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Pictorial warning labels reduce sharing intentions, blunt self-relevance processes elicited by social media posts promoting cannabis edibles

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Abstract

The implementation of warning labels has been shown to slow the spread of harmful content on social media, but the mechanisms by which these interventions affect individuals' sharing decisions are not yet known. This study sought to establish the efficacy of these interventions and to explore the mechanisms of their influence using two parallel studies conducted within the United States: an online experiment that tested the effects of cannabis warning labels on sharing intentions (N = 1,776), and a neuroimaging study (N = 40) to examine how warning labels influenced activity in brain regions implicated in sharing decisions. Results demonstrated that warning labels paired with cannabis posts reduced intentions to share and were associated with decreased activation of brain regions associated with self-processing compared to cannabis posts alone. These results suggest that warning labels may discourage sharing by negatively influencing perceptions of self-relevance.

Keywords: warning labels, cannabis, persuasion, sharing, neuroimaging

Introduction

The reach of online messages depends on sharing decisions made by individual social media users, who can retransmit messages to online networks or share them directly with offline acquaintances. When many users independently choose to share a message, the resulting diffusion cascade brings that message to a broader audience than the one targeted by the original broadcast (Liang, 2018). These cascades can amplify messages that threaten the public good. For example, social media sharing fueled the distribution of misinformation during the peak of the COVID-19 pandemic (Kouzy et al., 2020), and sometimes exposes underage consumers to content promoting alcohol (Winpenny et al., 2014), nicotine (Rutherford et al., 2023), and other harmful substances (Trangenstein et al., 2021).

Social media platforms are hesitant to throttle or remove harmful content directly due to free speech and other concerns (Young, 2022), but the policy of affixing warning labels to harmful content is broadly supported by U.S. social media users (Straub & Spradling, 2022). Such labels stem the spread of harmful content by appealing to users directly, dissuading sharing without imposing platform-level restrictions on freedom of expression. This has been tested repeatedly in the misinformation context, where evidence suggests labels reduce both sharing intentions and adoption of misbeliefs (Martel & Rand, 2023). Less is known about the effects of health-related warning labels on sharing (Thrasher et al., 2019), but posts promoting harmful health behaviors have been observed to receive less engagement when affixed with government-mandated health warnings (Wu et al., 2023).

This article expands our understanding of health warning labels using experimental methods, directly testing whether social media users are less likely to share content affixed with a health warning label and observing the effects of those labels on brain networks involved in sharing decisions. It presents the results of two parallel experiments, which were conducted using identical stimuli but different samples and methods. Both experiments tested the effects of a set of warning labels proposed for use with cannabis products and advertisements in California by pairing them with a set of real-world social media posts promoting edible cannabis products.

Study 1 presented these promotional posts to a nationwide sample of young adults who were likely cannabis users in an online experiment, randomly assigning participants to view the posts with or without warning labels and then assessing their intentions to share, like, or comment on the posts. The goal of this study was to test for a population-level effect of warning labels on deterring engagement with social media posts promoting a harmful health product (cannabis edibles). The results can inform ongoing policy initiatives to mandate warning labels and regulate online cannabis advertising, particulary those targeting minors, as legalization of recreational cannabis products expands.

Study 2 used neuroimaging methods to observe the brains of young adult cannabis users while they considered the promotional posts with and without addition of the warning labels. The goal of this study was to empirically test whether

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the presence of warning labels was associated with changes in activity within brain networks known to be implicated in online sharing decisions (Scholz et al., 2020). In doing so, this study sought to identify a set of specific cognitive and affective mechanisms underlying the population-level effects examined in Study 2.

Before presenting the methods and results of these studies, the following sections of this paper review existing literature that helps establish their significance. First, extant research into the effects of warning labels in the context of social media is reviewed to establish their likely efficacy in reducing intentions to share harmful messages online. Second, evidence from neuroimaging literature is used to identify likely mechanisms underlying the effects of warning labels on sharing intentions. Third and finally, information is presented to justify the specific communication domain explored by this research: the marketing of recreational cannabis products on social media.

Effects of warning labels on sharing decisions

Social media users broadly support adding warning labels to posts that contain false or misleading information or that can create hazards for public health (Straub & Spradling, 2022). Regarding the former, evidence suggests adding warning labels can slow the viral spread of posts classified as misleading. Experimental work has shown that participants are less likely to "like" or "love" Facebook posts presented alongside a warning label (McPhedran et al., 2023) and that participants are less likely to share posts that have been labeled as false or misleading (Clayton et al., 2020; Mena, 2020; Pennycook et al., 2020). Importantly, the effects of labels are robust to differences in partisanship—for both Democrats and Republicans, the presence of warning labels is associated with both reduced sharing intentions and reduced belief in the misbeliefs themselves (Martel & Rand, 2023).

Less research has explored the effects of health-related warning labels on social media, partly because it remains unclear whether federal laws that require labels on advertising for harmful products can be applied to social media posts (Lewis et al., 2004). Observational research using computer vision has found that Instagram posts promoting cigars and cigarillos tend to receive less engagement (likes and comments) when paired with health warnings (Wu et al., 2023), and an online experiment found that the addition of warning labels reduced the effectiveness of Instagram ads promoting e-cigarettes (Phua & Lim, 2023). Little is known about the ways warning labels might impact interpersonal outcomes like sharing, however, despite explicit calls for research into such effects (Thrasher et al., 2019).

It is unclear whether the psychological mechanisms underlying the effects of misinformation-related warning labels might also be engaged by health-related labels. Labels' effect on sharing in the misinformation context is mediated by perceptions about credibility of the message, which are negatively affected by the presence of warning labels (Mena, 2020). Past work suggests that social media users who share posts online do so to gratify their needs for information-seeking, socializing, and status-seeking (Lee & Ma, 2012). Similar motivations have also been found to drive the online sharing of advertising content (Plume & Slade, 2018) and to predict the sharing of rumors (Shen et al., 2021). Thus, it is possible that warning labels might reduce sharing intentions by undermining these motivations—suggesting that sharing a given post will not provide the desired gratification. For example, if a warning label causes users to see a post as less credible, they may also feel less confident that sharing the post would help them gratify their needs for information-seeking or status-seeking.

In sum, warning labels have been shown to reduce sharing intentions when they warn about misinformation, but research has not yet tested whether health-related warning labels might have the same effect. In addition to being an important consideration for public health (Thrasher et al., 2019), understanding whether health-related warning labels can affect sharing intentions might also suggest these effects can be attributed to mechanisms that are common across sharing contexts.

Psychological and neural mechanisms underlying sharing decisions

When seeking to understand mechanisms that underlie media effects, it is helpful to observe how media stimuli impact activity in the brain. Neural activity during the encoding of media stimuli offers a direct view of the processes engaged by that media, without reliance on participants' ability to introspect and accurately recall their experiences (Minich, Tao, et al., 2023). When interpreted cautiously, these observations can provide insights into mechanisms that can be generalized across a variety of contexts.

