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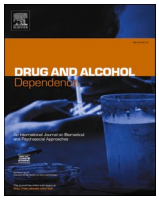

Appeal rating and visual attention associated with youth-appealing cannabis packaging: An eye-tracking experiment

Michael Cooper, Yuyan Shi *

Herbert Wertheim School of Public Health and Human Longevity Science, University of California, 9500 Gilman Dr La Jolla, San Diego, CA 92093, USA

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ABSTRACT

Background: Cannabis-infused edibles have grown in popularity particularly among young people in the United States. Youth-appealing cannabis packaging is common and associated with concerns on its public health impacts. This study aims to assess associations of youth-appealing cannabis edible package attributes with appeal ratings and visual attention of young adults.

Methods: Seventy-two young adults participated in an eye-tracking experiment, in which each participant viewed seven randomly ordered cannabis edible package images with varying youth-appealing attributes, including a cartoon character, a young adult model, bubble font, berry flavor, and gummy bear shape. Two primary outcomes were assessed: 1) appeal ratings elicited on a scale from 0 to 10 based on self-reporting, and 2) fixation durations on predefined areas of interest in the package images based on eye-tracking data. Multivariate linear regressions were conducted to assess associations.

Results: Packages containing a cartoon character, bubble font, berry flavor, or gummy bear shape received higher appeal ratings than the package with no youth-appealing attributes. Youth-appealing attributes received longer fixation durations than non-youth-appealing attributes. The presence of any youth-appealing attribute is associated with reduced fixation durations on the warning label, with the largest reduction in the package with multiple youth-appealing attributes.

Conclusions: Youth-appealing attributes on cannabis edible packages are associated with higher appeal ratings, more visual attention towards those attributes, and less visual attention towards warning labels among young adults in the United States. Regulations banning youth-appealing attributes may be effective in reducing appeal of cannabis edibles and increasing attention towards warning labels.

1. Introduction

Early onset of cannabis use and subsequent long-term and regular use among young people is associated with psychosocial impairment, altered brain development, and poor educational outcomes in addition to adverse effects common to adults. (Hall and Degenhardt, 2009; Volkow et al., 2014) Population surveys in the U.S. showed that the percentage of young adults aged 18–25 who used cannabis in the past year increased from 29.8% to 35.4% from 2002 to 2019. (Substance Abuse and Mental Health Services Administration, 2020) Although smoking dried cannabis flower remains the most popular administration method, cannabis-infused edibles have recently captured considerably increased market share, especially in legalized recreational cannabis markets. (Hammond et al., 2022) In 2022, cannabis edibles accounted for 12.1% of legal cannabis sales in the U.S. (Headset, 2022) Gummy products were the most popular type, making up 73.9% of edible sales.

Cannabis edibles present unique health risks and public health concerns compared to other administration methods. They have a significantly delayed onset of psychoactive effects, leading to a higher risk of overdose requiring healthcare visits. (Whitehill et al., 2021) They may particularly appeal to young people and nonusers due to easy and discreet use and similarity to other familiar food products. Evidence from poison center calls showed an increasing trend in pediatric exposure to cannabis requiring medical attention from 2017 to 2019, with the increase mainly caused by exposures to cannabis edibles in states with legalized recreational cannabis. (Whitehill et al., 2021).

Health risks to young people may be exacerbated by youth-appealing packaging of cannabis, which could include attributes such as cartoon characters, bright colors, bubble fonts, flavors, and food shapes. (Cao et al., 2020; Elliott, 2019) Evidence is still lacking in cannabis research,

* Correspondence to: 9500 Gilman Drive, La Jolla, CA 92093-0628, USA.
E-mail address: yus001@ucsd.edu (Y. Shi).

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but rich literatures on tobacco and food packaging have shown that youth-appealing packaging was associated with undesirable changes in visual attention, product preferences, brand recall, appeal ratings, and harm perceptions. (Cummings et al., 2002; Czoli and Hammond, 2014; Elliott, 2019; Elliott and Truman, 2020; Gallopel-Morvan et al., 2012; Ventresca and Elliott, 2022; Wakefield et al., 2002).

While over 20 U.S. states have legalized recreational cannabis, only 10 states implemented regulations specifically on cannabis edibles and all of these 10 states banned edible packages appealing to children in some form. (Barrus et al., 2016; Goundar et al., 2021) The bans range from broad but vague prohibitions on all youth-appealing styles to highly specific language prohibiting certain attributes such as cartoon characters. (Barrus et al., 2016; Goundar et al., 2021) Despite these regulations, several studies found the frequent appearance of youth-appealing edibles in legal cannabis marketplaces in practice. For example, an audit study of recreational cannabis dispensaries in California found youth-appealing products in 19.7% of dispensaries, with edibles being responsible for most of them. (Shi and Pacula, 2021) A study collected a sample of cannabis edible package images and reported that 15% imitated popular food products, 23% showed characters/mascots, and 91% contained flavor texts. (Tan et al., 2022) Another similar study found nearly 10% of sampled cannabis edible products mimicking real food brands. (Ompad et al., 2022) A study in New York city estimated a high incidence of youth-appealing attributes on discarded cannabis edible packages, with 31% mimicking a recognizable food brand, 38% depicting cartoon characters, and 76% containing two or more bright colors. (Blumenberg, 2022).

Some previous research has evaluated associations between cannabis packaging and self-reported consumer preferences with online surveys or focus groups. (Goodman and Hammond, 2020; Goodman et al., 2019, 2021; Kowitt et al., 2022; Leos-Toro et al., 2021; Mutti-Packer et al., 2018; Ventresca and Elliott, 2022) These studies assessed varied package attributes such as package style and warning labels and varied outcomes such as product appeal and credibility of warnings. Overall, the findings suggested that plain packages and warning labels reduced product appeal compared to branded packages and no warning labels. The style of package branding may also impact consumer perceptions; for example, packages based on an adventurous theme or those with celebrity sponsors or music references were perceived as more youth-oriented than other branding styles. (Kowitt et al., 2022; Leos-Toro et al., 2021) An important limitation of these studies is potentially biased subjective reporting. Little emphasis has been placed on explicitly youth-appealing packaging attributes.

