Received: 22 July 2022 | Revised: 12 May 2023 | Accepted: 16 May 2023
DOI: 10.1002/acp.4088

RESEARCH ARTICLE

WILEY

Memory, metamemory, and false memory for features of the Apple logo

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Abstract

Our memory for common, easily recognizable logos, like the Apple logo, is surprisingly poor because of attentional saturation, where we stop attending to details of frequently encountered objects. This lack of attention to details may leave us susceptible to misinformation effects. Across four experiments, we tested recognition memory for the Apple logo after incidentally encoding an accurate or altered version of the logo (Experiments 1–3), or after no incidental encounter of the logo prior to the surprise test (Experiment 4). Additionally, participants rated how much they liked the logo as a measure of processing fluency. Results demonstrated that incidentally viewing an altered version of the Apple logo can disrupt subsequent recognition of the correct logo, but this effect may diminish following a short delay. Considering our frequent exposure to everyday stimuli, we show conditions in which memory for a ubiquitous stimulus can be disrupted when incidentally presented with inaccurate information.

KEYWORDS
attentional saturation, marketing, metamemory, misinformation, recognition, visual memory

1 | INTRODUCTION

We are constantly bombarded with advertisements, brand logos, and product information across a variety of contexts, from billboards and advertisements along our daily commute to logos inscribed on our most essential objects, like cars, smartphones, and computers. The Apple logo is a simple, ubiquitous logo that is often considered among the most recognizable in the world (Blake et al., 2015; Farnham, 2013). Despite our high exposure to this stimulus, both recall and recognition memory are generally poor for the Apple logo, although confidence in memory is high (Blake et al., 2015; Iancu & Iancu, 2017). Similar results have emerged when examining memory for other common objects, such as the features of a penny (Nickerson & Adams, 1979), the spatial layout of a keyboard (Snyder et al., 2014), the features of familiar flags (Blake & Castel, 2019), the images on the cover of frequently-used textbooks (Hargis et al., 2018), the shape of specific letters in text (Wong et al., 2018), the spatial layout of elevator buttons (Vendetti et al., 2013), and even the location of bright red fire extinguishers in a hallway where one has worked for over 40 years (Castel et al., 2012).

Given that we are repeatedly exposed to these everyday stimuli, and that a typical human's storage capacity for detailed information in visual long-term memory is massive (Brady et al., 2008), it is unclear if and how this ubiquitous information is retained in our memory (cf. Misra et al., 2018) and whether aspects of memory for these everyday items can be altered by exposure to inaccurate information.

Portions of this work were presented at the Psychonomic Society's 60th Annual Meeting in Montréal, Quebec, Canada on November 15, 2019.

1.1 | Schematic support in memory for the apple logo

Blake et al. (2015) asked participants to rate their confidence in their ability to draw the ubiquitous Apple logo from memory, and then instructed participants to draw it to the best of their ability. Participants in this study were scored based on accuracy in each aspect of the logo (i.e., leaf direction, bite present, bite on correct side, etc.). Surprisingly, only one out of 85 participants received a perfect score, and average performance was around 40% accuracy. Further, when given a forced choice recognition test by asking participants to select the canonical (or correct) logo from eight options (i.e., seven modified similar lures), less than half of participants could identify the canonical logo, suggesting that participants may lack a strong, detailed representation for the Apple logo in visual memory.

When drawing the logo from memory, many participants also incorrectly incorporated schema-consistent details of an actual apple (i.e., stem, teeth marks) to their drawings, suggesting a potential reliance on a more gist-like compared to a more detailed, recollective representation of the logo (Blake et al., 2015; Iancu & Iancu, 2017). This reduction in detailed memory may occur as a consequence of overexposure to certain stimuli, leading to a form of attentional saturation (Castel et al., 2015). Hence, we may stop attending to the details of a highly prevalent stimulus—like the Apple logo—unless they suddenly become relevant, and we are required to effectively use the stimulus' details for achieving a particular goal. This reliance on more gist-based and semantic representations for everyday objects may also influence our confidence, making us believe that we have a strong representation of the stimulus stored in memory despite poor performance when probed to recognize or recollect it in a task (Brewer & Sampaio, 2006; Murphy & Castel, 2021; Prasad & Bainbridge, 2022). Thus, our memory for everyday visual information may be susceptible to interference from schema-consistent information.

1.2 | Incidental memory

Logos are generally designed with salient esthetic properties to capture our attention, making them quickly recognizable and easily associated with the products they represent. However, rich, detailed episodic representations of logos are not often aligned with the average consumer's goals. When encountering logos in everyday life, we typically only need to pay enough attention to recognize them in conjunction with relevant associative information and not necessarily richly encode the visual details for a later reproduction of the logo with high accuracy. Memory for stimuli is instead often better when individuals know explicitly a priori that they will later be tested on the details of that stimulus (Block, 2009). Furthermore, when given only a brief opportunity to study a stimulus, effortful study can result in better memory performance compared to an incidental encounter (Block, 2009; Marmie & Healy, 2004). Thus, incidental encoding of an object is likely to lead to poorer detailed memory for that object, which may reflect a more naturalistic account of individuals' everyday interactions with ubiquitous iconography.

1.3 | Misinformation effects

Presenting an inaccurate version of a common visual object, like the Apple logo, can be considered a misinformation effect, which occurs when inaccurate or misleading information (often presented subsequently to an initial encoding event) changes memory for the event itself (for a review, see Loftus, 2005). In a seminal study on misinformation effects, Loftus and Palmer (1974) had participants view a video of a car crash, and then asked how fast the cars were going when they "smashed" into each other (misleading information) or "contacted" each other (neutral information). The researchers found that estimates of speed were greater when participants heard "smashed" over "contacted"; 1 week later, participants who initially heard "smashed" were more likely to report broken glass even though there was no broken glass in the video they had previously watched (Loftus & Palmer, 1974). Misinformation effects have since been studied using a variety of materials and types of memory, including fictional stories (Fazio et al., 2015), music (Anglada-Tort et al., 2019), and visual scenes (Porter et al., 2010). These findings have highlighted the malleability of memory and suggest that, although we may have seen a stimulus hundreds of times, our memory is susceptible to modification when memory reactivation co-occurs with the presentation of inaccurate information.

Misinformation effects have also largely been studied when learning new information. However, it is unclear how the presentation of misinformation may influence memory for frequently encountered, everyday objects. On one hand, because we may have seen the objects many times and may have a strong accumulation of stored representations, misinformation may not affect our representation of everyday objects as much as would be expected for newly learned information. On the other hand, it is possible that, if memory for specific visual details is fairly weak for these objects, and our representation is more schema-based, then such a memory representation may be more susceptible to misinformation effects when a key visual detail of the object is manipulated.

1.4 | Likeability of logos

In the present research, we collected measures of how much participants liked the Apple logo. When presenting an inaccurate form of a well-established image, there may be a reduction in how much people like the logo. One explanation for this potential reduction in logo likeability is a reduction in perceptual fluency, which is the subjective ease with which information is processed (see Jacoby et al., 1989). Prior work has shown that stimuli which feel less fluent are rated as less esthetically pleasing (Reber et al., 2004). When fluency is manipulated (e.g., by degrading an image or priming the stimulus), participants rate more fluent stimuli as more esthetically pleasing (Claypool et al., 2015; Reber et al., 1998), and this effect is particularly salient when participants subjectively view the stimulus as more fluent (Blake & Castel, 2019; Forster et al., 2013). Processing fluency can also influence judgments of objects or attitudes toward brands (Bornstein & D'Agostino, 1994), such that increased fluency can lead to more positive attitudes about a brand that feels more fluent (Lee & Labroo, 2004), and thus an increased preference for a specific brand (Ferraro et al., 2009).

Repeated exposure to stimuli increases their perceptual fluency (Janiszewski & Meyvis, 2001; Shapiro & Nielsen, 2013), and seeing the same stimulus multiple times can increase likeability for that stimulus, even if it was initially neutral (Bornstein, 1989). This effect of increased fluency with repetition may be particularly prominent when participants are not deeply processing the details of the stimulus (Nordhielm, 2002), as is often the case when incidentally viewing a brand logo. Because we encounter the Apple logo regularly in the world, through our own technology and advertisements, we likely have high perceptual fluency for the logo. Thus, there is a possibility that, while participants may not notice subtle changes to the details of the Apple logo, the logo may feel less fluent when it is altered. Here, we measured fluency via a likeability rating for the Apple logo when it was presented in its normal and altered forms. Although this is not a direct measure of processing fluency, fluency is one potential explanatory factor for a change in logo likeability ratings.

1.5 | The current research

Despite massive visual long-term memory capacity and generally high familiarity and memory confidence for everyday iconography, recognition memory for everyday objects is subject to errors (Brady et al., 2008; Misra et al., 2018; Prasad & Bainbridge, 2022). In a study of the ubiquitous Apple logo, we sought to investigate the propensity for individuals to correctly recognize the canonical version of the Apple logo amongst other competing lures (i.e., manipulated Apple logos), and whether being shown the canonical version or a lure with one feature flipped (i.e., the bite appearing on the wrong side of the apple) prior to the surprise forced choice recognition task influenced subsequent recognition memory performance.

In Experiments 1–3, participants viewed the Apple logo incidentally in either its usual form (hereafter, *canonical*), or a version with the bite facing the opposite direction (hereafter, *flipped*), and rated how much they liked it. In Experiment 4, there was a third condition in which participants did not view nor rate the Apple logo (hereafter, *absent*). Then, participants completed an eight-alternative forced choice (8-AFC) recognition memory test in which they were tasked with selecting the canonical Apple logo out of eight possible options, either immediately (Experiments 1, 2, and 4) or following a 5-min delay (Experiment 3).