The interaction between motivations, content features, and psychological arousal that drives sharing decisions is thought to manifest in the brain through the interaction between three distinct networks (Scholz et al., 2020). Neuroimaging research has found that when people encode messages they choose to share with others, they exhibit increased activity in brain networks associated with self, social, and valuation processes (Baek et al., 2017). Similar findings have been observed at the message level, as news stories that elicited more activity in these regions in a study sample were also shared more often by actual online readers.

In their neural model of information virality, Scholz et al. (2017) suggest these patterns indicate a specific flow of cognitive resources. People first consider a message directly, considering its likely appeal to others, its appeal and relevance to themselves, and the degree to which they might improve their self-presentation by sharing it. These processes operate in parallel and engage two discernable brain systems. First, inferences about the thoughts and feelings of others engage a social-processing network comprised of the dorsal medial prefrontal cortex (dmPFC), bilateral temporal-parietal junction (TPJ), and the precuneus. Meanwhile, considerations of self-relevance and imaginings about self-presentation engage self-processing regions that include the medial prefrontal cortex (mPFC), posterior cingulate (PCC), and the precuneus. Information from these regions is then integrated into a common neural scale in value regions of the brain, consisting of the ventromedial prefrontal cortex (vmPFC) and ventral striatum (VS), which guides the decision to share or not share a piece of content (Scholz et al., 2020). This domain-general value signal has been shown to be particularly important in cases where people are exposed to multiple contradictory messages about a health behavior (Scholz et al., 2019), as this signal can sometimes be deliberately modulated by audiences during message encoding (Doré et al., 2019). Thus, this conceptualization of sharing decisions is appropriate for the warning label context, in which audiences are presented simultaneously with two messages with opposing persuasive goals.

Effects of warning labels on neural processes

The effect of warning labels on sharing intentions has not been explored using neuroimaging, but past work has examined the relationship between neural activity elicited by labels and other outcomes (Green et al., 2016; Owens et al., 2017; Wang et al., 2015). For example, Wang et al. (2015) found that graphic warning labels for tobacco products elicited activity in the hippocampi, amygdala, and insulae: regions associated with memory and affective processing. Labels that increased activity in these regions were also remembered better by participants, and exposure to these labels was associated with reduced smoking urges (Wang et al., 2015). Neuroimaging research has repeatedly found that labels elicit activity in affective processing regions (Green et al., 2016), and this activation has been associated with reduced cigarette cravings (Do & Galván, 2015) and smoking (Owens et al., 2017). Thus, the effects of warning labels on behaviors have been associated with their effects on the brain.

Warning labels have also been shown to elicit activity in the vmPFC, and activity in this region in response to labels has predicted smoking cessation after the scan (Owens et al., 2017). Activation of this region during message encoding has been repeatedly associated with message-consistent behavior (Falk et al., 2010, 2012), and it has been suggested that activity in this region might index perceptions of self-relevance and/or subjective value (Falk & Scholz, 2018) This region also overlaps with portions of the self- and value-processing networks associated with online sharing (Scholz et al., 2020). Thus, previous research suggests warning labels influence brain regions that are also implicated in the decision to share content online.

Importantly, past studies either displayed warning labels in isolation (Do & Galván, 2015; Wang et al., 2015) or paired them with images of cigarette packaging (Green et al., 2016; Owens et al., 2017). Little is known about labels' impact on encoding of persuasive messages such as marketing messages. Given that activity within self-, social-, and value-processing regions is associated with sharing decisions (Scholz et al., 2020), the addition of negatively valenced stimuli like warning labels could downgrade the signal elicited by positively valenced marketing messages. However, this possibility has not been explicitly tested.

Sharing in the context of cannabis marketing

Over the past decade, the sale and use of recreational cannabis products have become legal in many parts of the United States. This legalization has been accompanied by a marked decrease in public perceptions of the risks these products carry (Blevins et al., 2018), despite evidence associating THC consumption with risks such as impaired driving, onset of mental health conditions, suicidal ideation, and others (National Academies of Science and Medicine, 2017).

The decline of harm perceptions among young people parallels increasingly intensive marketing efforts by the cannabis industry on social media and in other settings (Park & Holody, 2018). Posts promoting cannabis products are considered appealing by adolescents (Liu et al., 2020), and exposure to these posts has been associated with increased rates of cannabis use disorder (CUD; Trangenstein et al., 2021). Dissemination of these posts on social media has been described as a critical public health issue (Moreno et al., 2022), partly because users' sharing decisions allow messages to bypass age restrictions (Moreno et al., 2018).

Though most social media platforms restrict or ban paid promotions of cannabis products (Berg et al., 2023) , manufacturers and vendors alike increasingly promote these products through posts on their public social media pages (Marinello et al., 2024). Policies governing this practice are inconsistent and vague (Berg et al., 2023), allowing cannabis promotions to reach potential underage customers while bypassing state and federal laws about cannabis product advertising. Thus, interventions that slow the spread of cannabis marketing materials could provide direct benefits to public health, particularly concerning the wellbeing of minors and young adults.

The current study

This article aims to establish whether the presence of health-related warning labels can negatively influence social media users' decisions to share certain content and explores the effects of those labels on the neural processes that underlie those decisions. Toward those aims, two parallel studies were conducted. First, a between-subjects online experiment was conducted to test whether people reported lower intentions to engage in viral behaviors (narrowcasting, broadcasting, liking, and replying) after viewing cannabis marketing posts with versus without warning labels. Second, a within-subjects neuroimaging protocol was used to test whether the addition of warning labels to cannabis posts influenced neural activity in self-, social- and value-processing networks in the brain.

Methods

Study 1

Participants

In summer 2022, 1,776 U.S. participants between 18 and 25 ($M = 21.56$, $SD = 2.11$) were recruited through an online panel. Only participants who responded positively to at least one of the following screening questions for susceptibility for cannabis use were deemed eligible: "Would you try marijuana if one of your best friends offered it to you?", "Do you think you would use marijuana in the next 6 months?", and "Are you curious about using marijuana?". Thus, this represents a population that is at an elevated risk for using cannabis either now or in the future. Participants reported all racial groups with which they identify and were coded to Black if they selected Black with or without other races (30.57%), another race if that was selected with or without another race (19.03%), and White if that was the only selected race (50.39%). Participants reported gender and were categorized as "Woman" (56.93%) or "Other", with participants reporting as another gender categorized into "Other." Complete participant demographics, including home state, are available in the Supplementary material (Supplementary Tables S3 and S4).