Our study aims to evaluate associations of youth-appealing attributes on cannabis edible packages with appeal ratings and visual attention of young adults. We assessed appeal ratings with self-reporting and visual attention with eye-tracking technology after participants viewed a series of realistic fictional cannabis edible packages featuring various youth-appealing attributes. Our study has the potential to address limitations in previous research and make unique contributions to literature and policymaking. 1) It is the first use of eye tracking in cannabis literature, despite its popular adoption in tobacco and food literatures supporting the link between visual attention and health-related outcomes. (Graham et al., 2012; Kerr-Gaffney et al., 2018; Ma and Zhuang, 2021; Meernik et al., 2016; Motoki et al., 2021; Valsecchi and Codispoti, 2022) The objectively assessed visual attention is free of concerns about subjective reporting and recall biases. 2) Our focus on youth-appealing package attributes is novel in cannabis literature, complemented by our sampling of a young adult population. 3) We exploited within-individual variation in visual attention between multiple trials with varying package attributes, leading to more credible estimates of associations. 4) Our findings hold policy implications regarding the likely effects of bans on various youth-appealing cannabis package attributes.

2. Methods

2.1. Study sample and recruitment

From October of 2022 to February of 2023, we recruited 75 participants through university email lists for undergraduate and graduate students at the University of California San Diego. This is a large public university in San Diego, California, U.S., with an undergraduate student population of around 33,000 and a graduate student population of around 8000. People were invited to an in-person survey and eye-tracking session. A financial incentive of $40 was paid after successful completion of the experiment. The inclusion criteria were being over age 18 with no upper age limit and not having any rare eye conditions that prevent eye tracking such as glass eyes or eye-related neurological disorders. We did not restrict the sample by cannabis use status because both nonusers and users may attempt to use edibles and both populations are of policy interest. Due to our method of convenience sampling, most of the participants were young adult undergraduate students and the remaining were graduate students and other university-affiliated individuals. The eye-tracking data for three participants were unable to be calibrated at an acceptable level of accuracy. The final analysis includes 72 participants.

This study was approved by the Human Research Protections Program at the University of California San Diego.

2.2. Cannabis edible package design

We worked with a professional graphic designer to create partially fictional cannabis edible package images. Instead of using multiple real-world packages with huge variations in package features, the creation of our own package images allows us to vary a single package attribute a time while holding all other features of the package constant. To increase realism and avoid introducing unintended bias with an entirely novel, fictional package design, our base package image was a close recreation of a real cannabis gummy edible package that has no existing youth-appealing attributes and is commonly featured as a popular product in online legal cannabis marketplaces in the U.S. This specific package was selected as our base image due to its popularity, visual similarity to other packages, use of mostly neutral colors, and clearly separable package regions. The graphic designer then created package images containing fictional youth-appealing attributes based on the base package image.

We created seven package images for the experiment, displayed in Fig. 1. All elements of the seven packages are held constant except for the explicitly varied youth-appealing attributes. We selected youth-appealing attributes based on a review of literature and state laws on youth-appealing cannabis packaging. (Blumenberg, 2022; Ompad et al., 2022; Tan et al., 2022) For ease of exposition, we name each package as follows. 1) “Normal” package: it is the base package without any youth-appealing attributes. 2) “Model” package: it replaces the circular brand logo space at the top-center of the package with a young adult female model’s face depicted eating a cannabis gummy edible. 3) “Cartoon” package: it replaces the same brand logo space with a cartoon character. 4) “Bubble” package: it replaces the plain brand name text with a colorful bubble font text. 5) “Flavor” package: it replaces the image of circular off-white gummies with a red version of the same image and replaces the text “Unflavored Gummies” with the red text “Berry Flavor.” 6) “Shape” package: it replaces the image of off-white circular gummies with an image of an off-white gummy bear and replaces the text “Unflavored Gummies” with the text “Unflavored Gummy Bears.” 7) “Multi” package: it replaces several attributes at once, including the brand logo space with the cartoon character, the plain brand text with the bubble font version, the image of off-white circular gummies with a large red gummy bear, and the “Unflavored Gummies” text with “Berry Flavor Gummy Bears”.

The instrumental, non-youth-appealing attributes remain constant

Fig. 1. Package Images Used in the Experiment. 1a. "Normal" Package. 1b. "Model" Package. 1c. "Cartoon" Package. 1d. "Bubble" Package. 1e. "Flavor" Package. 1 f. "Shape" Package. 1 g. "Multi" Package.

except for the "Flavor" and "Shape" packages: the quantity is 20 gummies, the potency is 5 mg tetrahydrocannabinol (THC) per gummy, and the warning label is the standard required label under California law placed at the bottom of the package. The positional layout of all attributes remains constant throughout all packages.

2.3. Experimental Procedure

We used the EyeLink 1000 Plus eye tracker designed by SR Research. This eye tracker operates at a sampling rate of 1000 Hz in remote mode, does not require head or chin rests (potentially resulting in more natural behavior and comfort), and has a high degree of accuracy (0.25–0.50 degrees in typical conditions). We used the eye tracker in the recommended monocular mode (tracking the right eye only).

The experiment procedure involved several phases: orientation, calibration, cannabis package viewing trials, and survey. The entire experiment lasted less than an hour, with most sessions lasting between 30 and 45 minutes. 1) Orientation. When a participant arrived at the eye-tracking lab, the experimenter provided a short orientation including a summary of what to expect during the session and a brief demonstration of the eye-tracking equipment. Participants signed the consent form if they agreed to participate. 2) Calibration. Participants were seated at a typical office computer desk setup with the eye tracker's camera lens placed on the desk just below the monitor. Participants looked at a series of dots in various locations on the screen until an accurate validation reading was obtained. 3) Packaging viewing trials. Participants were given detailed instructions for package viewing. They were instructed to view each image however they like with no particular objective. They were provided with a practice round, in which a cannabis edible package image unrelated to this study was displayed. Participants then viewed seven randomly-ordered cannabis gummy edible package images one at a time. Each trial took 15 seconds before the image automatically disappeared and prompted participants to submit an appeal rating. 4) Survey. Participants took a short survey on individual demographic characteristics and substance use status.