We hypothesized that participants in the flipped condition would show significantly lower recognition accuracy for the Apple logo and would be more likely to select the lure they had seen from the available choices (Blake et al., 2015; Iancu & Iancu, 2017). In addition, we hypothesized that participants would report high confidence for their recognition memory regardless of their actual performance. Finally, we expected participants in the canonical and absent conditions to report higher likeability ratings for the Apple logo than those in the flipped condition, as perceptual fluency may be disrupted by changing a salient perceptual feature of the logo and participants should be less familiar with the altered version of the logo than the canonical version.

2 | EXPERIMENT 1

In Experiment 1, we examined whether incidentally viewing the Apple logo for a brief period of time in an altered form would later influence recognition memory for the Apple logo. Participants incidentally viewed either the canonical or an altered version of the Apple logo (i.e., with the bite direction flipped) and were then asked to select the canonical logo from a set of alternatives, from which recognition memory accuracy was assessed, to determine if viewing the altered logo influenced later recognition memory.

2.1 | Method

2.1.1 | Participants

One hundred fifteen undergraduates at the University of California, Los Angeles (UCLA) participated for course credit ($M_{age} = 20.86$ years, $SD_{age} = 1.78$, 88 females), with 60 participants in the canonical condition and 55 in the flipped condition (i.e., bite on the left instead of the right side of the logo). This task was completed as part of another, unrelated task battery, and thus, there was no a priori sampling plan. Nonetheless, a post-hoc sensitivity analysis using G*Power (Faul et al., 2007) showed that with our total sample size of 115, α value of .05, and power of 80%, we could detect a medium effect size, φ, of 0.26 (Cohen, 1988).

2.1.2 | Stimuli

The same Apple logo stimuli from Blake et al. (2015) were used (see Figure 1). Participants first saw one of two versions of the Apple logo: canonical (i.e., unaltered) or flipped (i.e., bite on the left side instead of the right; see Figure 1a). The experiment was administered on a computer after participants completed an unrelated task, and the logo was presented in the center of the computer screen on a blank, white background.

2.1.3 | Procedure

All procedures were approved by the UCLA Institutional Review Board and were conducted in a controlled laboratory environment, where logos on computers or other devices were covered and taped

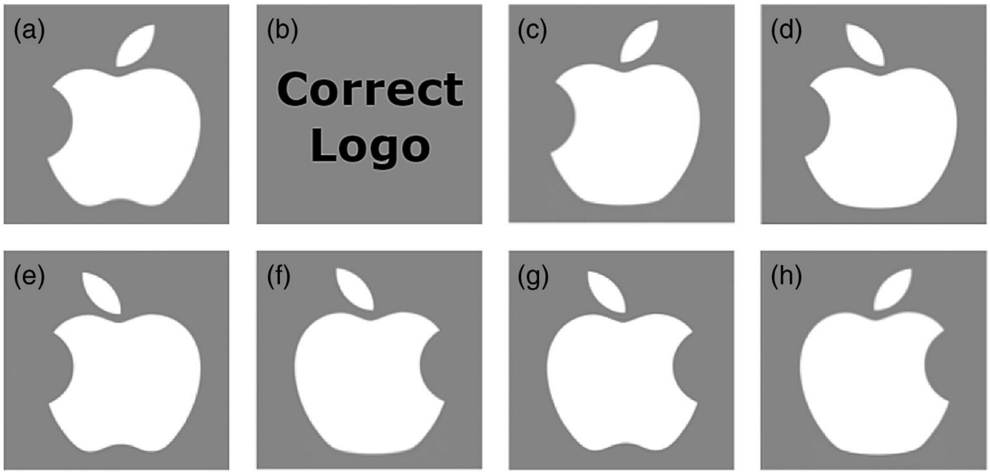

FIGURE 1 Recognition Memory Test Stimuli. This figure shows the eight response options presented as the recognition memory test choices. *Choice B* shows the correct (i.e., canonical) logo (masked for copyright reasons), and *choice A* shows the lure (i.e., the flipped logo).

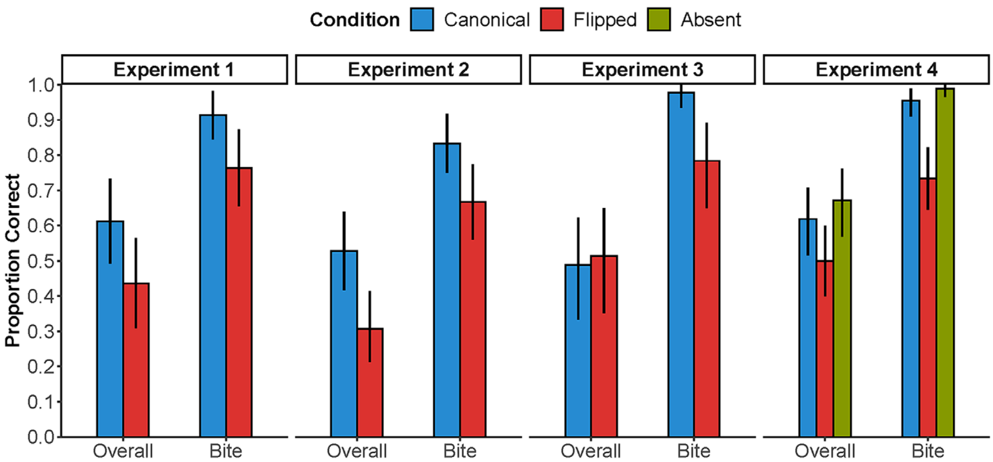

FIGURE 2 Recognition accuracy in Experiments 1, 2, 3, and 4. The proportion of participants who correctly selected the canonical Apple logo in the 8-AFC task (left) and correct bite feature (right) is shown for participants in the canonical condition and flipped condition (i.e., where only the bite of the apple was flipped to the wrong side), as well as an additional absent condition in Experiment 4 where no Apple logo was viewed or rated prior to the recognition memory test. Error bars represent the nonparametric bootstrapped 95% confidence interval of the mean (1000 iterations).

with sticky notes. After providing written informed consent, participants were first shown either the correct or incorrect version of the Apple logo on the screen for 6 s and were asked to rate how frequently they find themselves using Apple products on a Likert scale from 1 (*never*) to 7 (*every time*). These ratings are presented in Table 2. The purpose of this question was to distract participants from the primary memory manipulation of the experiment. Next, participants rated how much they like Apple products from 1 (*strongly dislike*) to 7 (*strongly like*). These ratings were self-paced. Then, participants were asked to count backward from 298 by 3's for 25 s. Following the distractor phase, participants were shown eight versions of the Apple logo (Figure 1), each with varying feature manipulations and asked to select which was the correct logo. Specifically, the logos had three features that could be altered: the direction of the leaf, the direction of the bite, and the presence/absence of a dip in the bottom. There were three versions of the 8-AFC test, each having the logos arranged in different positions in the matrix, and the version used for a given participant was counterbalanced across the flipped/canonical conditions.

2.2 | Results

All data and analysis files for all experiments can be found on the Open Science Framework (https://osf.io/bu5xa/https://osf.io/bu5xa/).

2.2.1 | Accuracy

The average overall recognition accuracy for the canonical Apple logo, as well as the accuracy of selecting a logo with the bite on the correct side in each condition, is shown in Figure 2. First, we compared the proportion of participants who selected the correct Apple logo in each condition. Overall, average accuracy was 53%, which was slightly higher than was found in previous research (e.g., Blake et al., 2015). This was expected, as participants in this experiment were shown the logo briefly before the 8-AFC recognition memory test. To examine differences in accuracy across conditions, we conducted a Chi Square test of independence. We report proportions (*Prop*) and standard deviations (*SD*) throughout. The results revealed that participants who saw

TABLE 1 Proportion of participants that selected each feature of the Apple logo across all Experiments.

	Accuracy		Critical lure		Bite direction		Leaf direction		Bottom feature	
	C	F	C	F	C	F	C	F	C	F
Exp 1	.62	.44	.05	.13	.92	.76	.75	.69	.78	.73
Exp 2	.53	.31	.04	.07	.83	.67	.65	.59	.88	.77
Exp 3	.49	.51	.00	.05	.98	.78	.60	.65	.82	.84

	Accuracy			Critical lure			Bite direction			Leaf direction			Bottom feature		
	A	C	F	A	C	F	A	C	F	A	C	F	A	C	F
Exp 4	.67	.62	.50	.00	.04	.21	.99	.96	.73	.72	.76	.77	.93	.84	.91

Note: "C" indicates the canonical condition, "F" indicates the flipped condition, and "A" indicates the absent condition.

the correct logo were marginally more accurate at selecting the correct logo (*Prop* = .62, *SD* = .49) than those who saw the incorrect logo (*Prop* = .44, *SD* = .50), $X^2(1, N = 115) = 3.75$, $p = .053$, $\varphi = 0.18$, albeit a weak effect. We also examined the proportion of those who chose the critical lure (i.e., the logo that participants in the flipped condition had seen and rated). The proportion of participants who chose the critical lure was not significantly different between the canonical condition (*Prop* = .05, *SD* = .22) and the flipped condition (*Prop* = .13, *SD* = .34), $X^2(1, N = 115) = 2.16$, $p = .14$, $\varphi = .14$.

To assess whether participants were more likely to choose incorrect logos with certain features, we conducted additional chi-square tests with proportion of selecting specific features of the logo as the dependent variables. The analyses first revealed that there was a significant difference between the canonical (*Prop* = .92, *SD* = .28) and flipped (*Prop* = .76, *SD* = .43) conditions in choosing a logo with the bite on the correct side, $X^2(1, N = 115) = 5.09$, $p = .02$, $\varphi = 0.21$ (see Figure 2, Panel 1). However, there was no difference between the two conditions in choosing the correct dip in the bottom, $X^2(1, N = 115) = 0.49$, $p = .49$, $\varphi = 0.07$, nor in choosing the correct direction of the leaf, $X^2(1, N = 115) = 0.50$, $p = .48$, $\varphi = 0.07$. Proportions of participants who correctly selected a logo with each feature are presented in Table 1.

