five experiments, this study used a cuing paradigm to establish meaningful associations among cues, targets, and nontarget items, forming a strong attentional suppression set to explore the conditions and constraints for the emergence of same-location cost at an abstract conceptual level. Experiment 1 strengthened the attentional suppression set for nontarget item features based on previous research and, for the first time, discovered the meaning-associated same-location cost phenomenon. Experiment 2 eliminated the meaningful association between cues and nontarget items, causing the same-location cost phenomenon to disappear and demonstrating that cue-target semantic inconsistency

is not a sufficient condition for meaning-associated same-location cost—rather, it requires attentional suppression based on nontarget features. Experiment 3 served as a baseline investigation of the influence of cues semantically unrelated to target color on visuospatial attentional orienting, finding no significant cue validity effects under any target display conditions, indicating that the attentional orienting effects in Experiments 1 and 2 resulted from experimental manipulation without interference from target-unrelated cues. Experiment 4 added cues appearing at impossible target positions, revealing differential modulation of attentional allocation depending on cue location, showing that same-location cost is a location-specific attention phenomenon based on possible target positions. Even when cues match an attentional control setting for suppressing certain features, they remain constrained by location-based limitations. Experiment 5 eliminated the meaningful association between cues and nontarget items based on Experiment 4, causing the same-location cost phenomenon to disappear regardless of cue location. While most research has focused on how perceptual associations between items influence spatial attentional allocation, finding that items consistent with target features attract attention and items inconsistent with target features are suppressed [**?**, **?**, **?**, **?**], this study is the first to discover the meaning-associated same-location cost phenomenon, demonstrating that this spatial attention phenomenon can occur at an abstract conceptual meaning level as a result of attentional suppression based on nontarget features and possible target positions.

7.1 Accounts That Cannot Explain Meaning-Associated Same-Location Cost

The same-location cost phenomenon discovered in this study did not result from object-file updating of inconsistent cue location information. Because regardless of whether cues were consistent with nontarget features, cue and target identity and features were identical under inconsistent conditions. If object-file updating were responsible, results should have been consistent across these conditions, which was clearly not the case (difference between Experiments 1 and 2). In fact, regardless of semantic consistency between cue and target, the two differed in attributes; if object-file updating were at play, same-location cost should have appeared under all conditions, which was not the case (attentional capture appeared under semantic consistency conditions). Some researchers have noted that certain same-location cost results cannot be explained by the object-file updating account and are more likely attributable to attentional factors [**?**]. For example, Schoeberl et al. (2018) required participants to search for the highest or lowest spatial frequency, creating a relational attentional control setting [**?**, **?**, **?**] where a frequency consistent with the target but not the highest or lowest became a relationally mismatched cue. Results showed same-location cost under these conditions. According to the object-file updating account, since this relationally mismatched cue shared the target frequency, no working memory updating should have been required, and thus no same-location cost should have appeared. Ansorge and Schoeberl (2017) also found

that during relational search, nonmatching cues sharing target features still produced same-location cost. Additionally, if the object-file updating account were valid, the degree of object-file updating should correlate with the degree of change in the same-location object (similarity between cue and target)—greater object change (more dissimilar cue-target) should produce more significant same-location cost. However, results showed that same-location cost was unaffected by similarity between cue and target and was positively correlated with cue effects under matching conditions, pointing to attentional factors as the source of same-location cost. Furthermore, Schoeberl et al.' s (2018) color-based experiments found that when only the cue circle changed color while other non-cue circles remained gray (homogeneous color condition), nonmatching cues produced same-location cost; however, when all circles in the cue display changed to some color (heterogeneous color condition), nonmatching cues produced attentional capture. The object-file updating account can explain the former—valid cue responses were delayed because the object at that location updated its color, delaying target responses—but cannot explain the latter, because all location objects changed color, so all location responses should have been delayed, and thus no cue effect should have appeared.