Study design

After consent, participants completed a demographic questionnaire and were then randomized into one of ten conditions in a 3 (no CWL, text-only CWL, pictorial CWL) x 3 (No comments, pro-cannabis comments, anti-cannabis comments) + 1 (no-message control)[1] factorial design. In each condition, participants saw a set of three cannabis marketing posts drawn from a pool of 60 real-world messages, then were presented with a set of comments from the corresponding comments condition. After exposure to each set of stimuli, participants were asked to report their intentions to engage in sharing behaviors. For example, participants in the pictorial CWL x pro-cannabis comments condition engaged in the following process three times: First, they viewed a marketing message paired with a pictorial warning label, then they viewed a set of pro-cannabis comments, then they completed a set of measures assessing their intentions to engage in sharing behaviors.

CWLs

Ten pictorial CWLs were designed to describe established health risks (National Academies of Sciences, 2017) specifically suggested for presentation on CWLs in the state of California (Pan, 2022). Content of pictorial CWLs is presented in Figure 1. Text-only warning labels presented identical information but without illustrations.

Cannabis marketing posts

Marketing posts were collected from Facebook in the spring of 2021 by study team members. All posts portrayed edible cannabis products (e.g., drinks, candy). An example cannabis marketing post presented with and without a CWL is shown in Figure 2.

Social media comments

Two-hundred cannabis comments were collected from Twitter, Reddit, and Facebook in 2021, and manually valanced to anti- or pro-cannabis. The comments were then equally split and used in randomized sets of 5. Comments were edited to remove emoji and author references, and for length.

Social media engagement

After exposure to each post, participants reported engagement intentions by responding to the following 4 prompts on a Likert-style scale from 1 (not at all likely) to 7 (extremely likely): How likely would you be to: 1) “share this post directly with someone you know (via email, direct message, etc)” (narrowcasting); 2) “share this post to your own social media timeline (e.g., Facebook, Twitter) so that many people could see it” (broadcasting); 3) “click the like button” (liking); and 4) “reply to this post” (replying).

Statistical analyses

To test whether social media engagement was influenced by the presence of CWLs, the data were fit to linear mixed effects models in which social media engagement (broadcasting, narrowcasting, liking, and replying) served as the outcome variables and warning label condition (pictorial CWL, text-only CWL, or no CWL) and comments condition (anti-cannabis, pro-cannabis, or no comments) served as the predictor variables with an interaction term. Regressions were run with both “no CWL” and “pictorial CWL” as referent groups to identify all between group contrasts. To account for clustering data, by-participant (UID) and by-marketing post (PID) random intercepts and slopes were modeled. These models were adjusted for covariates including race (White, Black, Another Race), Gender (Men, Women), sexual orientation (Heterosexual, LGBTQ+), income ($35k-$75k, less than $35k, over $75k), current tobacco use, social environment for cannabis use, and whether the participants' home state allowed legal recreational cannabis.

Study 2

Participants

Forty participants were recruited from a large midwestern university who were between 18 and 24 years of age ($M = 20.1$, $SD = 1.34$; female = 20) that scored at least a 1 on the Cannabis Use Disorder Identification Test (CUDIT), indicating at least ever-use of cannabis. All participants were right-handed, had normal (or corrected to normal) vision, were not taking any psychoactive medications, did not suffer from claustrophobia, and did not have metal in their bodies that was contraindicated for MRI. Complete participant demographics are available in Supplementary material (Supplementary Table S5).

fMRI study design

Following pre-screening, consent and safety screening, participants were trained on the neuroimaging tasks prior to starting the functional magnetic resonance imaging (fMRI) session. During the scanning session participants were exposed to cannabis marketing posts with and without CWLs, followed by sets of mock online comments Following the scanning session participants completed a series of self-report measures.

Cannabis Use Disorder Identification Test (CUDIT-R)

Prior to recruitment, participants completed the CUDIT-R (Adamson et al., 2010) 8-item measure to assess cannabis use over the previous 6 months. Sum scores were calculated and participants scored an average of 7.85 on this measure ($SD = 5.58$). Eleven of the 40 participants recruited (27.5%) reported a score of or greater than 12, the threshold for cannabis use disorder. Research suggests that roughly one in five cannabis users are at risk of developing cannabis use disorder (Leung et al., 2020), so this sample is only slightly above the population average with regards to incidence of disordered use.

fMRI CWL task

Before undergoing fMRI, participants completed a short training in which study staff described the nature of the task. Participants were instructed that they would be shown a set of advertisements for cannabis products and asked to evaluate how effective they thought these ads would be with other people their age. Participants were reminded of this objective immediately before the scan by study staff, who provided the following instructions:

> The first task you are going to be doing in the scanner will be evaluating ads for cannabis products. You'll also see social media comments. Please don't feel like you have to read all of them. You will be asked “How effective is this cannabis ad?” You will then have 3 seconds to respond from 4 options, ranging from strongly ineffective to strongly effective. In the scanner to select these options you will use your POINTER finger for strongly INEFFECTIVE and PINKY for strongly EFFECTIVE. Any questions?

Then, while undergoing fMRI, participants viewed a total of 60 cannabis marketing posts drawn pseudo-randomly from