2.2.2 | Ratings of Apple products

To examine whether those who saw the incorrect logo rated Apple products differently from those who saw the correct logo, we conducted an independent-samples *t*-test. The test revealed no significant differences in the rating of Apple products for those who saw the correct logo ($M = 6.10$, $SD = 1.30$) compared to those who saw the incorrect logo ($M = 5.80$, $SD = 1.31$), $t(113) = 1.23$, $p = .22$, $d = 0.23$.

2.3 | Discussion

In Experiment 1, we found a difference in the likelihood of selecting the correct logo, such that participants who incidentally viewed the incorrect Apple logo were less accurate in later identifying the correct logo from a set of alternative choices. Specifically, although participants in the flipped condition were not more likely to choose the critical lure (i.e., the option they had seen previously), they were more likely to choose a logo with the bite on the wrong side, which suggests viewing the incorrect logo did influence their memory for the logo itself. In Experiment 2, we sought to replicate the findings regarding accuracy that were found in Experiment 1 using an incidental paradigm with a richer cover task, as well as to assess potential differences in processing fluency indirectly via measures of likeability.

3 | EXPERIMENT 2

In Experiment 2, participants rated how much they liked four common logos (of which, one was the Apple logo) and then completed the same 8-AFC recognition memory test on the Apple logo, allowing for a more incidental examination of how visual misinformation of the Apple logo could influence later recognition memory and perceptual fluency (i.e., likability ratings) of it.

3.1 | Method

3.1.1 | Participants

Participants were 147 undergraduate students at UCLA who participated for partial fulfillment of a course requirement ($M_{age} = 20.74$ years, $SD_{age} = 2.57$, 111 females), with 72 in the canonical condition and 75 in the flipped condition. A total of 28 participants in the flipped condition reported noticing that the Apple logo was flipped or the bite was on the wrong side.[1] Again, these data did not follow an a priori sampling plan. A post-hoc sensitivity analysis showed that with an α value of .05 and power of 80%, we could detect a small-to-medium effect size (φ) of 0.23.

3.1.2 | Stimuli

Participants viewed four common logos during the experiment: Apple, Dell, Burger King, and In-N-Out. These logos were chosen to control

TABLE 2 Descriptives of Apple product use in Experiments 1, 2, and 3.

Condition	Frequency of Using Apple Products			Proportion of Users					
	Exp 1 (1–7)	Exp 2 (0–3)	Exp 3 (1–7)	Exp 2			Exp 3		
				Apple	PC	Mixed	Apple	PC	Mixed
Canonical	5.68 (1.99)	2.49 (0.90)	6.29 (1.36)	70.83%	12.50%	16.67%	71.11%	13.33%	15.56%
Flipped	5.55 (1.79)	2.45 (0.89)	5.54 (1.79)	64.00%	9.33%	26.67%	51.35%	29.73%	18.92%

Note: The left panel shows the mean (and SD) of frequency of using Apple products for Experiments 1, 2, and 3, split by each condition. Parentheses represent the rating scale for each experiment: Experiment 1 used a 1 to 7 scale, Experiment 2 used a 0 to 3 scale, and Experiment 3 used a 1 to 7 scale. The right panel shows the percentage of participants who identified as an Apple user, PC user, or mixed user in Experiments 2 and 3 (this was not assessed in Experiment 1).

for prevalence (i.e., In-N-Out in southern California) and type of brand (i.e., technology, restaurants). The canonical logos were scraped from the websites of the respective brands and were presented to participants in the middle of a blank computer screen with a white background. Importantly, only the Apple logo was manipulated to be either canonical or altered (i.e., bite on the wrong side). The purpose of adding these additional logos was twofold. First, showing only the Apple logo may have clued in participants that the experiment was testing something about that specific logo, leading them to allocate more attention to the logo than they typically would in an incidental encounter. Second, adding more logos to rate on likeability allowed us to ensure the groups did not just differ randomly in preferences for logos, by comparing likeability for all logos between those who saw the flipped versus canonical Apple logo. The experiment was administered via Microsoft PowerPoint, and participants recorded their responses on a paper questionnaire. As in Experiment 1, all logos on computers were masked with taped sticky notes.

3.1.3 | Procedure

Participants were instructed that they would be viewing logos and rating how much they liked them. Participants were not informed that there would be a memory test, nor that the experiment had anything to do with the Apple logo. First, participants viewed each logo for 10 s, and then the logo disappeared while participants rated how much they liked each logo on a scale of 0 (*Not at All*) to 10 (*Very Much*). The order in which the logos were presented was counterbalanced across participants. Following the rating phase, participants completed the same 8-AFC recognition memory test as in Experiment 1, where they were asked to indicate which of the eight choices was the correct Apple logo. Then, participants rated how confident they were that their answer was correct on a scale of 0 (*Not at All*) to 10 (*Extremely Confident*).

Following the rating phase and memory assessment, participants were asked to rate how often they use Apple products on a scale of 0 (*Never*) to 3 (*All the Time*), how much they like Apple products on a scale of 0 (*Not at All*) to 4 (*A Lot*), and whether they consider themselves to primarily be an Apple user, PC user, or both. These proportions are presented in Table 2. Finally, participants reported if they noticed anything unusual about the initial logos (and if so, to explain), and whether they had heard of the Apple logo experiment or any related experiments before (e.g., as part of a class) to assess level of naïveté.

3.2 | Results

3.2.1 | Accuracy

The proportion of participants who selected the correct logo, as well as those who selected a logo with the bite in the correct location, in each condition are shown in Figure 2. To analyze group differences in recognition accuracy for the Apple logo, we conducted a chi square test of independence. The results revealed that participants in the canonical condition ($Prop = .53$, $SD = .50$) were significantly more accurate than those in the flipped condition ($Prop = .31$, $SD = .46$), $X^2(1, N = 147) = 7.34$, $p = .007$, $\varphi = 0.22$. To assess whether participants in the flipped condition were also more likely to choose the lure (i.e., the logo that matched the previous logo they had seen), we conducted another Chi Square test with the dependent variable being the proportion who selected the lure. This test revealed no group differences in likelihood of choosing the lure, $X^2(1, N = 147) = 0.45$, $p = .50$, $\varphi = 0.06$. Thus, while viewing the flipped logo disrupted memory accuracy for the Apple logo, it did not make participants more likely to choose the logo they had previously encountered.

We also conducted the same tests as in Experiment 1, looking at differences across conditions in the likelihood of selecting logos with specific features. First, the results revealed that participants in the canonical condition were more likely to select the correct bite direction ($Prop = .83$, $SD = .38$) than those in the flipped condition ($Prop = .67$, $SD = .48$), $X^2(1, N = 147) = 5.42$, $p = .02$, $\varphi = 0.19$. However, there were no group differences in likelihood to choose the correct dip in the bottom, $X^2(1, N = 147) = 2.61$, $p = .11$, $\varphi = 0.13$, nor the correct leaf direction, $X^2(1, N = 147) = 0.68$, $p = .41$, $\varphi = 0.07$. The proportions of participants who selected a logo with each feature are shown in Table 1.

3.2.2 | Confidence

We examined group differences in confidence ratings by conducting an independent-samples *t*-test. Although there were group differences in memory performance, participants in the flipped condition

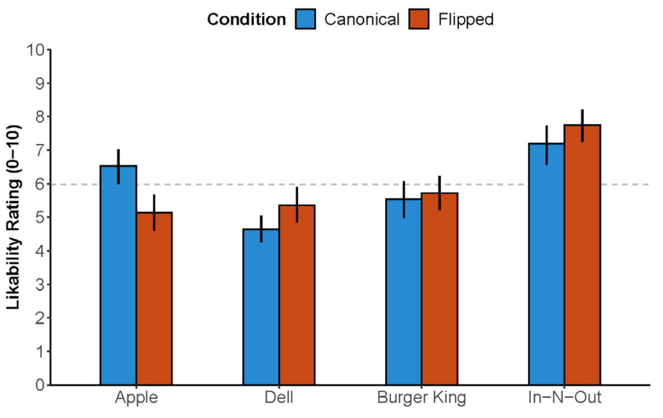

FIGURE 3 Likability ratings of logos in Experiment 2. Here, the average likability rating, on a scale from 0 (*not at all*) to 10 (*very much*), for each logo is shown for participants in both the canonical and flipped conditions. The dashed line represents the grand mean of all logo ratings across conditions. Error bars represent the nonparametric bootstrapped 95% confidence interval of the mean (1000 iterations).

were not less confident in their memory accuracy than those in the canonical condition ($M_{\text{canonical}} = 7.37$, $SD_{\text{canonical}} = 2.13$; $M_{\text{flipped}} = 7.25$, $SD_{\text{flipped}} = 2.13$), $t(144) = 0.32$, $p = .75$, $d = 0.05$.