2.4. Outcomes

Three outcomes were assessed, including two primary outcomes: 1) appeal ratings and 2) fixation durations, and one secondary outcome: 3) fixation counts. Appeal ratings were elicited immediately after participants viewed each package image. Participants were asked, "how appealing would this marijuana product be to try?" The options were a scale of 0–10, with 0 labeled as "not at all appealing" and 10 labeled as "extremely appealing." This outcome and scale have previously been used in cannabis packaging literature. (Goodman et al., 2019; Mutti-Packer et al., 2018).

Fixation duration and fixation count are common eye-tracking variables measuring how long and how many times participants look at a defined area, respectively. Informally, a fixation occurs when one's gaze settles on one area for a period of time. The eye-tracking software implements best-practice algorithms involving eye movement velocity and acceleration thresholds to separate eye movements from fixations in the raw eye position data. In our study, fixation duration measures the total number of seconds spent fixating within an interest area and fixation count measures the total number of distinct fixations within an interest area during the 15-second trial of viewing a cannabis package. Interest areas were pre-defined by rectangular or circular boundaries drawn in the EyeLink Data Viewer software, enclosing a specific package attribute such as the warning label box. These boundaries were drawn by the researchers but invisible to participants. All interest areas were defined to be non-overlapping so that any given fixation could be uniquely assigned to a single interest area, and the interest areas were identical between all package images in the experiment.

We defined five distinct interest areas. The "Logo Space" interest area is the circular region at the top-center of the package that may include brand logo, young adult model, or cartoon character depending on the package image. Other interest areas are: "Brand Name", which states the brand name in either regular font or bubble font; "Gummy", which is an image of the gummy product as circular or bear-shaped and off-white or red; "Gummy Description", which is text that describes the gummy shape and flavor; and "Warning Label", which contains a government warning text in a rectangular box.

2.5. Individual sociodemographic and behavioral variables

The following individual-level variables were gathered from the survey: cannabis package viewing trial order, sex, age, race/ethnicity, education, and past-month cannabis, alcohol, and cigarette use status.

2.6. Statistical analysis

Descriptive statistics of the study sample are provided. We display heatmaps that visually represent the unadjusted mean fixation durations across all participants on a given package, with a spectrum of color progressing from green to yellow to red indicating increasing fixation durations on each area of the package. We also show the unadjusted mean and 95% confidence intervals for the three outcome measures by package and (for eye-tracking measures only) by interest area.

Three sets of multivariate linear regressions were conducted to estimate associations between youth-appealing package attributes and outcome measures while controlling for trial order and all individual sociodemographic and behavioral variables listed in the subsection above. In all regression models, standard errors are clustered at the participant level. 1) In the first set of regressions, we compare appeal ratings between packages. The key explanatory variables are indicators for each package image, and the coefficients may be interpreted as the additional appeal rating score associated with each package relative to the reference category of the "Normal" package. 2) In the second set of regressions, we compare fixations on the same interest area between packages. For each regression, the sample is restricted to only fixations on a single interest area, and it includes all seven package images. The key explanatory variables are indicators for each package image. The coefficients on package indicators may be interpreted as the additional seconds or distinct fixations on a given interest area associated with each package relative to the reference "Normal" package. 3) In the third set of regressions, we compare fixations on the same package between interest areas. For each regression, the sample is restricted to only fixations on a single package image, and it includes all five interest areas. The key explanatory variables are indicators for each interest area, and the coefficients may be interpreted as the additional seconds or distinct fixations associated with each interest area relative to the reference "Warning Label" interest area.

We conducted a robustness check by dropping nine participants who did not have good calibration or data quality and rerun the second and third sets of regressions. These dropped participants satisfied at least one of two criteria: they were missing at least 5 seconds of eye position data within any trial, or their calibration quality was "Fair" instead of "Good." Fair calibration quality is defined as the worst point error being between 1.5 degrees and 2.0 degrees or the average error being between 1.0 degrees and 1.5 degrees. This sort of inaccuracy may be a concern if eye position data are systematically biased in a certain direction, potentially resulting in assigning fixations to incorrect interest areas or to no defined interest area at all.

Eye-tracking data cleaning and interest area creation were completed in Data Viewer 4.3.1. Data analysis was conducted in Stata SE 17.0.

3. Results

3.1. Sample characteristics

Table 1 displays the sample characteristics. The sample is majority female and racially diverse. About 60% participants are aged 18–20, and 94.44% of participants are under age 30. The 25th percentile, median, and 75th percentile of age in our sample are 19, 20, and 21.5, respectively. Past-month cannabis use prevalence is 38.89%.

3.2. Appeal Ratings

Table S1 shows the unadjusted mean and 95% confidence intervals of appeal ratings for each package. The highest mean appeal ratings are 6.18, 5.15, and 4.33 for the "Multi," "Flavor," and "Cartoon" packages, respectively. The "Normal" package containing no youth-appealing attributes has the lowest mean appeal rating at 3.19.

Table 2 reports multivariate regression results with appeal rating as the outcome variable and package indicators as the key explanatory variables. The results reinforce the observations from descriptive data in Table S1. The "Multi", "Flavor", and "Cartoon" packages are associated with higher appeal ratings than the "Normal" package, by 3.03, 1.97, and 1.09 points, respectively.

3.3. Visual attention

Table S2 shows the unadjusted mean and 95% confidence intervals of fixation duration in seconds on each interest area and package combination. In general, participants tended to look longer at interest areas containing youth-appealing attributes. The longest fixation durations are 3.85 s, 2.93 s, and 2.92 s on the young adult model, cartoon character, and flavored gummy image, respectively. The warning label received the longest fixation duration (1.56 s) on the "Normal" package, which contains no youth-appealing attributes.

Figure S1 shows heatmaps which visualize the eye-tracking data. When a package contained only one youth-appealing attribute, participants heavily fixated on that attribute. This is apparent in the "Model" and "Cartoon" packages, in which participants fixated for a long duration on the central circular area, and in the "Flavor" and "Shape" packages, in which participants fixated for a long duration on the gummy product image. In the "Normal" and "Multi" packages, participants' visual attention appears to be more evenly split between multiple competing interest areas.

Table 3 reports multivariate regression results with fixation duration as the outcome variable and package indicators as the key explanatory variables, with each column restricting the sample to a single interest area at a time. The findings generally support our observations from the raw data in Table S2 that participants looked longer at a given interest

Table 1
Descriptive Statistics of the Study Sample.