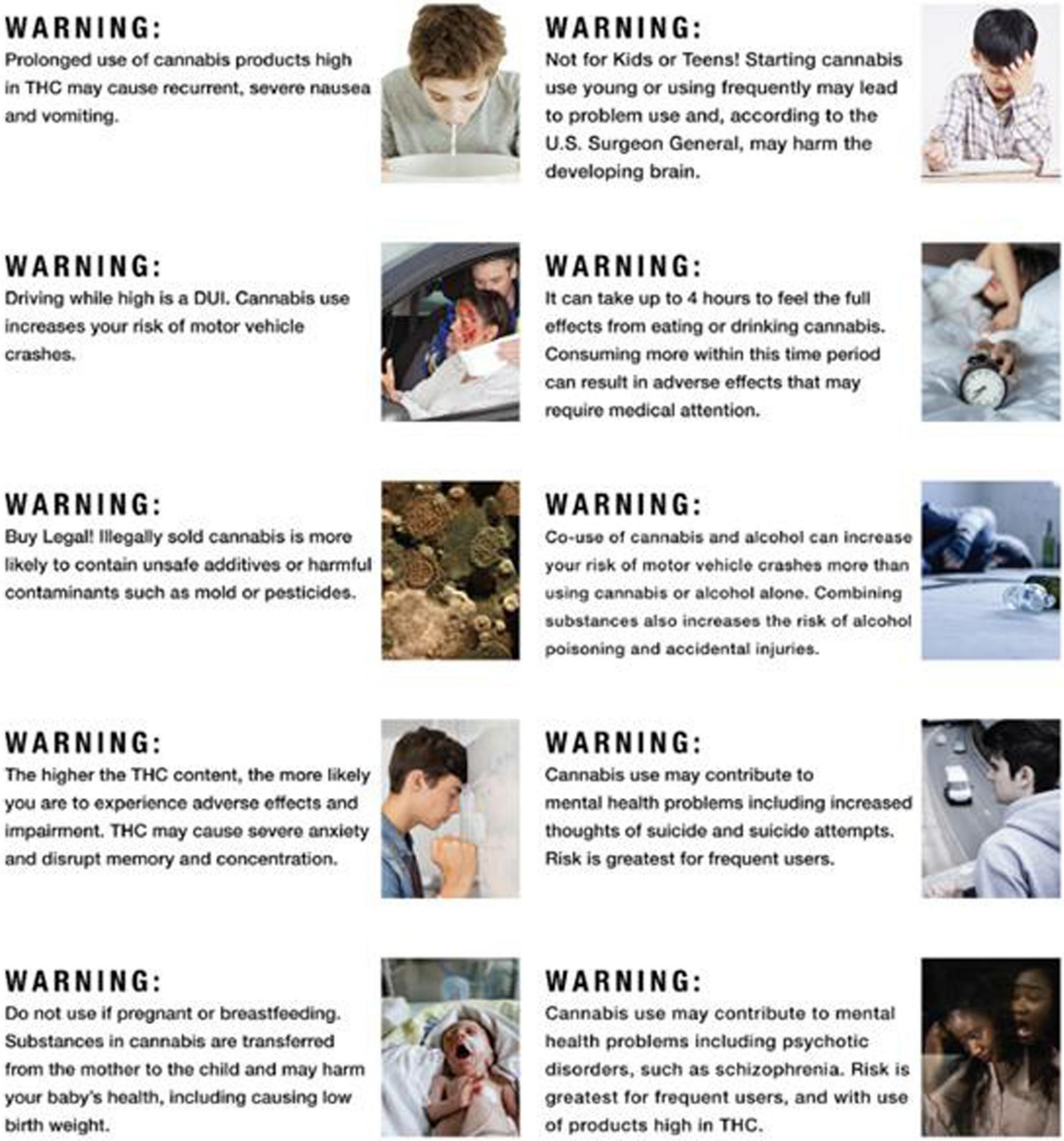

Figure 1. Pictorial CWLs. Ten pictorial CWLs were designed to describe established health risks cited in a bill introduced in the state of California.

the same stimuli pool used for Study 1. Each of these 60 posts was either paired with one of 10 pictorial warning labels (described in the following section) or with no warning label using a gray rectangle of equal dimensions. Post/label pairings were assigned using a randomized, counterbalanced design. Participants viewed each post/label pairing for a period of 7 seconds, then viewed either a set of pro- or anti- cannabis comments or a visually similar set of comment boxes containing lorem ipsum filler text for a period of 6 seconds. Content of pro- and anti-cannabis comments were identical to the comments used in study 1, however, measures of sharing intentions were not included. Finally, participants responded to the prompt "How effective is this cannabis ad?" on a scale of 1 (not effective) to 4 (very effective) using a four-button Current Designs response pad held in the participant's right hand. Participants were given three seconds to respond to this prompt, then were presented with a fixation cross for a randomized, jittered period of an average of 1.5 seconds.

fMRI data acquisition and analysis

Structural and functional brain imaging was conducted using a 3 Tesla GE Discovery MR750 scanner. The structural imaging

Figure 2. Stimuli presentation. An example of cannabis marking posts as presented in the No CWL (left) and Pictorial CWL (right) conditions.

procedure was changed mid-study to reduce scan time. For 3 participants, structural scans were obtained using a motion-corrected T1-weighted MPnRAGE acquisition with 1.0 mm isotropic spatial resolution (Kecskemeti et al., 2018) For the remaining 37 participants, scans were obtained using a FSPGR BRAVO sequence. Two functional runs were recorded (TR = 800ms, TE = 20ms, flip angle = 60°, matrix size = 96x96, 54 axial slices, 3mm thick; voxel size = 3.0x3.0x3.0) for 36 participants, and one run was recorded for the remaining four participants.

Preprocessing

Preprocessing was performed using the afni_proc.py program within the Analysis for Functional Neuroimaging (AFNI) software package (Cox, 1996). Functional and structural runs were warped to align with the Montreal Neurological Institute MNI151 template brain and smoothed with a 4-mm Gaussian kernel.

Modeling

Data were modeled at the single subject level using the general linear model as implemented in AFNI. Two trial types were modeled during the 7-s exposure to the cannabis ads (cannabis ads with CWLs, cannabis ads without CWLs). Exposure to the jittered fixation cross was modeled as a baseline. In total, three trial types were modeled (with/without CWLs and rest), as well as random effects, motion, and nuisance regressors.

Regions of interest

The self, social, and value regions of interest (ROIs) for the current study were based on Scholz et al. (2017) and were obtained from that research team. Each network included clusters for each of the regions described in the above literature review. Because parts of the social-processing network overlapped with frontal portions of both the self and value networks, voxels that were part of these networks were removed from the social network mask. ROI details can be found in Table 1 and Figures 3–5. To test the possibility that the presence of warning labels might also have induced distraction in participants, we also tested ROIs derived from association tests for the keywords "attention" and "distraction," using the association test maps by the meta-analytic platform Neurosynth (Yarkoni et al., 2011).

Supplemental ROI analyses that examined whether the search terms value, self-referential, and mentalizing using the

Table 1. ROI coordinates.

	X	Y	Z	voxels
Self				
mPFC	−7.5	−53.2	−2	164
PCC	0	59.2	13	144
Social				
TPJ—left	−47.5	−3.2	−47	3846
TPJ—right	62.5	64.2	8	1700
PFC	10	−43.2	20.5	2424
Precuneus	5	61.8	10.5	1894
Value				
vmPFC	−10	−8.2	−12	235
Precuneus	2.5	−35.8	−17	233

Note. Peak X, Y, and Z coordinates are presented in MNI space.

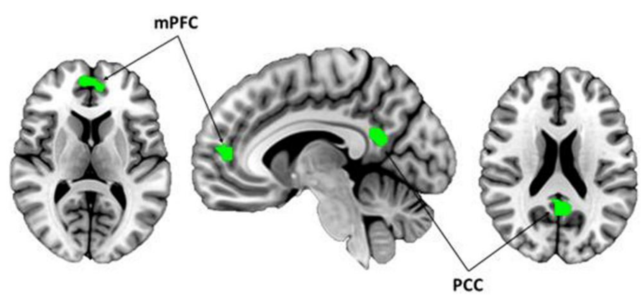

Figure 3. Self-processing ROI. The self-processing ROI includes the vmPFC and PCC (Baek et al., 2017).