3.2.3 | Logo ratings

Figure 3 shows the average rating of each logo in the canonical and the flipped conditions. To assess group differences in ratings across the four logos, we performed a 2 (Condition: *canonical*, *flipped*) × 4 (Logo: *Apple*, *Dell*, *In-N-Out*, *Burger King*) mixed analysis of variance (ANOVA). Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for the logo variable, so all results reported include Greenhouse–Geisser corrections where applicable. The ANOVA revealed a significant main effect of logo, $F(2.70, 389) = 32.77$, $p < .001$, $\eta_p^2 = .185$, but no significant main effect of condition, $F(1, 144) < .001$, $p = .99$, $\eta_p^2 < .001$. Follow-up *t*-tests using Bonferroni corrections revealed that In-N-Out ($M = 7.50$, $SD = 2.38$) was rated significantly higher than all other logos ($M_{\text{Burger King}} = 5.62$, $SD_{\text{Burger King}} = 2.35$; $M_{\text{Dell}} = 5.00$, $SD_{\text{Dell}} = 2.11$; $M_{\text{Apple}} = 5.83$, $SD_{\text{Apple}} = 2.39$; all *p*s < .001), and the Apple logo was rated significantly higher than the Dell logo, $t(144) = 3.33$, $p = .007$, $d = 0.25$. Of most interest, there was a significant interaction between logo and condition, $F(2.70, 389) = 6.61$, $p = < .001$, $\eta_p^2 = .04$. Using Bonferroni corrections, follow-up *t*-tests showed that participants in the canonical condition rated the Apple logo significantly higher ($M = 6.54$, $SD = 3.43$) than those in the flipped condition ($M = 5.13$, $SD = 3.33$), $t(144) = 3.55$, $p = .02$, $d = 0.58$, but there were no significant differences between the conditions in ratings for the other logos (*p*s > .99).

One possibility for why participants in the flipped condition gave lower likeability ratings for the Apple logo than those in the canonical condition is that they noticed something was "off" about the logo. Although we did not ask participants to explain why they rated the Apple logo as they did, we did ask whether they recalled anything unusual about the logos they rated at the end of the task, which allowed us to assess whether those who reported noticing that the logo was wrong rated the logo lower than those who did not notice, using an independent-samples *t*-test. Additionally, we limited this test to only participants in the flipped condition, as participants in the canonical condition could not have noticed the logo being flipped, and therefore, condition would be confounded with noticing the altered logo. The *t*-test revealed a marginally significant effect of noticing the logo change, $t(73) = 1.75$, $p = .085$, $d = 0.42$, wherein those who noticed the change rated the logo lower in likeability ($M = 4.50$, $SD = 2.32$) than those who did not ($M = 5.51$, $SD = 2.48$). It is important to note that this analysis is exploratory in nature, and because we are limiting the analysis to only those in the flipped condition, the sample size is much smaller ($n = 75$). Additionally, there were unequal group sizes, with only 28 participants reporting noticing the flip, with 47 who reported not noticing. Thus, this large difference in group size can bias the results of the analysis and make it more difficult to interpret these findings, in addition to likely being underpowered to detect significant effects. Lastly, we did not have a reliable measure of whether participants correctly noticed something being "off" about the logo, so it is possible that participants could have misunderstood the question. Taken together, this finding should be viewed as an interesting avenue for future work to explore.

As a comparison to Experiment 1 regarding participants' ratings of how much they like *Apple products*, we also conducted an independent-samples *t*-test on ratings of Apple products (made on a 0 to 4 scale). The results showed that there was no significant difference in ratings of liking Apple products between participants in the canonical condition ($M = 3.22$, $SD = 0.91$) and participants in the flipped condition ($M = 3.25$, $SD = 0.90$), $t(145) = 0.21$, $p = .84$, $d = 0.03$. Thus, the flipped logo seemed to have influenced participants' ratings of the logo, but not their overall ratings of Apple products in general, consistent with the results from Experiment 1.

3.3 | Discussion

In Experiment 2, we extended the finding that viewing an altered version of the Apple logo prior to a recognition memory test for the correct logo impaired memory for the correct logo when presented amongst additional logos, which reduced the potential that participants may have guessed the purpose of the study. Additionally, we found a significant reduction in likeability ratings for the Apple logo while viewing the incorrect, flipped version. Thus, there appears to be some awareness of a change in the logo, possibly influencing processing fluency over and above poorer detailed representations of the correct Apple logo in memory. However, we found that participants in the flipped condition who reported noticing the Apple logo being incorrect liked the logo less than those who did not notice – although this was only marginally significant – suggesting there could be a conscious process influencing likeability ratings.

4 | EXPERIMENT 3

In Experiments 1 and 2, we found a misinformation effect on an immediate recognition memory test for the Apple logo within participants who incidentally encoded an inaccurate version of the Apple logo for only a few seconds. While these findings showcase a particular example of misinformation effects for a ubiquitous, incidentally encoded everyday stimulus, we further investigated the fidelity of these effects after a delay period. Following a brief delay, participants may be less influenced by their recent exposure to the incorrect logo and thus revert to their original representations of the logo (much like a "return to primacy effect" that is shown in various memory tasks following a delay, see Bjork, 2001). In Experiment 3, we examined whether this misinformation effect would persist following a brief delay.

4.1 | Method

4.1.1 | Participants

Participants were 82 (M_{age} = 21.24 years, SD_{age} = 4.68, 68 females) UCLA undergraduate students who participated for partial fulfillment of a course requirement, with 45 participants in the canonical condition and 37 in the flipped condition. Twenty-two participants in the flipped condition reported noticing the Apple logo was flipped.[2] As with the previous two experiments, there was no a priori sampling plan. A post-hoc sensitivity analysis revealed that with an alpha value of .05 and power of 80%, we could detect a medium effect size, φ, of .31.

4.1.2 | Materials

The logos were the same as those used in Experiment 2, with the addition of two new logos. Because the Apple logo was visually less complex than, and did not include text like, some of the other logos, two additional simple (and similarly prominent) logos were added to the ratings phase to help control for these factors: Nike and Starbucks. The Nike logo, in particular, is a simple shape, with a solid fill color and no text, and is likely as well-known as the Apple logo. The Starbucks logo similarly features one primary color, and likely yields greater familiarity than Dell, for example.

4.1.3 | Procedure

The procedure was identical to that of Experiment 2, except that after rating all logos, participants underwent a 5-min delay period during which they played Tetris. If participants lost the game during the five-minute period, they were instructed to start a new game. When the 5 min had passed, the Tetris game automatically disappeared from the screen and participants completed the same recognition task as in Experiments 1 and 2, followed by the same questions regarding frequency of use, type of user, and questions to determine knowledge of the experiment. Additionally, the rating scales were the same as those used in Experiment 1. Specifically, logo ratings were made on a 1 (*do not like at all*) to 10 (*like very much*) scale, frequency of use was rated on a 1 (*never*) to 7 (*every time*) scale, and ratings of Apple products were on a 1 (*strongly dislike*) to 7 (*strongly like*) scale.

4.2 | Results

4.2.1 | Accuracy

Figure 2 shows the proportion of participants in each condition who correctly selected the logo from the alternative choices, as well as the proportion who selected a logo with the bite on the correct side. To examine group differences in recognition accuracy, we conducted a Chi Square test of independence on recognition accuracy. The results revealed that, after the five-minute delay, participants in the canonical condition (*Prop* = .49, *SD* = .51) were not significantly more accurate than those in the flipped condition (*Prop* = .51, *SD* = .51), $X^2(1, N = 82) = 0.05$, $p = .82$, $\varphi = 0.03$. In addition, there was no significant difference between conditions in the likelihood of choosing the lure, $X^2(1, N = 82) = 2.49$, $p = .11$, $\varphi = 0.17$, nor in choosing either the correct dip at the bottom of the apple, $X^2(1, N = 82) = 0.04$, $p = .85$, $\varphi = 0.02$, or the correct leaf direction, $X^2(1, N = 82) = 0.20$, $p = .65$, $\varphi = 0.05$. However, participants in the canonical condition (*Prop* = .98, *SD* = .15) did select the correct bite direction significantly more often than those in the flipped condition (*Prop* = .78, *SD* = .42), $X^2(1, N = 82) = 7.82$, $p = .005$, $\varphi = 0.31$. All proportions for each feature are shown in Table 1. Thus, following a brief delay, viewing the incorrect logo did not disrupt overall recognition performance, but did bias memory toward the specific feature that was presented.

4.2.2 | Logo ratings

The average rating of each logo in both conditions is presented in Figure 4. To examine whether there were any overall differences in logo ratings, and whether these differed between conditions, we conducted a 6 (Logo) × 2 (Condition: *canonical*, *flipped*) mixed ANOVA. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for the logo variable, so all statistics reported include Greenhouse–Geisser corrections, where applicable. The main effect of logo was significant, $F(4.50, 361) = 38.89$, $p < .001$, $\eta_p^2 = .33$, as was the main effect of condition, $F(1, 80) = 5.16$, $p = .03$, $\eta_p^2 = .06$, such that participants in the canonical condition rated the logos higher on average ($M = 6.85$, $SD = 1.41$) than did those in the flipped condition ($M = 6.32$, $SD = 1.56$). Critically, the interaction between logo and condition was significant, $F(4.50, 361) = 8.51$, $p < .001$, $\eta_p^2 = .10$. Follow-up pairwise comparisons using Bonferroni corrections revealed that participants in the canonical

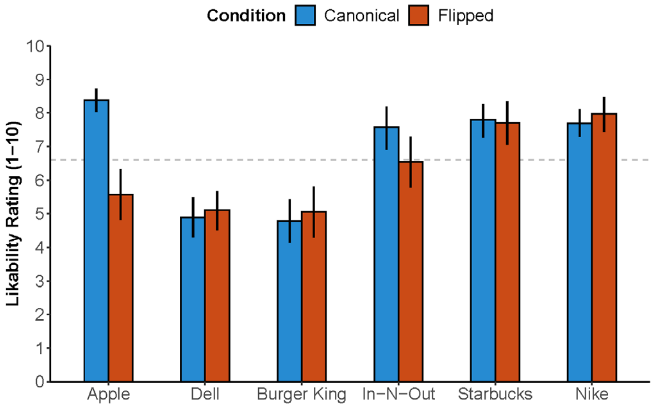

FIGURE 4 Likability Ratings of Logos in Experiment 3. Here, the average likability rating, on a scale from 1 (*not at all*) to 10 (*very much*), for each logo is shown for participants in both the canonical condition and the flipped condition. The dashed line represents the grand mean of all logo ratings across conditions. Error bars represent the nonparametric bootstrapped 95% confidence interval of the mean (1000 iterations).

condition rated the Apple logo ($M = 8.38$, $SD = 2.65$) significantly higher than did participants in the flipped condition ($M = 5.57$, $SD = 2.92$), $t(80) = 6.44$, $p < .001$, $d = 1.43$ consistent with results from Experiment 2. Ratings of the other logos did not significantly differ between conditions (all Bonferroni corrected *ps* > .99).