	Unadjusted Mean (%)
Sex	
Male	36.11
Female	63.89
Age	
18–20	59.72
21+	40.28
Race & Ethnicity	
Non-Hispanic White	19.44
Non-Hispanic Black	5.56
Hispanic	22.22
Non-Hispanic Other	52.78
Education	
High School or Less	27.78
Some College or Associate Degree	54.17
Bachelor's or Graduate Degree	18.06
Substance Use	
Past-month Cannabis Use	38.89
Past-month Alcohol Use	55.56
Past-month Cigarette Use	2.78
Number of Participants	72

Table 2
Multivariate Linear Regression with Appeal Rating as Outcome Variable and Package Indicators as Key Explanatory Variables.

	Appeal Rating (0–10) Coefficient [95% CI]
Package	
Normal	Reference
Model	0.28 [−0.15,0.72]
Cartoon	1.09*** [0.67,1.50]
Bubble	0.44* [0.06,0.82]
Flavor	1.97*** [1.53,2.41]
Shape	0.56** [0.15,0.98]
Multi	3.03*** [2.49,3.57]
Trial Order	
Trial 1	Reference
Trial 2	-0.56* [−0.99,−0.13]
Trial 3	-0.56* [−1.05,−0.07]
Trial 4	-0.45 [−0.96,0.05]
Trial 5	-0.08 [−0.60,0.45]
Trial 6	-0.40 [−0.98,0.18]
Trial 7	-0.19 [−0.70,0.32]
Sex	
Female	Reference
Male	0.92* [0.15,1.69]
Age	
18–20	Reference
21+	0.30 [−0.71,1.30]
Race & Ethnicity	
Non-Hispanic White	Reference
Non-Hispanic Black	0.78 [−0.64,2.20]
Hispanic	-0.57 [−2.02,0.88]
Non-Hispanic Other	0.40 [−0.75,1.55]
Education	
High School or Less	Reference
Some College or Associate Degree	0.58 [−0.37,1.53]
Bachelor's or Graduate Degree	0.58 [−0.78,1.93]
Substance Use	
Past-month Cannabis Use	0.24 [−0.95,1.44]
Past-month Alcohol Use	0.02 [−1.12,1.15]
Past-month Cigarette Use	1.57* [0.00,3.13]
Constant	2.38*** [0.98,3.77]
Number of Views	504

Notes: The table displays the results of a multivariate linear regression with appeal rating as the outcome variable and indicators for package image as the key explanatory variables, and include control variables for trial order, sex, age, race and ethnicity, education, and substance use.
* P<0.05, **P<0.01, ***P<0.001

Table 3
Multivariate Linear Regressions with Fixation Duration (seconds) as Outcome Variable and Package Indicators as Key Explanatory Variables, by Interest Area.

	Interest Area				
	Logo Space Coefficient [95% CI]	**Brand Name**	**Gummy Image**	**Gummy Description**	**Warning Label**
Package					
Normal	Reference	Reference	Reference	Reference	Reference
Model	2.23***	-0.34	-0.79***	-0.13	-0.38
	[1.68,2.78]	[−0.71,0.03]	[−1.16,−0.42]	[−0.34,0.08]	[−0.83,0.08]
Cartoon	1.28***	-0.09	-0.31	0.03	-0.17
	[0.94,1.63]	[−0.46,0.27]	[−0.68,0.06]	[−0.19,0.24]	[−0.52,0.19]
Bubble	0.03	1.11***	-0.26	-0.02	-0.30
	[−0.33,0.39]	[0.73,1.48]	[−0.66,0.15]	[−0.22,0.18]	[−0.75,0.16]
Flavor	-0.06	-0.15	1.01***	0.15	-0.49*
	[−0.39,0.27]	[−0.51,0.20]	[0.59,1.43]	[−0.07,0.38]	[−0.90,−0.08]
Shape	-0.22	-0.42*	0.71**	0.50***	-0.17
	[−0.49,0.04]	[−0.74,−0.10]	[0.28,1.15]	[0.24,0.75]	[−0.63,0.29]
Multi	0.57**	0.22	-0.10	0.59***	-0.48*
	[0.18,0.95]	[−0.14,0.57]	[−0.51,0.32]	[0.29,0.88]	[−0.92,−0.03]
Trial Order					
Trial 1	Reference	Reference	Reference	Reference	Reference
Trial 2	0.31	-0.25	0.22	0.06	-0.20
	[−0.11,0.74]	[−0.58,0.08]	[−0.10,0.54]	[−0.18,0.30]	[−0.57,0.17]
Trial 3	0.57**	-0.30	0.49**	0.07	-0.25
	[0.21,0.93]	[−0.63,0.03]	[0.17,0.82]	[−0.16,0.29]	[−0.71,0.22]
Trial 4	0.66**	-0.33	0.75***	0.13	-0.71**
	[0.21,1.11]	[−0.66,0.00]	[0.39,1.11]	[−0.15,0.40]	[−1.20,−0.23]
Trial 5	0.64*	-0.10	0.65***	0.17	-0.64**
	[0.15,1.13]	[−0.48,0.28]	[0.29,1.01]	[−0.09,0.43]	[−1.07,−0.22]
Trial 6	0.46*	-0.08	0.71***	0.30*	-0.84***
	[0.03,0.90]	[−0.44,0.28]	[0.32,1.10]	[0.04,0.56]	[−1.24,−0.45]
Trial 7	0.50*	-0.11	0.88***	0.47**	-0.71***
	[0.09,0.92]	[−0.47,0.25]	[0.50,1.26]	[0.17,0.77]	[−1.12,−0.30]
Sex					
Female	Reference	Reference	Reference	Reference	Reference
Male	-0.11	0.04	0.04	-0.04	-0.16
	[−0.52,0.30]	[−0.32,0.40]	[−0.33,0.40]	[−0.33,0.25]	[−0.70,0.39]
Age					
18–20	Reference	Reference	Reference	Reference	Reference
21+	0.11	0.08	-0.07	-0.13	-0.00
	[−0.32,0.54]	[−0.27,0.42]	[−0.61,0.46]	[−0.48,0.23]	[−0.70,0.69]
Race & Ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	-0.10	-0.26	0.28	1.08	-1.18**
	[−1.43,1.23]	[−0.68,0.15]	[−0.46,1.02]	[−0.09,2.25]	[−2.06,−0.29]
Hispanic	-0.38	0.29	-0.25	0.19	0.26
	[−0.93,0.17]	[−0.19,0.77]	[−0.79,0.30]	[−0.26,0.64]	[−0.63,1.15]
Non-Hispanic Other	0.09	0.31	-0.08	-0.01	-0.21
	[−0.42,0.60]	[−0.06,0.67]	[−0.52,0.37]	[−0.35,0.32]	[−0.88,0.45]
Education					
High School or Less	Reference	Reference	Reference	Reference	Reference
Some College or Associate Degree	0.17	-0.23	0.34	0.17	-0.36
	[−0.30,0.64]	[−0.59,0.13]	[−0.13,0.80]	[−0.09,0.43]	[−1.08,0.36]
Bachelor's or Graduate Degree	-0.31	-0.22	0.07	0.65*	-0.39
	[−0.97,0.34]	[−0.64,0.20]	[−0.58,0.72]	[0.08,1.23]	[−1.33,0.56]
Substance Use					
Past-month Cannabis Use	0.06	0.28	-0.30	0.01	-0.28
	[−0.30,0.42]	[−0.16,0.71]	[−0.70,0.10]	[−0.28,0.30]	[−0.92,0.37]
Past-month Alcohol Use	0.24	0.08	0.15	0.09	-0.36
	[−0.19,0.67]	[−0.39,0.56]	[−0.36,0.67]	[−0.22,0.40]	[−1.12,0.40]
Past-month Cigarette Use	-0.95*	-0.55**	0.33	-0.15	0.14
	[−1.75,−0.14]	[−0.90,−0.20]	[−0.12,0.78]	[−0.62,0.31]	[−0.42,0.71]
Constant	1.08**	1.98***	1.30***	0.89***	2.80***
	[0.35,1.81]	[1.47,2.49]	[0.62,1.99]	[0.44,1.33]	[1.53,4.07]
Number of Views	504	504	504	504	504