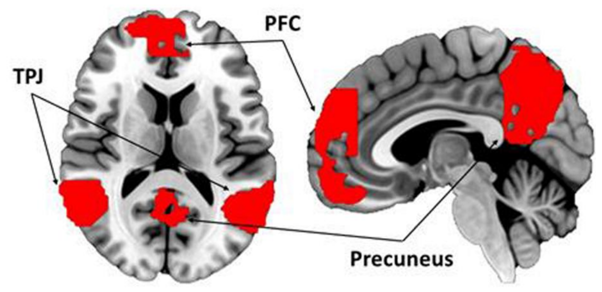

Figure 4. Social-processing ROI. The social-processing ROI includes the PFC, TPJ, and precuneus. Voxels that overlap with self and processing networks were removed, as per (Baek et al., 2017).

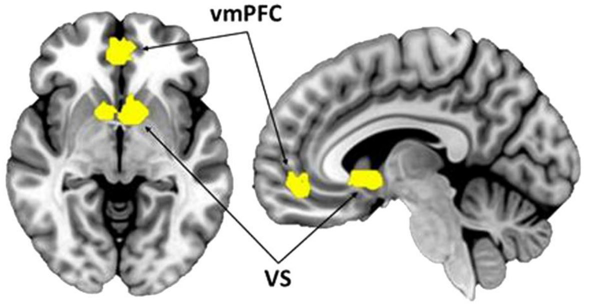

Figure 5. Value-processing ROI. The value-processing ROI includes the vmPFC and another in the VS (Baek et al., 2017).

Neurosynth association test maps are included in Supplementary material. These findings were consistent with the main findings reported in the manuscript. Finally, to test the possibility that the inclusion of CWLs induced counterarguing we examined whether neural activity in the bilateral dorsal lateral prefrontal cortex (DLPFC), a region previously associated with counterarguing (Liu et al., 2021), differed for cannabis ads with and without CWLs. Results, reported in Supplementary material, indicated that there were no significant differences in neural activity in the DLPFC between the two conditions.

Statistical analysis

Multilevel linear regression was used to quantify the effects of warning labels on activity in ROIs. In each model, mean ROI activity during the encoding of ads (compared to a fixation cross baseline) served as the outcome variable and warning label condition (present/absent) served as the predictor variable. Anticipating that responses to stimuli might vary as a factor of participants' experience with cannabis, CUDIT scores were included as a covariate. By-participant and by-post random intercepts and random slopes for warning label condition were modeled to account for the clustered nature of the data[2].

Exploratory whole brain analysis

An exploratory whole brain analysis was conducted to examine whether there were differences in neural activity between cannabis ads with CWLs compared to cannabis ads without CWLs beyond our hypothesized ROIs. Methods, results, and a brief discussion of the findings can be found in Supplemental materials.

Results

Study 1

Pictorial CWLs compared to no CWLs

The first of these two studies examined whether cannabis marketing posts paired with pictorial CWLs compared to those without CWLs influenced sharing intentions. Results demonstrated that pictorial CWLs compared to cannabis marketing ads with no warning labels was negatively associated with intentions to "like" the post ($b = -0.18$, 95% CI= -0.27, -0.09, $F(1, 1754) = 14.06$, $p = <0.001$), to share the post with specific friends (narrowcasting) ($b = -0.20$, 95% CI= -0.29, -0.11, $F(1, 1754) = 18.66$, $p < .001$), and to share the post with a larger social media network (broadcasting) ($b = -0.14$, 95% CI= -0.24, -0.05, $F(1, 1754) = 8.94$, $p = .003$). In addition, replying or commenting on a cannabis marketing post was lower for cannabis posts paired with CWLs ($b = -0.12$, 95% CI= -0.2, -0.02, $F(1, 1754) = 5.95$, $p = .015$) compared to no warning labels.

Text-only CWLs compared to no CWLs

Next, we examined cannabis marketing posts paired with text-only CWLs compared to marketing posts without CWLs influenced sharing intentions. Results indicated that text-only CWLs compared to marketing posts without CWLs were also negatively associated with liking ($b = -0.12$, 95% CI= -0.22, -0.03, $F(1,1754) = 6.45$, $p = .011$), narrowcasting ($b = -0.13$, 95% CI= -0.22, -0.04, $F(1,1754) = 8.12$, $p = .004$), and broadcasting ($b = -0.1$, 95% CI= -0.19, -0.00, $F(1,1754) = 4.16$, $p = .041$), but not replying to posts ($p > .05$).

Pictorial CWLs compared to text-only CWLs

In addition, we examined whether cannabis marketing posts paired with pictorial CWLs compared to text-only CWLs influenced sharing intentions. Results indicated that there were no significant differences between the pictorial CWL and text-only CWLs on any engagement intention ($p > .05$).

Moderation of CWLs by social media comments

Finally, we examined whether CWLs (text-only, pictorial) influence on sharing intentions were moderated by the social media comment conditions (pro-cannabis, anti-cannabis). No significant interactions were found to be associated with sharing intentions for either text-only or pictorial CWLs ($p > .05$), so we then conducted main effects analyses. Subsequent analyses examined whether the main effects of the social media comments, presented alongside social media marketing posts, were associated with sharing intentions. Results demonstrated that the presence of anti-cannabis comments along with cannabis marketing ads, compared to ads without comments, were associated with decreased intentions to like ($b = -0.16$, 95% CI= -0.26, -0.07, $F(1,1765) = 10.96$, $p = .001$) and narrowcasting ($b = -0.11$, 95% CI= -0.20, -0.02, $F(1,1765) = 5.24$, $p = .022$), however there were no significant association with broadcasting or replying or commenting ($p > .05$). Participants viewing pro-cannabis comments did not report any significantly different sharing intentions compared to seeing no comments alongside the marketing posts ($p > .05$). Complete results are presented in Table 2 and illustrated in Figure 6.