To explore whether ratings differed based on whether participants noticed the change to the Apple logo or not, we conducted an independent-samples *t*-test on ratings of the Apple logo to compare those who noticed the change and those who did not, only within those in the flipped condition (as no one in the canonical condition could have noticed the flip, and thus condition would be confounded with noticing the change). The test revealed no significant effect of participants noticing the change, $t(35) = 0.32$, $p = .75$, $d = 0.11$, although, again, the sample size was greatly reduced for this test ($n = 37$). However, unlike in Experiment 2, we manually coded participants' open-ended responses to the question of whether they noticed something about the logo t. Therefore, responses should be based on *accurately* noticing the change to the logo, rather than just reporting that they noticed something. We also examined overall ratings of liking Apple products between conditions using an independent-samples *t*-test and found that there was no significant difference between participants in the canonical condition ($M = 6.13$, $SD = 0.94$) and those in the flipped condition ($M = 5.73$, $SD = 1.22$) on ratings of Apple products, $t(67) = 1.65$, $p = .10$, $d = 0.37$. Thus, likeability ratings of the logo were reduced for those who saw the incorrect logo, while overall ratings of Apple products were not.

4.3 | Discussion

In Experiment 3, with the introduction of a 5-min delay period, we did not find the same misinformation effect on recognition memory of the Apple logo as revealed in Experiments 1 and 2. However, participants who saw the incorrect logo were still more likely to select a logo with the bite on the wrong side than those in the canonical condition, suggesting that memory was biased toward this feature, and that this biased memory for certain features can persist following a brief delay. Additionally, we replicated the finding from Experiment 2 that participants who saw the incorrect Apple logo reported that they liked the logo significantly less than those who saw the correct logo, suggesting that the presentation of an altered logo may disrupt processing fluency and influence subsequent attitudes about the stimulus. Unlike in Experiment 2, however, we did not find evidence that this difference in likeabiilty ratings may have been driven by consciously noticing the change in the logo.

The findings from the previous experiments suggest that seeing an altered version of the common Apple logo disrupts memory for the logo. However, there is an alternative possibility that seeing the correct Apple logo prior to the test could have actually boosted memory, rather than the alternative logo disrupting memory, or, perhaps, both processes could be working in parallel. Thus, in Experiment 4, we sought to examine whether memory would be disrupted by the alternative logo compared to seeing the correct logo or not seeing any form of the Apple logo prior to the surprise recognition memory test.

5 | EXPERIMENT 4

In Experiment 4, we examined whether memory for the Apple logo would differ for participants who were incidentally shown (i.e., asked to rate) the correct logo, an alternate logo, or were not shown/did not rate the Apple logo before being tested. Participants completed the same paradigm as in Experiment 3, but in addition to the flipped and canonical conditions, there was a new 'absent' condition, where participants did not see nor rate the Apple logo. Then, after a short delay, all participants were given a recognition memory test for the correct Apple logo.

5.1 | Method

5.1.1 | Participants

Participants were 267 UCLA undergraduates ($M_{Age} = 19.85$, $SD_{Age} = 1.94$; 212 females) who participated for partial fulfillment of course requirements, with 89 participants in the canonical condition, 90 participants in the flipped condition, and 88 in the absent condition. A total of 47 participants in the flipped condition noticed the change in the logo. To determine sample size, we conducted an a priori power analysis. For a chi square test and α of .05, power of .80, 2 degrees of freedom, and an effect size of $\varphi = 0.2$ (average of Experiment 1 and 2 effect sizes), we needed a sample size of 241.

5.1.2 | Stimuli and procedure

The stimuli were the same as those used in Experiment 3. There were three conditions; the canonical condition and the flipped condition

TABLE 3 Descriptives of Apple product use in Experiment 4.

Condition	Desktops	Laptops	Tablets	Smartphones
Absent	Apple: 51.14%	Apple: 84.09%	Apple: 84.09%	Apple: 94.32%
	PC: 21.59%	PC: 14.77%	Non-Apple: 2.27%	Non-Apple: 5.68%
	Mixed: 5.68%	Mixed: 1.14%	Mixed: 3.41%	Mixed: 0.00%
	N/A: 21.59%	N/A: 0.00%	N/A: 10.23%	N/A: 0.00%
Canonical	Apple: 49.44%	Apple: 74.16%	Apple: 84.26%	Apple: 91.01%
	PC: 22.47%	PC: 19.10%	Non-Apple: 5.62%	Non-Apple: 5.62%
	Mixed: 15.73%	Mixed: 6.74%	Mixed: 2.25%	Mixed: 3.37%
	N/A: 12.36%	N/A: 0.00%	N/A: 7.87%	N/A: 0.00%
Flipped	Apple: 51.11%	Apple: 73.33%	Apple: 81.11%	Apple: 90.00%
	PC: 17.78%	PC: 18.89%	Non-Apple: 1.11%	Non-Apple: 7.78%
	Mixed: 15.56%	Mixed: 6.67%	Mixed: 2.22%	Mixed: 2.22%
	N/A: 15.55%	N/A: 1.11%	N/A: 15.56%	N/A: 0.00%

Note: The percentage of participants who reported using Apple products (Apple), non-Apple products (PC or Non-Apple), an equal mix of both Apple and non-Apple products (Mixed), or reported not using that technology (N/A) is shown for desktop computers, laptop computers, tablets, and smartphones.

were the same as in Experiment 3, while the absent condition rated all logos as in Experiment 3 but did not see or rate the Apple logo. All other aspects of the general procedure were the same as that of Experiment 3, with a few exceptions. First, there was a 30-s distractor phase prior to the test (rather than a 5-min delay), during which participants were asked to count backwards by 3 from 298 aloud. Second, we included a confidence rating after the recognition test. Participants were asked to rate on a 1 (*not at all confident*) to 10 (*extremely confident*) Likert scale how confident they were in their response to the recognition question. Additionally, because the frequency and type of user questions were fairly broad in the previous experiments, we made changes to the way those questions were asked. Participants were asked to report whether they primarily use Apple, non-Apple, or a mix of both products when using desktop computers, laptop computers, tablets, and smartphones. There was also an "I do not use this product" option for each question. The responses to these questions are reported in Table 3.

5.2 | Results

5.2.1 | Accuracy

The proportion of correct responses for each condition are shown in Figure 2. We conducted a logistic regression with accuracy (0,1) as the dependent variable and condition (canonical, flipped, absent) as the predictor. The results of the log likelihood ratio test showed that there was an overall marginally significant effect of condition, $\chi^2(2) = 5.64$, $p = .06$. To assess differences between conditions, we conducted Bonferroni corrected post-hoc tests. We found no significant difference between the canonical ($Prop = 0.62$, $SD = 0.49$) and absent conditions ($Prop = 0.67$, $SD = 0.47$; *odds ratio* [*OR*] $= 1.26$, $SE = 0.40$, $z = 0.73$, $p > .99$), nor between the canonical and flipped conditions ($Prop = 0.50$, $SD = 0.50$; $OR = 0.62$, $SE = 0.19$, $z = 1.59$, $p = .34$). The flipped condition, however, was marginally significantly less accurate than the absent condition ($OR = 2.03$, $SE = 0.63$, $z = 2.29$, $p = .065$). Thus, the absent condition was most accurate, and the flipped condition was least accurate.

We next examined whether the likelihood of choosing the critical lure varied across conditions using a logistic regression. The overall test showed there was a significant effect of condition on likelihood of choosing the critical lure, $\chi^2(2) = 31.33$, $p < .001$. We again conducted follow-up tests using Bonferroni corrections. The results showed that the flipped condition ($Prop = 0.21$, $SD = 0.41$) was more likely to choose the critical lure than the canonical condition ($Prop = 0.04$, $SD = 0.21$; $OR = 5.69$, $SE = 3.26$, $z = 3.03$, $p = .007$). We could not conduct the logistic regression comparing the canonical or flipped conditions with the absent condition, given that no participants chose the critical lure in the absent condition. A Chi Square test revealed the same overall significant effect of condition, $\chi^2(2, N = 267) = 28.07$, $p < .001$. Then, we conducted three follow-up 2×2 chi square tests on the proportion of participants who chose the lure to determine which conditions differed from each other. Bonferroni corrections were made by comparing the observed *p*-value to the Bonferroni-corrected alpha value of .017. The results showed that there was no significant difference between the absent and canonical conditions in choosing the critical lure, $\chi^2(1, N = 177) = 4.05$, $p = .04$ (i.e., $p_{adj.} > .017$). However, participants in the flipped condition were more likely to choose the critical lure than those in the absent condition, $\chi^2(1, N = 178) = 20.80$, $p < .001$, as well as those in the canonical condition, $\chi^2(1, N = 179) = 11.03$, $p < .001$.