Second, the source of meaning-associated same-location cost should not be rapid disengagement of attention after capture by semantically inconsistent cues. Different explanations exist for why salient stimuli fail to attract attention, among which Theeuwes (2004, 2010) proposed the rapid disengagement hypothesis. He argued that salient stimuli still automatically attract attention first, with subsequent responses influenced by current tasks or subjective intentions. When an attended stimulus matches the current attentional control setting or happens to be the target to be operated on, it receives rapid processing to improve efficiency; when the stimulus does not match the attentional control setting or is a distractor to be ignored, attention rapidly disengages from that location and quickly shifts to the actual target. When the stimulus onset asynchrony (SOA) between cue and target is short (approximately 50 ms), mismatched cues that have attracted attention delay target search; when SOA is longer (greater than 100 ms), attention has already disengaged from the cue location within this time window, so mismatched cues do not affect responses to subsequent targets [**?**]. In this study, the SOA between cue and target was 200 ms, well beyond the time range in which mismatched cues could affect subsequent targets. Even if mismatched cues attracted attention due to their salience, attention would have already disengaged from this location and conducted normal target search. Moreover, temporally, the rapid disengagement hypothesis does not match the characteristics of same-location cost emergence. If rapid disengagement caused same-location cost, the phenomenon should gradually decrease as cue-target SOA increases. In reality, same-location cost is most pronounced within the 150–200 ms range, decreasing or even disappearing with shorter or longer SOAs [**?**, **?**, **?**].

Finally, some researchers argue that under certain conditions, salient feature singletons unrelated to attentional control settings are actively suppressed and

do not capture attention [?, ?]. If distractors appear with higher probability at a certain location, attentional capture at that location is reduced and selection probability is lower [?], while also eliciting the PD component of signal suppression [?, ?]. Some research suggests that attentional suppression of frequent distractor locations can be established through feature-based attention [?]. In this study, cue locations were random, eliminating any statistical learning process, so the observed same-location cost could not result from signal suppression of mismatched cues. Additionally, since no other objects appeared in the cue display besides the cue, same-location cost could not result from contextual cueing of attention [?, ?].

7.2 Meaning-Associated Same-Location Cost Phenomenon Originates from Attentional Suppression of Nontarget Features and Possible Target Positions

This study' s results support the view that same-location cost results from attentional suppression based on features or concepts, influenced by current attentional control settings. Under identical task conditions, same-location cost appeared when cues were semantically associated with nontarget items but disappeared after eliminating this semantic association. In many perceptual-level studies, cues causing same-location cost were inconsistent with target features but consistent with some nontarget feature within the search array [?, ?]. When participants search for a particular feature, they may also hold an attentional control setting for suppressing inconsistent features within the search array; the stronger this setting, the more likely inconsistent cues will be suppressed. At the perceptual level of spatial attentional modulation, participants can suppress multiple irrelevant features, with suppression effects manifesting in reaction times when an item matches any one of them. At the abstract conceptual meaning level, in similar search arrays, items consistent with target meaning can attract attention, while items inconsistent with target meaning do not show significant suppression effects. Research also indicates that spatial attentional allocation at the meaning conceptual level is similar in form but reduced in magnitude compared to the feature perceptual level [?]. Therefore, it is possible that previous meaning-level studies had not achieved sufficient strength in their attentional control settings for suppressing inconsistent cues to manifest same-location cost. This study maintained the same experimental design and task as previous research while reducing the number of search items, retaining only a single nontarget item to ensure participants held the strongest possible attentional control setting for suppressing target-inconsistent features, resulting in the discovery of meaning-associated same-location cost. This suggests that meaning-level same-location cost requires stronger attentional control settings, with more stringent conditions for emergence than perceptual-level same-location cost.