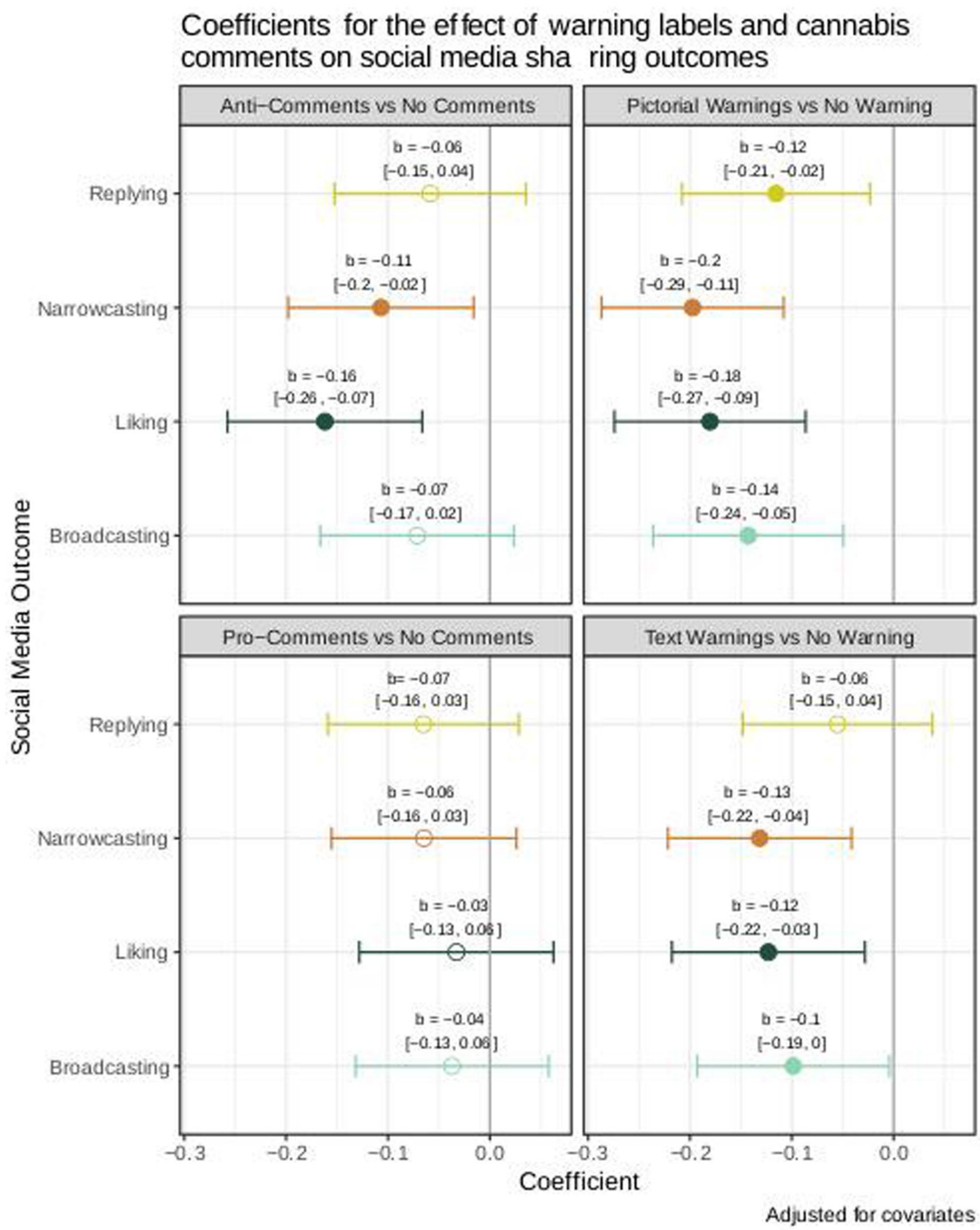

Figure 6. Effects of pictorial CWLs and cannabis comments on intentions to share. CWLs were significantly associated with decreased narrowcasting, liking, and broadcasting intentions ($p < .05$) and marginally associated with decreased replying ($p = .052$).

Study 2

Our second study tested whether neural activity in regions associated with self (mPFC+PCC), social (TPJ+PFC+precuneus), and value (VS+vmPFC) were significantly different for cannabis marketing posts presented with CWLs versus without CWLs. Results indicated that the presence of CWLs was negatively associated with activity in self-processing regions ($\beta = -0.08$, $F(1, 22.72) = 5.42$, $p = .03$). No association was observed between the presence of CWLs and activity in social- or value-processing networks, nor in attention or distraction networks ($p > .05$). Participant CUDIT scores did not significantly affect activation in any network ($p > .05$).

Discussion

Individual sharing decisions play an important role in the spread of messages on social media, and these decisions can sometimes result in the dissemination of harmful messages like those promoting risky health behaviors (Moreno et al., 2022). Thus, practitioners often attempt to negatively influence sharing decisions using interventions like warning labels (Straub & Spradling, 2022). Through two studies in the context of cannabis marketing, the present research demonstrates that the addition of pictorial warning labels can reduce both self-reported sharing intentions and activity in a network of brain regions implicated in sharing decisions.

Table 2. Study 1 results for CWL (none, picture, text) and Comments (none, anti-cannabis, pro-cannabis) conditions on social media outcomes (adjusted for covariates).