Looking at the individual features of the selected logo, we found a significant effect of condition on choosing a logo with the bite on the correct side, $\chi^2(2) = 35.52$, $p < .001$ (see Figure 2, Panel 4). Follow-up tests indicated that there was no significant difference between the absent ($Prop = 0.99$, $SD = 0.11$) and canonical ($Prop = 0.96$, $SD = 0.21$) conditions in choosing the correct bite direction ($OR = 4.09$, $SE = 4.62$, $z = 1.25$, $p = .64$). However, participants

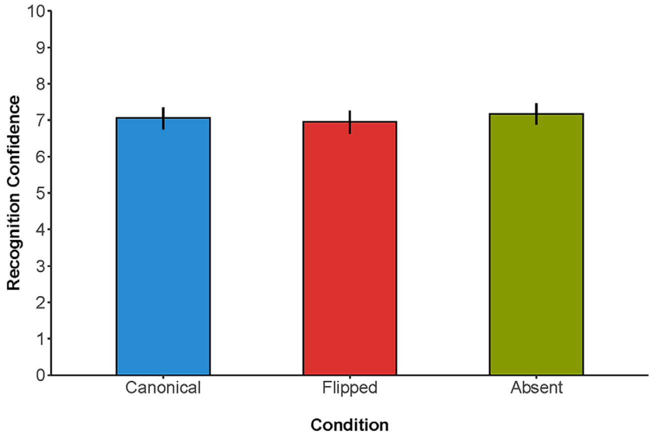

FIGURE 5 Recognition confidence by condition in Experiment 4. Here, participants' recognition confidence ratings, on a scale from 1 (*not at all confident*) to 10 (*extremely confident*), are shown for participants in the incidental Apple logo canonical, flipped, and absent conditions. Error bars represent the nonparametric bootstrapped 95% confidence interval of the mean (1000 iterations).

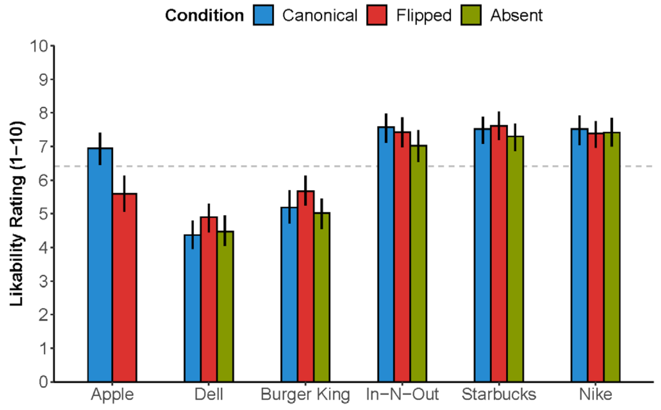

FIGURE 6 Likability ratings of logos in Experiment 4. Here, the average likability rating, on a scale from 1 (*not at all*) to 10 (*very much*), for each logo is shown for participants in the canonical, flipped, and absent conditions (participants in the absent condition did not rate the Apple logo). The dashed line represents the grand mean of all logo ratings across conditions. Error bars represent the nonparametric bootstrapped 95% confidence interval of the mean (1000 iterations).

in the flipped condition were significantly less likely (*Prop* = 0.73, *SD* = 0.44) to choose the correct bite direction than participants in either the absent (*OR* = 31.64, *SE* = 32.70, *z* = 3.34, *p* = .002), or the canonical conditions (*OR* = 0.13, *SE* = 0.07, *z* = 3.62, $p < .001$). There was no significant effect of condition on choosing a logo with the correct leaf direction, $\chi^2(2) = 0.76$, *p* = .68. There was also no significant effect of condition on the likelihood of choosing a logo with the correct dip feature in the bottom, $\chi^2(2) = 3.17$, *p* = .21. Proportions of participants in each condition who selected each logo feature correctly are shown in Table 1.

5.2.2 | Recognition confidence

We analyzed differences in participants' confidence ratings in their memory for the Apple logo across conditions. Average confidence ratings for each condition are shown in Figure 5. To analyze differences by condition, we conducted a one-way ANOVA. The results revealed there was no overall significant difference in confidence between the canonical (*M* = 7.06, *SD* = 1.97), flipped (*M* = 6.95, *SD* = 2.17), or absent (*M* = 7.17, *SD* = 1.98) conditions, *F*(2, 259) = 0.25, *p* = .78, $\eta_p^2 = 0.002$.

5.2.3 | Logo ratings

We again analyzed differences in logo ratings across conditions, with the main interest being the Apple logo, as the other logos were not altered in any condition. Likeability ratings are displayed in Figure 6. Because participants in the absent condition did not rate the Apple logo, we could not include Apple logo ratings in an ANOVA, so we analyzed logo ratings in two phases. First, to ensure that the conditions did not differ in their overall ratings of non-Apple logos, we conducted a 5 (Logo) × 3 (Condition) mixed ANOVA. Mauchly's test of Sphericity indicated that the assumption of sphericity had been violated for the logo variable, so all statistics reported include Greenhouse–Geisser corrections, where applicable. There was an overall effect of logo, *F*(4, 1013) = 143.23, $p < .001$, $\eta_p^2 = 0.35$, which indicated that the Dell logo was rated lower than all other logos (all Bonferroni-corrected *ps* < .001) and the Burger King logo was rated lower than the In-N-Out, Starbucks, and Nike logos (all *ps* < .001). No other pairwise comparisons were significant. However, there was no overall effect of condition on logo ratings, *F*(2, 264) = 1.66, *p* = .19, $\eta_p^2 = 0.01$, suggesting that the conditions did not differ in their general ratings of logos. There was also no significant interaction, *F*(8, 1013) = 0.92, *p* = .50, $\eta_p^2 = 0.01$.

Then, we conducted a *t*-test to examine the difference in logo ratings between the canonical and flipped conditions for the Apple logo only. The results showed a significant difference between the canonical (*M* = 6.94, *SD* = 2.32) and flipped condition (*M* = 5.59, *SD* = 2.62) on Apple logo ratings, *t*(177) = 3.66, $p < .001$. Thus, we replicated the finding that the canonical logo was rated higher than the altered logo. To further explore whether this effect was potentially driven by awareness of the altered nature of the logo, we conducted an independent-samples *t*-test on Apple ratings comparing those who noticed the logo changes and those who did not within participants in the flipped condition. The test showed that those who noticed the change to the logo did not rate the logo significantly lower (*M* = 5.17, *SD* = 2.60) than those who did not notice the change (*M* = 6.05, *SD* = 2.59), *t*(88) = 1.60, *p* = .11, *d* = 0.34. Again, we manually coded responses to ensure only those who noted that they noticed the logo being flipped, or mirrored, or having the bite on the wrong side were marked as noticing the change; 47 out of 90 participants noticed the change. Again, this analysis was post-hoc and does have relatively unequal group sizes, so it is helpful to view as an avenue for future work to pursue.

Finally, we examined differences between groups on overall ratings of Apple products and found no significant effect of condition, $F(2, 264) = 0.45$, $p = .64$, $\eta_p^2 = 0.003$. Thus, as in previous experiments, the condition did not affect participants' overall views of Apple products.

5.3 | Discussion

Overall, we found that participants in the flipped condition did show impaired recognition memory performance compared to participants who did not see the Apple logo incidentally prior to the test. However, performance in the canonical condition was not significantly different from either of the other two conditions, likely because of high variability within each group. Nonetheless, the findings generally support the idea that seeing the altered logo does impair memory, rather than the alternative explanation that seeing the correct logo boosts memory.

We also replicated the finding from Experiment 2 that confidence did not vary across conditions. Despite the flipped condition showing lower memory performance, confidence ratings were not different between groups, suggesting participants are not metacognitively aware of the impairment in memory. Additionally, we replicated the finding that the Apple logo was rated lower on likeability ratings in the canonical condition than in the flipped condition.

6 | GENERAL DISCUSSION

In the current study, we found that incidentally viewing a single presentation of an altered common logo can create a visual misinformation effect, such that memory for the correct logo is less accurate when shown an altered version compared to being shown the correct logo (or not seeing the logo) prior to the surprise recognition test. However, this effect diminished following the introduction of a 5-min delay period between incidental encoding and test, although memory was still influenced regarding the altered feature. These findings extend the literature on everyday, incidental memory, in that incidentally encoding an incorrect stimulus may reduce the accuracy of one's memory for the correct stimulus features, at least on short time scales. In Experiments 1, 2, and 3, we did not find that participants who viewed the critical lure were more likely to remember that version of the logo when tested, but we did find that participants in the flipped condition were more likely to remember the critical lure in Experiment 4. This finding makes it unlikely that the results are due to demand characteristics or simply guessing the purpose of the experiments. Instead, participants' memory for the logo seemed to be more generally disrupted, as those in the flipped condition did not select the critical lure at greater proportions than those who saw the canonical logo in Experiments 1, 2, and 3. Thus, it is possible that presenting a stimulus that contradicts our previous experiences may briefly interfere with the representation of the stored stimulus in memory, rather than completely overriding it.

These findings can also be interpreted from a Bayesian perspective. The Bayesian approach would suggest that we build our representations of objects via "priors," or encounters with the stimulus over time (Bayes & Price, 1763; see Hemmer & Steyvers, 2009 for an example of using a Bayesian approach to assess the influence of prior knowledge on memory reconstruction). Importantly, by knowing the priors and the new "data" (i.e., the canonical or altered stimulus participants were presented with in the current task), we can calculate one's knowledge updating about that stimulus. In the current experiments, although memory was not significantly biased toward the critical lure for those who saw the incorrect logo in Experiments 1–3, it was biased toward choosing a logo with the specific feature of the critical lure (i.e., the bite on the left instead of the right). This finding suggests that the new data (presentation of the incorrect logo) may have temporarily disrupted participants' stored representation of the Apple logo and biased it toward a stimulus with a specific feature. However, over time, there may be a "return to priors," where participants weigh priors more heavily across longer time intervals.