In Carmel and Lamy's (2014) crucial Experiment 3, same-location cost appeared under continuous object conditions but disappeared under discontinuous object conditions. The researchers attributed this difference to the presence or absence

of continuously changing objects requiring updating of stored information. However, the nontarget feature suppression account can also explain these results. Under continuous object conditions, placeholders prevented color-inconsistent cues and targets from appearing as abrupt onsets, eliminating shared attributes and thus preventing contingent attentional capture, leaving only same-location cost. Under discontinuous object conditions, both color-inconsistent cues and targets appeared as abrupt onsets, potentially causing contingent attentional capture, while cues were also suppressed because they always matched a nontarget item' s color. Attentional capture and feature suppression may have cancelled each other out, reducing or eliminating the effect. Additionally, under discontinuous object conditions, significant same-location cost only appeared at a cue-target SOA of 150 ms, decreasing or disappearing with longer SOAs, possibly because the SOA exceeded the optimal time window for same-location cost [**?**, **?**]. Harris et al. (2023) used a similar paradigm and obtained consistent results: cues matching target color caused attentional capture, eliciting N2pc followed by PD; cues matching nontarget color caused same-location cost, eliciting no N2pc followed by smaller PD. Goller et al. (2020) also found that mismatched cues either elicited no N2pc or elicited PD. However, Harris et al. (2023) argued that the negative correlation between PD elicited by nontarget-matching cues and same-location cost was inconsistent with the feature-based attentional suppression account, favoring instead the object-file updating account and attempting to explain it as attentional suppression of nontarget-matching cue signals weakening these stimuli' s representation to facilitate updating. In fact, this explanation cannot negate the existence of suppression and even requires attentional suppression to explain possible object-file updating.

Furthermore, to investigate the location specificity of meaning-associated same-location cost, we examined how cue appearance at possible versus impossible target positions influences spatial attentional allocation. Results showed that semantically consistent cues captured attention equally under all conditions, while semantically inconsistent cues only produced same-location cost at possible target positions when they were semantically consistent with nontarget items; no significant cue effects appeared under other conditions. Combined with all experimental results, we propose that meaning-associated same-location cost results from attentional suppression of nontarget features and possible target positions. "Suppression of nontarget features" and "suppression of possible target positions" are two necessary conditions for same-location cost emergence; meaning-associated same-location cost occurs only when both nontarget feature meaning association and possible target position suppression are satisfied. The phenomenon will not appear if either condition is missing. Note that when cues appear at impossible target positions, there are no valid cue responses; when calculating cue effects, we always subtract valid cue reaction times at possible target positions, so the obtained cue effect is also an estimate. However, reaction times show that when nontarget-consistent cues appear at impossible target positions, invalid cue responses are delayed similarly to when same-location cost occurs. Therefore, we speculate that for cues semantically

inconsistent with the target but consistent with nontarget items, possible target positions remain in an inhibitory state until the cue appears at a possible target position, at which point location-specific same-location cost emerges while the other possible target position is released from inhibition. Research shows that distractor suppression increases with proximity between target and distractor, resulting in strongest suppression of distractors presented near the target and weakest selection of targets presented near distractors [**?**], partially explaining the location-specific characteristic of same-location cost [**?**]. For semantically consistent cues, no location-based differences were found in reaction times, suggesting that although both attentional selection and suppression are influenced by top-down attentional control settings, their spatial allocation differs, warranting further investigation. Of course, these inferences are based on current reaction time analyses; future research could more directly examine attentional modulation of cues at different locations using electrophysiological indices of attentional selection and suppression.

7.3 Summary and Outlook

This study is, to our knowledge, the first to discover the meaning-associated same-location cost phenomenon, proposing that it results from attentional suppression of nontarget features and possible target positions. Our findings support Lamy et al.' s (2004) feature suppression account and do not support Carmel and Lamy' s (2014) object-file updating account, nor rapid disengagement or signal suppression accounts. When participants search for a particular feature attribute, meaning concepts consistent with it become activated, allowing corresponding cues to attract attention and causing meaning-associated attentional capture. When participants hold an attentional control setting for suppressing a particular feature attribute, meaning concepts consistent with that attribute also become activated, causing corresponding cues to be suppressed and resulting in meaning-associated same-location cost. Whether searching for or suppressing a feature attribute, meaning concepts consistent with it can be activated and appropriately modulate spatial attentional allocation according to current task demands. This study' s results indicate that the influence of attribute concept semantic activation on spatial attention is conditional: this process only occurs when concepts are target-relevant or match current attentional control settings. Research shows that semantic activation effects are not automatic; semantic analysis of task-irrelevant stimuli is modulated by feature-specific attentional allocation, with only selectively attended stimulus information influencing subsequent task processing, where task settings play a crucial role [**?**, **?**, **?**]. Negative feature cue suppression effects are influenced by current task demands [**?**, **?**], and suppression effects under nonmatching conditions are positively correlated with attentional enhancement under matching conditions [**?**], all pointing to attentional factors as the source of same-location cost.