	Narrowcast				Broadcast				Like				Reply			
Predictors	*b*	*CI*	*F*	*p*	*b*	*CI*	*F*	*p*	*b*	*CI*	*F*	*p*	*b*	*CI*	*F*	*p*
(Intercept)	1.60	1.44,1.77	351.56	**<.001*****	1.37	1.20–1.55	237.78	**<.001*****	1.78	1.61–1.96	394.42	**<.001*****	1.56	1.39, 1.74	315.77	**<.001*****
Picture Warning	−0.20	−0.29, −0.11	18.66	**<.001*****	−0.14	−0.24, −0.05	8.94	**.003****	−0.18	−0.27, −0.09	14.06	**<.001*****	−0.12	−0.21, −0.02	5.95	**.015***
Text Warning	−0.13	−0.22, −0.04	8.12	**.004****	−0.10	−0.19, −0.00	4.16	**.041***	−0.12	−0.22, −0.03	6.45	**.011***	−0.06	−0.15, 0.04	1.32	.248
Anti-Cannabis Comments	−0.11	−0.20, −0.02	5.24	**.022***	−0.07	−0.17, 0.02	2.16	.142	−0.16	−0.26, −0.07	10.96	**.001****	−0.06	−0.15, 0.04	1.49	.223
Pro-Cannabis Comments	−0.06	−0.16, 0.03	1.93	.164	−0.04	−0.13, 0.06	0.58	.446	−0.03	−0.13, 0.06	0.45	0.501	−0.07	−0.16, 0.03	1.85	.174
Message																
Message 2	−0.02	−0.06, 0.03	0.59	.439	−0.00	−0.04, 0.04	0.00	.962	−0.08	−0.12, −0.03	12.46	**<.001*****	0.00	−0.04, 0.04	0.00	.958
Message 3	−0.01	−0.06, 0.03	0.48	.488	0.01	−0.03, 0.05	0.17	.684	−0.10	−0.14, −0.06	20.79	**<.001*****	0.02	−0.02, 0.06	0.79	.375
Race																
Black	0.13	0.05, 0.22	8.94	**.003****	0.27	0.18, 0.36	35.05	**<.001*****	0.16	0.07, 0.25	11.76	**.001****	0.24	0.15, 0.33	27.67	**<.001*****
Another Race	0.02	−0.08, 0.12	0.17	.682	0.04	−0.07, 0.14	0.50	.478	0.05	−0.06, 0.16	0.88	0.350	0.05	−0.05, 0.16	0.96	.326
Woman	−0.04	−0.12, 0.04	1.06	.304	−0.16	−0.24, −0.08	15.76	**<.001*****	−0.11	−0.19, −0.03	7.18	**.007****	−0.23	−0.31, −0.15	32.04	**<.001*****
LGBTQ+	−0.05	−0.13, 0.03	1.54	.215	0.00	−0.08, 0.08	0.00	.960	0.02	−0.06, 0.11	0.31	0.578	0.03	−0.06, 0.11	0.37	.545
Income																
Over $75k	−0.03	−0.13, 0.08	0.24	.622	−0.04	−0.14, 0.07	0.42	.514	−0.03	−0.14, 0.07	0.38	0.532	−0.02	−0.12, 0.09	0.08	.773
Under $35k	0.01	−0.08, 0.09	0.03	.873	0.10	0.01, 0.19	5.02	**.025***	0.02	−0.07, 0.11	0.15	0.694	0.06	−0.02, 0.15	2.07	.150
Current/Previous Tobacco Use	0.32	0.24, 0.41	54.02	**<.001*****	0.29	0.20, 0.37	39.06	**<.001*****	0.31	0.22, 0.40	45.56	**<.001*****	0.38	0.30, 0.47	72.08	**<.001*****
Social environment	0.20	0.17, 0.23	145.93	**<.001*****	0.18	0.15, 0.22	109.83	**<.001*****	0.22	0.18, 0.25	156.75	**<.001*****	0.14	0.11, 0.18	69.89	**<.001*****
Statewide Legal Cannabis	−0.04	−0.12, 0.03	1.23	.267	−0.02	−0.10, 0.06	0.18	.665	−0.05	−0.13, 0.03	1.28	0.260	−0.03	−0.11, 0.04	0.72	.393
Random effects																
σ^2	0.40				0.35				0.42				0.36			
τ_{00}	0.50 $_{\text{ResponseId}}$				0.58 $_{\text{ResponseId}}$				0.56 $_{\text{ResponseId}}$				0.56 $_{\text{ResponseId}}$			
N	1770 $_{\text{ResponseId}}$				1770 $_{\text{ResponseId}}$				1770 $_{\text{ResponseId}}$				1770 $_{\text{ResponseId}}$			
	60 $_{\text{id\_post\_num}}$				60 $_{\text{id\_post\_num}}$				60 $_{\text{id\_post\_num}}$				60 $_{\text{id\_post\_num}}$			

Note. $^{***} = p < 0.001$, $^{**} = p < 0.01$, $^{*} = p < 0.05$.

Pictorial and textual CWLs reduce self-reported social engagement intentions

Participants in Study 1 who viewed marketing posts paired with pictorial or text CWLs reported lower intentions to share and engage with those posts than participants who viewed posts not paired with CWLs. This was true of sharing with friends (narrowcasting) and networks (broadcasting). Notably, pictorial CWLs showed effects on a wider range of activities (pictorial CWLs also reduced intentions to like or reply to a post). This finding aligns with past work in suggesting warning labels suppress engagement with social media content (Wu et al., 2023) and reduce the efficacy of marketing materials (Niederdeppe et al., 2019).

This finding also has important policy implications, because the viral spread of cannabis marketing content is an emerging public health concern (Moreno et al., 2022). Given that social media sharing allows marketing content to bypass age-restricting filters (Moreno, Gower, et al., 2018), the viral spread of these messages may facilitate distribution to adolescents and other social media users under the legal age for cannabis use. Cannabis warning labels are in their nascency and likely to undergo several iterations as public health officials, policy makers, and the cannabis industry vie for space on the packages, much like tobacco warning labels (Hiilamo et al., 2014). Absent federal guidance, states with legalized cannabis have created their own, mainly text, warning labels, which this study and others have been found less effective (Massey et al., 2024; Popova et al., 2024). This study adds valuable evidence for state legislatures to consider regarding the validity of warning labels in the complex media environment, in which products are propelled by manufacturers, influencers, and consumers, not just advertisements (Razali et al., 2023).

Posts with pictorial CWLs elicit less activity in self-processing networks

Study 2 found that the presence of pictorial CWLs during cannabis post encoding was associated with decreased activity in a brain network implicated in self-processing. Given that CWLs were also associated with reduced sharing intentions in Study 1, this finding aligns with past findings that activity in self-processing regions is positively associated with sharing decisions (Baek et al., 2017; Scholz et al., 2017). These findings were not consistent with the neural model of value-based virality (Scholz et al., 2017), however, because differences were not observed in activation of the social- or value-processing networks. This is important because the value-based virality model does not assert that sharing decisions are influenced by activity in these three networks equally. Instead, the model claims that sharing decisions are directly informed by a domain-general value signal that reflects information from self- and social-processing regions and is indexed by activity in the VMPFC and VS (Scholz et al., 2017, 2020).

Although CWLs affected one of the two antecedent processes, the presence of CWLs was not associated with changes in neural activity within value regions. These findings are also inconsistent with those of other studies of sharing. For example, Falk et al. (2013) found that sharing of information after a scanner session could be predicted by activity in the social and value networks during encoding, and Motoki et al. (2020) found that only activity in the social-processing network during the encoding of videos predicted their real-world virality on Facebook (Falk et al., 2013; Motoki et al., 2020).

Differences between the findings of this study and those of other studies of sharing might be partly explained by study design. The data used to develop the neural model of value-based virality was obtained using a procedure that sometimes explicitly prompted participants to consider the act of sharing stimuli, either with close friends or with a larger online audience (Baek et al., 2017; Scholz et al., 2017). Thus, participants were primed to consider the act of sharing while encoding stimuli, and this structure may have made participants more likely to consider the relative benefits and potential social consequences of their sharing decisions. The Study 2 procedure contained no such prompt—participants were asked only to consider the marketing messages as they were presented, then to rate their effectiveness. Although this procedure arguably better resembles the passive nature of real-world social media scrolling, it also precludes us from describing observed neural processes as part of a social media sharing decision. For this reason, we do not see the findings of this study as in contrast with those of past work. Instead, these findings suggest that warning labels impact self-related processing even during evaluative encoding, which precedes real-world decisions to share social media content. This may be an early step in the process of informing sharing decisions, with social and value processes being engaged closer to the moment of the decision itself.

Though these findings differ from those of past studies on the neuroscience of sharing, they have important implications for the growing body of work associating persuasive message success with processes of self-relevance, self-reflection, and subjective value (Falk & Scholz, 2018). Dozens of studies have associated persuasive success with activation of self-processing networks during message encoding, with activation in these regions predicting perceptions of message effectiveness (Minich, Chang, et al., 2023) and message-consistent behaviors at both the individual (Falk et al., 2010) and population (Cooper et al., 2015; Falk et al., 2012) levels. Some have proposed that activity in these regions indexes processes of *subjective valuation* (Falk & Scholz, 2018) or *self-value integration* (Vezich et al., 2017), in which participants recognize message content as having specific value to themselves or their perceptions of their self-concept. Perceptions of self-relevance, as indexed by activation of self-processing regions, have also been proposed as a direct predictor of sharing intentions (Baek et al., 2017).