The findings also extend the misinformation literature in an applied consumer context. Most work on misinformation effects shows that the effect gets stronger with a delay (Frost et al., 2002; Horry et al., 2014; Loftus & Palmer, 1974). In most misinformation studies, participants are presented with misinformation regarding newly learned information, whereas the current research involved memory for an everyday object with which participants expectedly had an abundance of prior experience. It is therefore possible that the stored representation of a well-known stimulus, although not highly detailed, may be less susceptible to long-term misinformation effects compared to a newly encountered stimulus, especially since overlapping, schema-consistent features of that stimulus can aid the reconstructive process of memory for it. This possibility could be tested by having participants learn a new logo, and then testing misinformation effects for that learned stimulus.

It is worth noting that in the present research, we examined logo memory using a recognition memory-based task, though misinformation is also often studied using recall-based assessments. We chose to use a recognition-based task in the current study to allow for more straightforward coding of responses (see also Blake et al., 2015; Blake & Castel, 2019), as a recall-based task of visual stimuli would have required a more complex and less exact scoring system (i.e., requiring independent coders to reliably apply a scoring rubric to hand-drawn responses from participants). However, it is important for future work to additionally address misinformation for common logos using recall-based tasks, as logo recognition can be based on familiarity with the logo and/or on recollection of logo features and source memory from previous encounters with a logo. Thus, visual misinformation may differentially disrupt performance on tests of logo memory depending on which types of mnemonic processes individuals rely upon when attempting to bring to mind the correct version of any given logo.

The type of logo could influence the extent to which we find misinformation effects. For example, the Apple logo has schematic features of an actual apple, making it a schema-consistent logo, whereas other logos do not necessarily align with prior schemas of their name (e.g., Nike–a check mark). Thus, recall and recognition could vary in the extent to which misinformation affects memory for logos that differ in their level of abstraction (i.e., more or less semantic overlap with prior schemas). It is also possible that these results would differ if examining logos of differing complexity. We only looked at memory performance for the Apple logo in the present research, which is a fairly simple logo (i.e., it is composed of simple shapes, one color, etc.). However, other logos are composed of many colors, words, images, and details. It is possible that misinformation effects may be stronger for more complex logos that exhibit higher variability across stimulus dimensions, as participants may be less likely to remember all features. On the contrary, potential misinformation effects may be weaker for complex logos, because a change in one or a few details may have a less salient impact on participants' stored representation during reactivation and/or the more complex logos may provide more dimensions that could serve as partial retrieval cues when reconstructing the conjunctive features of the logo from memory. Future work should therefore systematically examine the effect that logo complexity might have on misinformation effects.

This work may have implications for identification of counterfeit brand logos. For example, if a logo was altered in a way that did not affect its schematic features—as was the case in the current research (i.e., the Apple logo as an exemplar of the fruit, apple)—people might be less aware that their memory for the actual logo has been disrupted, making it harder to distinguish the correct from the incorrect logos. This could subsequently increase the likelihood that someone might fall for a similar, counterfeit logo (cf. Pathak et al., 2019). However, if the schematic features of the Apple logo were altered (e.g., to make it look less like a prototypical apple), then perhaps memory would be less affected, and counterfeit logos would be less convincing.

In the present work, we did not find that participants were metacognitively aware of the disruption to their memory after viewing an altered logo. We assessed confidence ratings after the recognition test in Experiments 2 and 4, and in both experiments, we found no difference between conditions in confidence ratings. This finding suggests that participants may have been unaware of their disruption in memory for the Apple logo. Prior research (Blake et al., 2015; Prasad & Bainbridge, 2022) reports similar results, where participants indicate high confidence, despite low accuracy for common visual stimuli. The primary explanation for this result is the presence of a gist-based representation of common logos. Participants in the current research were overwhelmingly users of Apple products (see Tables 2 and 3), and most people report high familiarity with common logos, including the Apple logo (Prasad & Bainbridge, 2022). Given that participants feel familiar with the logo and likely have a gist-based representation of the logo that fits within a schema of the brand, they may feel confident in their memory of the logo, despite poor memory for the details. To note a potential limitation of these claims, we did not collect confidence ratings in Experiments 1 or 3; however, future work should look more specifically at factors influencing confidence in memory for everyday objects to better understand the boundary conditions of these effects and hopefully improve individuals' metacognitive awareness of fluency disruptions and misinformation effects, when present.

In addition to disrupting memory for the correct logo, viewing the incorrect Apple logo reduced how much participants liked the logo. In Experiments 2, 3, and 4, when we asked participants to rate how much they liked the logo immediately after viewing it, participants who saw the canonical logo reported liking the Apple logo more than those who saw the altered logo. This result is consistent with prior research on perceptual fluency showing that when objects or images feel more fluent, they are rated as more esthetically pleasing (Claypool et al., 2015; Reber et al., 1998). Likeability could be influenced by other factors, such as consciously noticing that the logo is incorrect, which we found weak evidence for in Experiment 2, but not in Experiments 3 or 4, or because the correct version of the logo is inherently more pleasing. While there are other explanations for why participants may have given lower likeability ratings after viewing the incorrect logo, prior research supports the idea that viewing an altered version of a common logo may disrupt perceptual fluency.

Future work might investigate how this finding further relates to advertising contexts, as a change in the logo's esthetics may cause people to like the logo or brand less due to a change in perceptual fluency (Ferraro et al., 2009; Lee & Labroo, 2004). Interestingly, those who saw the incorrect logo did not rate their overall liking of *Apple products* lower, which suggests that the change in attitude as a function of visual misinformation appears limited to the logo itself. In any case, this is something for common, well-known brands to be aware of if considering a change, even if minor, to their logo's esthetics.

We recognize that the current research has a few limitations that are worth discussing. First, our measure of processing fluency was likeability ratings. Prior work has shown that when processing fluency is disrupted, ratings of esthetics are typically reduced (e.g., Claypool et al., 2015; Forster et al., 2013; Lee & Labroo, 2004). Additionally, Reber et al. (2004) propose that esthetic experience, including liking, is a function of processing fluency. Thus, reduced likeability ratings of the logo may indicate a disruption in processing fluency. However, it is worth noting that this is an indirect measure of fluency, compared to measures like reaction time (which was not measured consistently in the current study), and there are other potential explanations for our findings, including greater familiarity and a pre-existing preference for the correct logo. Thus, future work should further investigate perceived fluency when logos are modified.

In addition, we have only investigated our question for one common logo. The Apple logo was chosen for a few reasons. First, there is prior work showing that memory is fairly poor for the Apple logo despite its ubiquitous nature (Blake et al., 2015), which supports the idea that memory for the logo may be subject to influence when its esthetics are changed. Additionally, the Apple logo is a relatively simple logo, that, combined with high familiarity, should be fairly easy to remember. However, deficits in memory for this highly common and simple logo suggest that we might not incidentally store detailed representations of this type of common information in memory when we already maintain schemas that overlap with the target logo and/or our goals do not depend on later use of such detailed representations. Additionally, recent research suggests that people do not store details of common and familiar logos, which results in inaccurate recognition and a Visual Mandela Effect (Prasad & Bainbridge, 2022).

Lastly, our sample size determination procedure in Experiments 1 through 3 was not generated a priori but was sufficient to detect medium effects in all three experiments. However, these experiments were underpowered to find small effects. While we were able to reliably detect effects of the main accuracy variable in Experiments 1 and 2, some of the other effects (i.e., memory for the critical lure, bite direction, etc.) may thus be limited by our sample size. In Experiment 3, we did not find that the flipped condition showed poorer accuracy. Although we were underpowered to detect small effects, the effect size for group differences in accuracy in Experiment 3 was $\varphi = 0.03$, while a small effect size is generally regarded as $\varphi = 0.10$. Although it is possible that our sample size was too small to detect this effect, the effect was small enough to potentially be considered not meaningful. Thus, our sample size may ultimately impact some of our results, but it did not seem to limit interpretation of our main finding (i.e., recognition accuracy).

7 | SUMMARY AND CONCLUSIONS

Overall, in four experiments, we found that altering the details of a well-known brand logo can influence subsequent incidental recognition memory for that logo, even when participants have many prior exposures to the logo. However, this effect diminishes over time, as we may then revert back to our original representations of this ubiquitous visual information. These results provide further evidence for an attentional saturation account in that attentional resources are oriented away from goal-irrelevant everyday stimuli, making detailed memory representations for that visual information poorer due to less of a reliance on stored representations and more of a dependence on semantically related schemas. Here, we used an ecologically relevant and commonly occurring everyday stimulus to provide evidence that misinformation effects in incidentally encoded, everyday visual information can lead to subsequent reductions in memory accuracy and perceptual fluency, and these reductions may be due to weaker representations of stimulus-specific details as a consequence of frequent but goal-irrelevant incidental encoding of this information.

ACKNOWLEDGMENTS

The authors would like to thank Alex Siegel, Adam Blake, Mary Hargis, Karina Agadzhanyan, Alma Franco, and the members of the Castel Lab for their helpful suggestions and comments.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to report.

DATA AVAILABILITY STATEMENT

Data and analysis code for the current study are available on the Open Science Framework at https://osf.io/bu5xa/.

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ENDNOTES

1 We chose to include all participants in the analyses, regardless of whether they reported that they noticed the flipped Apple logo for two reasons. First, excluding participants from the flipped condition only led to highly unequal group sizes, creating problems for interpreting the analyses. Second, we analyzed the results excluding those 28 participants, and the central results (e.g., accuracy, critical lure, bite correctness, fluency) did not change.

2 Again, we chose not to exclude participants who reported noticing that the logo was flipped to ensure we could interpret the analyses by keeping sample sizes relatively equal. However, we again conducted the analyses excluding those 22 participants, and the pattern of results did not change.