Notes: The table displays the results of five multivariate linear regressions, each presented in a different column. Each column restricts the sample to a different interest area. All regressions use fixation duration as the outcome variable and indicators for package image as they key explanatory variables, and include control variables for trial order, sex, age, race and ethnicity, education, and substance use.

* P<0.05, **P<0.01, ***P<0.001

area where the package contained a youth-appealing attribute. Compared to the "Normal" package, fixation durations on the "Logo Space" interest area are longer on the "Model", "Cartoon", and "Multi" packages which contain youth-appealing attributes in the logo area (by 2.23 s, 1.28 s, and 0.57 s, respectively). Differences are also reported for the "Brand Name" interest area on the "Bubble" package (1.11 s) and for the "Gummy Image" interest area for the "Flavor" and "Shape" packages (1.01 s and 0.71 s, respectively).

Table 3 also reveals interesting results about visual attention towards warning labels. Participants looked at the "Warning Label" interest area

for shorter durations on the "Multi" and "Flavor" packages than on the "Normal" package (by 0.48 s and 0.49 s, respectively). Additionally, the coefficients on the trial order indicators provide evidence that participants looked at warning labels for shorter durations in later trials regardless of which package image was presented.

Table 4 reports multivariate regression results with fixation duration as the outcome variable and interest area indicators as the key explanatory variables, with each column restricting the sample to a single package image at a time. On the "Normal" package, none of the four interest areas received longer fixation durations than the reference "Warning Label" interest area. On all other packages, longer fixation durations are seen on interest areas containing youth-appealing attributes for a given package. A particularly large coefficient is estimated on the "Logo Space" interest area containing the young adult model on the "Model" package, which indicates 2.61 additional seconds of fixation compared to the warning label for that package. On the "Multi" package, all four interest areas received longer fixation durations than the warning label.

Table 4
Multivariate Linear Regressions with Fixation Duration (seconds) as Outcome Variable and Interest Area Indicators as Key Explanatory Variables, by Package.