Feature-based attention can guide attentional suppression just as it guides attentional enhancement [**?**]. Additionally, research shows that consciousness has

different effects on feature-based attentional selection: conscious perception can modulate selective enhancement of visual features, while suppression of these features is largely independent of consciousness [?]. The interaction between consciousness and feature-based attentional selection could be a topic for future in-depth research.

Previous research shows that semantically associated attentional capture and perceptually associated attentional capture share similarities in capture form but differ in capture magnitude; perceptual representations and meaning concepts of target-associated items can activate bidirectionally, increasing attentional priority and guiding visuospatial attentional shifts [?]. The present study' s results show that same-location cost caused by items inconsistent with target features exhibits the same pattern: semantically associated attentional suppression and perceptually associated attentional suppression share similarities in suppression form but differ in suppression magnitude, specifically in that same-location cost can still occur at an abstract conceptual meaning level, though it requires stronger attentional suppression settings compared with perceptually associated same-location cost. It must be emphasized that cue-target semantic inconsistency is not a sufficient condition for meaning-associated same-location cost emergence; rather, cue-nontarget item semantic consistency is a necessary condition. Therefore, meaning-associated same-location cost emergence requires at least two conditions: (1) cue-nontarget item semantic consistency, and (2) sufficiently strong attentional control settings for suppressing nontarget features. When participants must suppress three nontarget features, meaning-associated same-location cost is insufficient to emerge [?], but when only a single nontarget feature must be suppressed, the attentional suppression setting is strong enough for meaning-associated same-location cost to emerge (this study). This study supports and extends the contingent attentional orienting hypothesis [?], demonstrating that attentional control settings can influence not only perceptually associated attentional orienting but also meaning-associated attentional orienting, causing not only attentional enhancement (capture) for contingently consistent items but also attentional suppression (same-location cost) for contingently inconsistent items, expanding its applicability to different dimensions and directions.

Item meaning, as a nonsalient high-level attribute, influences visuospatial attentional allocation [?]. Even without intentional attention, human perceptual and cognitive systems are highly sensitive to semantic inconsistency [?]. Research shows that semantic information, whether as a search target or competing distractor, immediately attracts attention, a process independent of low-level visual salience [?]. In real-world scenes, item semantic information plays a key role in guiding attention, with semantically relevant scene regions receiving more attention [?], and task-irrelevant scene semantic information can also involuntarily guide overt attention in scenes, with an effect significantly greater than image salience [?]. Of course, some research suggests that semantic inconsistency or violation of semantic relations does not automatically attract attention [?, ?]. This study found that semantic meaning associations between items can mod-

ulate current spatial attentional allocation: items matching target features or concepts attract attention, while items matching nontarget features or concepts are suppressed. Compared with perceptual-level spatial attentional modulation, meaning-level modulation has stricter conditions and more limited magnitude. Therefore, investigating the boundary conditions for meaning-level attentional modulation is a direction for future research. Additionally, researchers note that fully understanding how semantic information modulates real-world attention requires studying more than isolated vision; the real world provides semantic information across all sensory modalities, creating greater complexity. Thus, investigating crossmodal semantic guidance of attention is also essential [**?**].

8. Conclusion

1. The same-location cost phenomenon can occur at an abstract conceptual meaning level, contingent on current attentional control settings.
2. Compared with perceptually associated same-location cost, meaning-associated same-location cost requires stronger attentional suppression settings.
3. Meaning-associated same-location cost originates from suppression of nontarget features but is limited to possible target positions.

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Note: Figure translations are in progress. See original paper for figures.