Past work has largely approached this brain-behavior connection from the perspective of encouraging behavior, finding that subjective valuation elicited by messages can predict desired behaviors like sharing (Baek et al., 2017) or sunscreen use (Falk et al., 2010). However, many pieces of health communication (such as health warnings) are intended to discourage behavior, a goal that is often in direct conflict with the messages they are presented alongside. Research has found that warning information can limit the effectiveness of marketing materials in a real-world setting (Niederdeppe et al., 2019), and our findings suggest that subjective valuation may also play an important role in this process. For example, it is possible that CWLs' effects on both social engagement intentions and self-processing activity can be explained by a process in which the presence of these labels distracts from or negatively impacts perceptions of message content as self-relevant. One alternative explanation for this finding is that the presence of pictorial warning labels merely distracted attention from the content of messages in general, but this is unlikely because post-hoc tests (presented in Supplementary material) suggested the presence of warning labels was not associated with changes in activation of regions associated with attention or distraction. Thus, our results suggest that the effect of warning labels is specific to processes of self-relevance.

Participants in both samples were screened for likely cannabis use (survey sample) or symptoms of cannabis use disorder (fMRI sample). This sample of habitual cannabis users may have been particularly likely to view cannabis marketing materials as self-relevant because they have experience with or would consider buying the products featured. Pictorial warning labels have previously been shown to reduce product appeal (Phua & Lim, 2023) and cravings (Wang et al., 2015) among product users, and our results suggest the disruption of self-relevance and self-reflection processes may play a role in these effects.

Limitations and future research

The findings from these studies provide interesting and useful insights that can inform both public policy and the emerging understanding of the way labels and media messages interact with the brain. However, these results are limited in some important ways. Most notably, sharing intentions were not assessed after exposure to stimuli in Study 2 due to concerns about task length and participant fatigue, so these analyses did not include any tests directly relating neural activity with sharing intentions. Although the presence of graphic CWLs on cannabis marketing messages was associated with both lower likelihood of sharing in Study 1 and less activation of brain regions associated with self-processing in Study 2, these methods were unable to provide any direct evidence connecting these two outcomes.

Past research has provided compelling evidence for brain-behavior connections in the context of message effects using the brain-as-predictor framework (Scholz et al., 2017), and future research in the area should follow a similar approach. Further, future studies seeking to test the effects of warning labels on neural activity should modify the presence of warning labels at the between-participants level. This change in design would allow researchers to capture the encoding of cannabis marketing posts by viewers naive to the content of warning labels, eliminating the possibility of carryover effects that may have obscured this study's ability to capture the true strength of warning label effects, potentially causing these effects to be underestimated.

Second, the results of this study are complicated by our choice to test the effects of both graphic CWLs and promotional messages simultaneously. This approach reflects the real-world use of product and advertisement warning labels, which are designed to interact with product packaging or marketing materials, but it allows for the possibility of stimulus confounding. Though instructions given to participants before our fMRI protocol specified they should direct their attention to the marketing materials themselves, it is likely that warning labels also induced some degree of self- and social-processing in our sample of cannabis users. Indeed, past study of pictorial warning labels in isolation has found that they affect brain regions that overlap with our networks of interest (Do & Galván, 2015). Future work in this area should strive to untangle these potentially co-occurring effects, possibly by pre-testing and deliberately manipulating the degree to which warning labels used are perceived as self-relevant by young adult cannabis users.

Finally, the samples for both studies were constrained to include cannabis users or likely cannabis users, who research suggests are most likely to encounter real-world cannabis marketing materials (Trangenstein et al., 2021). Additional analyses (presented in Supplementary material) found no evidence that the effects of warning labels were moderated by levels of cannabis use, but it remains possible that our use of different screening criteria may have led to meaningful differences in our two samples' involvement with cannabis products. Further, it is possible that our samples may have processed study stimuli differently than never-users would. For example, cannabis users might see both marketing materials and the content of warning labels as more self-relevant. Understanding these differences is important because never-users exposed to cannabis marketing materials online may be at risk of initiating cannabis use, which has been associated with a range of long-term harms (Levine et al., 2017). Thus, future research should explore the ways warning labels might affect the ways cannabis never-users experience cannabis marketing materials, with a particular interest on never-users attitudes, intentions, and efficacy perceptions surrounding cannabis use.

Conclusions

The purpose of this study was to test the effects of CWLs on decisions to share marketing posts promoting cannabis edibles and on activity in brain regions associated with similar sharing decisions. Results confirmed that the presence of CWLs was associated with reduced intentions to share these posts through social media and other online channels, which aligns with past work suggesting health warnings reduce engagement with social media content. The presence of pictorial CWLs was also associated with less activation of self-processing regions. Given past research implicating these regions in sharing decisions, this may suggest that pictorial CWLs reduce social engagement intentions partly because they reduce perceptions of self-relevance that inform sharing decisions.

Supplementary material

Supplementary material is available at *Journal of Communication* online.

Citation diversity and positionality statements

To further the importance of diversity in authorship (Zurn et al., 2020), acknowledging that papers from women and people of color are less-cited (Wang et al., 2021), we considered the first and last authors of our citations, and the predicted gender to find that our references contain 31% woman(first)/woman(last), 11% man/woman, 20% woman/man, and 37% man/man. Probabilistic matching of race revealed that our references contain 13% author of color (first)/author of color(last), 8% white author/author of color, 21% author of color/white author, and 58% white author/white author.

When the manuscript for this article was drafted, four authors self-identified as U.S. White American, and two authors self-identified as Asian.

Conflict of interest: The authors have no conflicts of interest to declare.

Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Notes

1. Note: Participants in the no-message control condition did not view any marketing posts or report any sharing intentions. This condition was intended for use in independent analyses that do not relate to sharing intentions, and so observations from this condition have not been included in this report.
2. Note: Effects of the comment condition were not modeled in the current study because comments were presented to participants during independent trials after the presentation of the cannabis ads with and without CWLs were acquired. Though it was not possible for neural processes to be impacted by the content of comments presented after stimuli, it is possible that these processes may have been impacted by the comments presented in the previous trial. To account for this possibility, we have conducted a supplemental analysis in which the condition of these comments (pro, anti, or lorem ipsum) was added as a covariate. The results, presented in supplementary materials, show no evidence that the comment condition exerted effects on neural activity or that inclusion of this parameter in our models meaningfully affected other results.

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