	Package						
	Normal	Model	Cartoon	Bubble	Flavor	Shape	Multi
	Coefficient [95% CI]						
Interest Area							
Logo Space	0.14	2.61***	1.53***	0.44	0.53*	-0.03	1.16***
	[−0.52,0.80]	[1.86,3.36]	[0.82,2.24]	[−0.10,0.98]	[0.06,1.00]	[−0.49,0.44]	[0.57,1.76]
Brand Name	0.47	0.48*	0.58	1.88***	0.81***	0.19	1.18***
	[−0.18,1.12]	[0.02,0.94]	[−0.01,1.16]	[1.25,2.52]	[0.37,1.26]	[−0.29,0.67]	[0.66,1.69]
Gummy Image	0.37	-0.16	0.23	0.38	1.84***	1.16***	0.76*
	[−0.33,1.07]	[−0.62,0.29]	[−0.39,0.84]	[−0.19,0.96]	[1.22,2.46]	[0.49,1.83]	[0.17,1.35]
Gummy Description	-0.23	-0.03	-0.00	0.05	0.42	0.40	0.87**
	[−0.79,0.34]	[−0.50,0.43]	[−0.60,0.60]	[−0.40,0.51]	[−0.03,0.87]	[−0.14,0.93]	[0.35,1.39]
Warning Label	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Trial Order							
Trial 1	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Trial 2	-0.16	0.07	0.55**	-0.15	0.19	-0.21	0.03
	[−0.44,0.11]	[−0.21,0.35]	[0.18,0.92]	[−0.38,0.08]	[−0.03,0.42]	[−0.45,0.04]	[−0.25,0.30]
Trial 3	0.26*	0.10	0.10	0.12	0.17	-0.05	0.12
	[0.00,0.51]	[−0.24,0.43]	[−0.15,0.35]	[−0.10,0.34]	[−0.10,0.44]	[−0.34,0.24]	[−0.20,0.45]
Trial 4	0.19	0.15	0.22	-0.05	0.07	-0.19	0.11
	[−0.09,0.47]	[−0.16,0.46]	[−0.03,0.47]	[−0.33,0.24]	[−0.39,0.52]	[−0.38,0.01]	[−0.19,0.40]
Trial 5	0.16	0.17	0.10	0.07	0.15	0.20	0.19
	[−0.10,0.41]	[−0.22,0.56]	[−0.12,0.33]	[−0.14,0.28]	[−0.07,0.38]	[−0.03,0.43]	[−0.19,0.58]
Trial 6	0.04	-0.04	-0.00	0.26*	0.23*	-0.16	0.21
	[−0.21,0.29]	[−0.43,0.36]	[−0.21,0.20]	[0.02,0.50]	[0.02,0.43]	[−0.42,0.09]	[−0.08,0.51]
Trial 7	0.16	0.30	0.24	-0.07	0.48***	0.18	0.28
	[−0.18,0.49]	[−0.00,0.60]	[−0.02,0.50]	[−0.29,0.16]	[0.23,0.73]	[−0.02,0.38]	[−0.01,0.57]
Sex							
Female	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Male	-0.05	-0.01	-0.03	-0.03	-0.11	-0.13	-0.08
	[−0.18,0.09]	[−0.20,0.19]	[−0.19,0.13]	[−0.16,0.11]	[−0.27,0.05]	[−0.28,0.03]	[−0.22,0.06]
Age							
18–20	Reference	Reference	Reference	Reference	Reference	Reference	Reference
21+	-0.07	-0.02	-0.11	0.06	-0.16	0.07	0.10
	[−0.23,0.08]	[−0.24,0.21]	[−0.29,0.06]	[−0.09,0.21]	[−0.33,0.01]	[−0.10,0.24]	[−0.03,0.23]
Race & Ethnicity							
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	-0.18	-0.13	-0.22	0.41*	0.06	0.07	0.08
	[−0.51,0.15]	[−0.57,0.31]	[−0.64,0.19]	[0.09,0.72]	[−0.15,0.28]	[−0.17,0.31]	[−0.36,0.52]
Hispanic	0.16	0.08	-0.22	-0.09	0.06	0.21	-0.03
	[−0.06,0.38]	[−0.18,0.34]	[−0.45,0.01]	[−0.31,0.13]	[−0.17,0.29]	[−0.01,0.42]	[−0.20,0.13]
Non-Hispanic Other	0.02	0.07	-0.05	0.07	0.17	0.05	0.01
	[−0.16,0.21]	[−0.17,0.30]	[−0.23,0.13]	[−0.09,0.24]	[−0.03,0.37]	[−0.11,0.22]	[−0.17,0.19]
Education							
High School or Less	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Some College or Associate Degree	-0.09	0.15	0.09	0.01	0.07	0.04	0.05
	[−0.26,0.07]	[−0.10,0.39]	[−0.13,0.32]	[−0.14,0.16]	[−0.15,0.29]	[−0.12,0.20]	[−0.11,0.21]
Bachelor's or Graduate Degree	-0.13	0.14	0.15	-0.04	0.02	-0.20	-0.16
	[−0.36,0.10]	[−0.20,0.48]	[−0.14,0.44]	[−0.26,0.19]	[−0.24,0.28]	[−0.45,0.04]	[−0.39,0.07]
Substance Use							
Past-month Cannabis Use	-0.09	0.05	-0.03	-0.17*	0.01	-0.05	-0.13
	[−0.25,0.06]	[−0.18,0.29]	[−0.25,0.18]	[−0.33,−0.01]	[−0.15,0.16]	[−0.19,0.08]	[−0.31,0.06]
Past-month Alcohol Use	0.11	-0.07	0.13	0.22**	-0.05	0.05	0.06
	[−0.05,0.27]	[−0.30,0.15]	[−0.09,0.34]	[0.06,0.38]	[−0.23,0.14]	[−0.09,0.18]	[−0.09,0.21]
Past-month Cigarette Use	-0.16	-0.33	-0.56***	-0.15	-0.14	-0.20	-0.32
	[−0.41,0.08]	[−1.03,0.36]	[−0.75,−0.37]	[−0.65,0.35]	[−0.85,0.57]	[−0.87,0.47]	[−0.88,0.24]
Constant	1.51***	1.03***	1.28***	1.14***	0.87***	1.41***	0.95***
	[0.91,2.11]	[0.51,1.54]	[0.65,1.91]	[0.71,1.57]	[0.48,1.27]	[0.93,1.90]	[0.42,1.47]
Number of Views	360	360	360	360	360	360	360

Notes: The table displays the results of seven multivariate linear regressions, each presented in a different column. Each column restricts the sample to a different package image. All regressions use fixation duration in seconds as the outcome variable and indicators for interest areas as the key explanatory variables, and include control variables for trial order, sex, age, race and ethnicity, education, and substance use.

* P<0.05, **P<0.01, ***P<0.001

Table S3 shows the unadjusted mean fixation counts by interest area and package combination, and Tables S4 and S5 report multivariate regression results with fixation counts as the outcome variable. These results are in line with those using fixation durations as the outcome variable.

3.4. Robustness check

As a robustness check, we dropped nine participants who did not have good calibration or data quality. The results remain qualitatively similar to our main results (results not reported).

4. Discussion

This is the first study using both subjective (via self-reporting) and objective (via eye tracking) assessments to examine associations of youth-appealing attributes on cannabis packages with appeal ratings and visual attention. Overall, we find that youth-appealing package attributes are associated with higher appeal ratings and longer visual attention. This finding is supported by tobacco and food literatures, which have demonstrated substantial evidence that youth-appealing attributes were associated with increased visual attention, product preference, brand recall, appeal ratings, and reduced harm perceptions. (Cummings et al., 2002; Czoli and Hammond, 2014; Elliott, 2019; Elliott and Truman, 2020; Gallopel-Morvan et al., 2012; Ventresca and Elliott, 2022; Wakefield et al., 2002).

Some observations are noteworthy regarding specific youth-appealing attributes. First, the package with multiple youth-appealing attributes received the highest appeal rating out of all packages. Because of the presence of multiple attributes, these attributes compete for visual attention and no specific attribute stands out. Second, the package changing from no flavor to berry flavor is associated with a substantial increase in appeal ratings and visual attention. Third, the package replacing the logo with a cartoon character also increases appeal ratings and visual attention substantially. Lastly, in one case, appeal ratings and visual attention are at odds with each other. The image with the face of a young adult model received low appeal ratings but long fixation durations on the face. The finding on fixation duration was expected, as tobacco literature suggested that images of people in e-cigarette ads attracted more visual attention of young adults than any other ad features such as product descriptors or brand logos, but the finding on appeal ratings was unexpected. (Stevens et al., 2020) Further research is needed to replicate and interpret the findings.