REFERENCES

Anglada-Tort, M., Baker, T., & Müllensiefen, D. (2019). False memories in music listening: Exploring the misinformation effect and individual difference factors in auditory memory. *Memory*, *27*(5), 612–627. https://doi.org/10.1080/09658211.2018.1545858

Bayes, T., & Price, R. (1763). An essay towards solving a problem in the doctrine of chance. By the late Rev. Mr. Bayes, communicated by Mr. Price, in a letter to John Canton. *Philosophical Transactions of the Royal Society of London*, *53*, 370–418.

Bjork, R. A. (2001). Recency and recovery in human memory. In *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 211–232). American Psychological Association. https://doi.org/10.1037/10394-011

Blake, A. B., & Castel, A. D. (2019). Memory and availability-biased metacognitive illusions for flags of varying familiarity. *Memory & Cognition*, *47*(2), 365–382. https://doi.org/10.3758/s13421-018-0872-y

Blake, A. B., Nazarian, M., & Castel, A. D. (2015). The Apple of the mind's eye: Everyday attention, metamemory, and reconstructive memory for the Apple logo. *The Quarterly Journal of Experimental Psychology*, *68*(5), 858–865.

Block, R. A. (2009). Intent to remember briefly presented human faces and other pictorial stimuli enhances recognition memory. *Memory & Cognition*, *37*(5), 667–678. https://doi.org/10.3758/MC.37.5.667

Bornstein, R. F. (1989). Exposure and affect: Overview and meta-analysis of research, 1968–1987. *Psychological Bulletin*, *106*(2), 265–289. https://doi.org/10.1037/0033-2909.106.2.265

Bornstein, R. F., & D'Agostino, P. R. (1994). The attribution and discounting of perceptual fluency: Preliminary tests of a perceptual fluency/attributional model of the mere exposure effect. *Social Cognition*, *12*, 103–128.

Brady, T. F., Konkle, T., Alvarez, G. A., & Oliva, A. (2008). Visual long-term memory has a massive storage capacity for object details. *Proceedings of the National Academy of Sciences*, *105*(38), 14325–14329. https://doi.org/10.1073/pnas.0803390105

Brewer, W. F., & Sampaio, C. (2006). Processes leading to confidence and accuracy in sentence recognition: A metamemory approach. *Memory*, *14*(5), 540–552. https://doi.org/10.1080/09658210600590302

Castel, A. D., Nazarian, M., & Blake, A. B. (2015). Attention and incidental memory in everyday settings. In *The Handbook of Attention* (pp. 463–483). MIT Press.

Castel, A. D., Vendetti, M., & Holyoak, K. J. (2012). Fire drill: Inattentional blindness and amnesia for the location of fire extinguishers. *Attention, Perception, & Psychophysics*, *74*, 1391–1396.

Claypool, H. M., Mackie, D. M., & Garcia-Marques, T. (2015). Fluency and attitudes. *Social and Personality Psychology Compass*, *9*(7), 370–382. https://doi.org/10.1111/spc3.12179

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Routledge. https://doi.org/10.4324/9780203771587

Farnham, A. (2013, September 30). *ABC News*. http://abcnews.go.com/Business/quiz-recognize-15-iconic-logos/story?id=20423733

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*, 175–191. https://doi.org/10.3758/bf03193146

Fazio, L. K., Dolan, P. O., & Marsh, E. J. (2015). Learning misinformation from fictional sources: Understanding the contributions of transportation and item-specific processing. *Memory*, *23*(2), 167–177. https://doi.org/10.1080/09658211.2013.877146

Ferraro, R., Bettman, J. R., & Chartrand, T. L. (2009). The power of strangers: The effect of incidental consumer brand encounters on brand choice. *Journal of Consumer Research*, *35*(5), 729–741. https://doi.org/10.1086/592944

Forster, M., Leder, H., & Ansorge, U. (2013). It felt fluent, and I liked it: Subjective feeling of fluency rather than objective fluency determines liking. *Emotion*, *13*(2), 280–289. https://doi.org/10.1037/a0030115

Frost, P., Ingraham, M., & Wilson, B. (2002). Why misinformation is more likely to be recognised over time: A source monitoring account. *Memory*, *10*(3), 179–185. https://doi.org/10.1080/09658210143000317

Hargis, M. B., McGillivray, S., & Castel, A. D. (2018). Memory for textbook covers: When and why we remember a book by its cover. *Applied Cognitive Psychology*, *32*(1), 39–46. https://doi.org/10.1002/acp.3375

Hemmer, P., & Steyvers, M. (2009). A Bayesian account of reconstructive memory. *Topics in Cognitive Science*, *1*, 189–202.

Horry, R., Colton, L.-M., & Williamson, P. (2014). Confidence–accuracy resolution in the misinformation paradigm is influenced by the availability of source cues. *Acta Psychologica*, *151*, 164–173. https://doi.org/10.1016/j.actpsy.2014.06.006

Iancu, I., & Iancu, B. (2017). Recall and recognition on minimalism. A replication of the case study on the Apple logo. *KOME*, *5*(2), 57–70. https://doi.org/10.17646/KOME.2017.24

Jacoby, L. L., Kelley, C. M., & Dywan, J. (1989). Memory attributions. In *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 391–422). Lawrence Erlbaum Associates, Inc.

Janiszewski, C., & Meyvis, T. (2001). Effects of brand logo complexity, repetition, and spacing on processing fluency and judgment. *Journal of Consumer Research*, *28*(1), 18–32. https://doi.org/10.1086/321945

Lee, A. Y., & Labroo, A. A. (2004). The effect of conceptual and perceptual fluency on brand evaluation. *Journal of Marketing Research*, *41*(2), 151–165. https://doi.org/10.1509/jmkr.41.2.151.28665

Loftus, E. F. (2005). Planting misinformation in the human mind: A 30-year investigation of the malleability of memory. *Learning & Memory*, *12*(4), 361–366. https://doi.org/10.1101/lm.94705

Loftus, E. F., & Palmer, J. C. (1974). Reconstruction of automobile destruction: An example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior*, *13*(5), 585–589. https://doi.org/10.1016/S0022-5371(74)80011-3

Marmie, W. R., & Healy, A. F. (2004). Memory for common objects: Brief intentional study is sufficient to overcome poor recall of US coin features. *Applied Cognitive Psychology*, *18*(4), 445–453. https://doi.org/10.1002/acp.994

Misra, P., Marconi, A., Peterson, M., & Kreiman, G. (2018). Minimal memory for details in real life events. *Scientific Reports*, *8*(1), Article 1. https://doi.org/10.1038/s41598-018-33792-2

Murphy, D. H., & Castel, A. D. (2021). Tall towers: Schemas and illusions when perceiving and remembering a familiar building. *Applied Cognitive Psychology*, *35*(5), 1236–1246. https://doi.org/10.1002/acp.3855

Nickerson, R. S., & Adams, M. J. (1979). Long-term memory for a common object. *Cognitive Psychology*, *11*, 287–307.

Nordhielm, C. L. (2002). The influence of level of processing on advertising repetition effects. *Journal of Consumer Research*, *29*(3), 371–382. https://doi.org/10.1086/344428

Pathak, A., Velasco, C., & Calvert, G. A. (2019). Implicit and explicit identification of counterfeit brand logos based on logotype transposition. *Journal of Product & Brand Management*, *28*(6), 747–757. https://doi.org/10.1108/JPBM-06-2018-1921

Porter, S., Bellhouse, S., McDougall, A., ten Brinke, L., & Wilson, K. (2010). A prospective investigation of the vulnerability of memory for positive and negative emotional scenes to the misinformation effect. *Canadian Journal of Behavioural Science / Revue Canadienne Des Sciences Du Comportement*, *42*(1), 55–61. https://doi.org/10.1037/a0016652

Prasad, D., & Bainbridge, W. A. (2022). The Visual Mandela Effect as evidence for shared and specific false memories across people. *Psychological Science*, *33*(12), 1971–1988. https://doi.org/10.1177/09567976221108944

Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing Fluency and Aesthetic Pleasure: Is Beauty in the Perceiver's Processing Experience? *Personality and Social Psychology Review*, *8*(4), 364–382. https://doi.org/10.1207/s15327957pspr0804_3

Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science*, *9*(1), 45–48. https://doi.org/10.1111/1467-9280.00008

Shapiro, S. A., & Nielsen, J. H. (2013). What the blind eye sees: Incidental change detection as a source of perceptual fluency. *Journal of Consumer Research*, *39*(6), 1202–1218. https://doi.org/10.1086/667852

Snyder, K. M., Ashitaka, Y., Shimada, H., Ulrich, J. E., & Logan, G. D. (2014). What skilled typists don't know about the QWERTY keyboard. *Attention, Perception, & Psychophysics*, *76*, 162–171.

Vendetti, M., Castel, A. D., & Holyoak, K. J. (2013). The floor effect: Impoverished spatial memory for elevator buttons. *Attention, Perception, & Psychophysics*, *75*(4), 636–643. https://doi.org/10.3758/s13414-013-0448-7

Wong, K., Wadee, F., Ellenblum, G., & McCloskey, M. (2018). The devil's in the g-tails: Deficient letter-shape knowledge and awareness despite massive visual experience. *Journal of Experimental Psychology: Human Perception and Performance*, *44*(9), 1324–1335. https://doi.org/10.1037/xhp0000532

How to cite this article: Whatley, M. C., Schwartz, S. T., Block, J. B., & Castel, A. D. (2023). Memory, metamemory, and false memory for features of the Apple logo. *Applied Cognitive Psychology*, *37*(5), 904–918. https://doi.org/10.1002/acp.4088