The observations on the "Warning Label" interest area are also interesting. Participants looked at the warning labels for the longest when youth-appealing attributes were absent. They looked at the warning labels for a shorter duration when the package had any single youth-appealing attribute. In addition, the package with multiple youth-appealing attributes further reduced visual attention to the warning labels than any single attribute alone. As the trials progressed, visual attention on warning labels became shorter, suggesting that static visual stimulus may be only effective in the first few times that people view it.

Our study findings have several implications regarding implementing cannabis packaging regulations to reduce harms among the vulnerable young adult population. First, policymakers may consider banning youth-appealing attributes on cannabis packages, particularly attributes highlighting flavors and adding cartoon characters, to reduce their appeal and ability to attract attention. Literature on tobacco and food packaging showed that people tended to choose products which received longer fixation durations or higher fixation counts, indicating that visual attention is linked to subsequent purchase and consumption behaviors. (Bialkova et al., 2014; Graham and Jeffery, 2012; Meernik et al., 2016) Restricting youth-appealing attributes has the potential to reduce initiation and consumption of cannabis among young adults. Second, comprehensive bans on all possible youth-appealing attributes seem likely to have the largest effects. The plain packaging requirements for cannabis sold in Canada are an example of such a strict regulatory regime, where only explicitly permitted package attributes are allowed with no room for the cannabis industry to push the boundaries of youth-appealing designs. Third, even partial bans that only target a subset of youth-appealing attributes are still likely to impact consumer behaviors. Some partial bans may have larger impacts than others, such as those banning flavors or cartoon characters, compared to those banning bubble fonts or animal shapes. Many states in the U.S. have adopted this partial ban strategy. However, the enforcement of partial bans seems to lack success, as youth-appealing cannabis packages have been frequently observed in studies auditing dispensaries and packages. (Blumenberg, 2022; Ompad et al., 2022; Shi and Pacula, 2021; Tan et al., 2022) Fourth, banning youth-appealing attributes is likely to increase visual attention towards warning labels. Lastly, the impacts of static warning labels may fade as consumers see them multiple times, whereas policies renewing the novelty of warning labels are likely to increase visual attention towards them. Similar results have been found in tobacco control literature, which led public health advocates to recommend rotating warning messages. (Hammond, 2011) Our study provides support to state laws or pending bills that add rotating warning messages on cannabis packages or in cannabis packages as inserts.

Our study has limitations. First, we recruited a small sample with convenience sampling, which is inevitable in all eye-tracking studies because the experiment requires in-person lab visits. The sample naturally provides a policy-relevant sample of young adults but is not representative of the broader U.S. young population. Because of the university being public and located in Southern California, our sample is not representative of the undergraduate population in the U.S., either, with non-Hispanic Whites and non-Hispanic Blacks being underrepresented and non-Hispanic other minorities being overrepresented. Further, our findings may not extend to adolescents under age 18. Future research to validate the study findings in larger samples outside of the current setting is needed.

Second, our package images are partially fictional even though they were based on a real cannabis gummy edible package, so our findings may not extend to other real-world package designs. There may be other versions of the same youth-appealing attributes such as a different cartoon character or combinations of attributes, which may yield different impacts than those found in our study. Third, we focused our study on youth-appealing package attributes, but a promising direction for future research could be to use similar experimental methods to analyze the effects of other package attributes such as warning label size, placement, and texts.

Fourth, we chose gummy products in this study because they have by far the largest market share out of all cannabis edibles, (Headset, 2022) but the findings may not generalize to other forms of edibles. In addition, we did not measure substance use directly prior to the experiment nor ask subjects to abstain from substance use before arriving at the lab. Lastly, we measured appeal ratings and visual attention, but our research did not directly test how higher appeal ratings or visual attention may impact purchase or consumption behaviors.

5. Conclusion

This study elicited self-reported appeal ratings and used eye tracking to measure the visual attention of a group of young adults in the U.S. after they viewed cannabis edible packages with varied youth-appealing attributes. We find that youth-appealing attributes on cannabis edible packages are associated with higher appeal ratings, more visual attention towards those attributes, and less visual attention towards warning labels. Regulations banning youth-appealing attributes may be effective in reducing appeal of cannabis edibles and increasing attention towards warning labels.

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CRediT authorship contribution statement

MC: conceived the study, designed the study, collected data, performed data analysis, and drafted the manuscript. YS: obtained the funding, supervised the study, conceived the study, designed the study, participated in data analysis, and edited the manuscript. Both authors approved the final version of the manuscript.

Declaration of Competing Interest

No conflict of interest declared.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.drugalcdep.2023.110992.

References

Barrus, D.G., Capogrossi, K.L., Cates, S.C., Gourdet, C.K., Peiper, N.C., Novak, S.P., Lefever, T.W., Wiley, J.L., 2016. Tasty THC: promises and challenges of cannabis edibles. Methods Rep. RTI Press 2016.

Bialkova, S., Grunert, K.G., Juhl, H.J., Wasowicz-Kirylo, G., Stysko-Kunkowska, M., van Trijp, H.C., 2014. Attention mediates the effect of nutrition label information on consumers' choice. Evidence from a choice experiment involving eye-tracking. Appetite 76, 66–75.

Blumenberg, A., 2022. A cross-sectional assessment of package labels aimed at children of edible and leaf cannabis discarded in New York City. Toxicol. Commun. 6 (1), 78–84.

Cao, Y., Carrillo, A.S., Zhu, S.H., Shi, Y., 2020. Point-of-Sale marketing in recreational marijuana dispensaries around california schools. J. Adolesc. Health 66 (1), 72–78.

Cummings, K.M., Morley, C.P., Horan, J.K., Steger, C., Leavell, N.R., 2002. Marketing to America's youth: evidence from corporate documents. Tob. Control 11. Suppl 1 (Suppl 1), I5-17.

Czoli, C.D., Hammond, D., 2014. Cigarette packaging: Youth perceptions of "natural" cigarettes, filter references, and contraband tobacco. J. Adolesc. Health 54 (1), 33–39.

Elliott, C., 2019. Tracking kids' food: comparing the nutritional value and marketing appeals of child-targeted supermarket products over time. Nutrients 11 (8).

Elliott, C., Truman, E., 2020. The power of packaging: a scoping review and assessment of child-targeted food packaging. Nutrients 12 (4).

Gallopel-Morvan, K., Moodie, C., Hammond, D., Eker, F., Beguinot, E., Martinet, Y., 2012. Consumer perceptions of cigarette pack design in France: a comparison of regular, limited edition and plain packaging. Tob. Control 21 (5), 502–506.

Goodman, S., Hammond, D., 2020. Does unit-dose packaging influence understanding of serving size information for cannabis edibles? J. Stud. Alcohol Drugs 81 (2), 173–179.

Goodman, S., Leos-Toro, C., Hammond, D., 2019. The impact of plain packaging and health warnings on consumer appeal of cannabis products. Drug Alcohol Depend. 205, 107633.

Goodman, S., Rynard, V.L., Iraniparast, M., Hammond, D., 2021. Influence of package colour, branding and health warnings on appeal and perceived harm of cannabis products among respondents in Canada and the US. Prev. Med 153, 106788.

Goundar, P., Macaulay, T., Szafron, M., 2021. A comparative analysis of laws on recreational cannabis edibles between Canada and the United States of America. Int J. Drug Policy 94, 103191.

Graham, D.J., Jeffery, R.W., 2012. Predictors of nutrition label viewing during food purchase decision making: an eye tracking investigation. Public Health Nutr. 15 (2), 189–197.

Graham, D.J., Orquin, J.L., Visschers, V.H.M., 2012. Eye tracking and nutrition label use: A review of the literature and recommendations for label enhancement. Food Policy 37 (4), 378–382.

Hall, W., Degenhardt, L., 2009. Adverse health effects of non-medical cannabis use. Lancet 374 (9698), 1383–1391.

Hammond, D., 2011. Health warning messages on tobacco products: a review. Tob. Control 20 (5), 327–337.

Hammond, D., Goodman, S., Wadsworth, E., Freeman, T.P., Kilmer, B., Schauer, G., Pacula, R.L., Hall, W., 2022. Trends in the use of cannabis products in Canada and the USA, 2018 - 2020: Findings from the International Cannabis Policy Study. Int J. Drug Policy 105, 103716.

Headset, 2022. Cannabis Edibles: An analysis of category trends & performance. Availale at https://www.headset.io/industry-reports/cannabis-edibles-an-analysis-of-category-trends-performance. Accessed on July 10, 1023. Headset.

Kerr-Gaffney, J., Harrison, A., Tchanturia, K., 2018. Eye-tracking research in eating disorders: a systematic review. Int J. Eat. Disord.

Kowitt, S.D., Yockey, R.A., Lee, J.G.L., Jarman, K.L., Gourdet, C.K., Ranney, L.M., 2022. The impact of cannabis packaging characteristics on perceptions and intentions. Am. J. Prev. Med 63 (5), 751–759.

Leos-Toro, C., Fong, G.T., Hammond, D., 2021. The efficacy of health warnings and package branding on perceptions of cannabis products among youth and young adults. Drug Alcohol Rev. 40 (4), 637–646.

Ma, G., Zhuang, X., 2021. Nutrition label processing in the past 10 years: contributions from eye tracking approach. Appetite 156, 104859.

Meernik, C., Jarman, K., Wright, S.T., Klein, E.G., Goldstein, A.O., Ranney, L., 2016. Eye tracking outcomes in tobacco control regulation and communication: a systematic review. Tob. Regul. Sci. 2 (4), 377–403.

Motoki, K., Saito, T., Onuma, T., 2021. Eye-tracking research on sensory and consumer science: a review, pitfalls and future directions. Food Res Int 145, 110389.

Mutti-Packer, S., Collyer, B., Hodgins, D.C., 2018. Perceptions of plain packaging and health warning labels for cannabis among young adults: findings from an experimental study. BMC Public Health 18 (1), 1361.

Ompad, D.C., Snyder, K.M., Sandh, S., Hagen, D., Collier, K.J., Goldmann, E., Goodman, M.S., Tan, A.S.L., 2022. Copycat and lookalike edible cannabis product packaging in the United States. Drug Alcohol Depend. 235, 109409.

Shi, Y., Pacula, R.L., 2021. Assessment of recreational cannabis dispensaries' compliance with underage access and marketing restrictions in California. JAMA Pedia 175 (11), 1178–1180.

Stevens, E.M., Johnson, A.L., Leshner, G., Sun, F., Kim, S., Leavens, E.L.S., Tackett, A.P., Hebert, E.T., Wagener, T.L., 2020. People in E-cigarette ads attract more attention: an eye-tracking study. Tob. Regul. Sci. 6 (2), 105–117.

Substance abuse and mental health services administration, 2020. Key substance use and mental health indicators in the United States: results from the 2019 National Survey on Drug Use and Health. Substance Abuse and Mental Health Services Administration, Rockville, MD.

Tan, A.S.L., Weinreich, E., Padon, A., Sanchez, M., Snyder, K.M., Vasilyeva, A., Sandh, S., Goldmann, E., Goodman, M., Ompad, D.C., 2022. Presence of content appealing to youth on cannabis-infused edibles packaging. Subst. Use Misuse 57 (8), 1215–1219.

Valsecchi, M., Codispoti, M., 2022. Eye tracking applied to tobacco smoking: current directions and future perspectives. J. Eye Mov. Res 15 (1).

Ventresca, M., Elliott, C., 2022. Cannabis edibles packaging: communicative objects in a growing market. Int J. Drug Policy 103, 103645.

Volkow, N.D., Baler, R.D., Compton, W.M., Weiss, S.R., 2014. Adverse health effects of marijuana use. N. Engl. J. Med 370 (23), 2219–2227.

Wakefield, M., Morley, C., Horan, J.K., Cummings, K.M., 2002. The cigarette pack as image: new evidence from tobacco industry documents. Tob. Control 11. Suppl 1 (Suppl 1), I73-80.

Whitehill, J.M., Dilley, J.A., Brooks-Russell, A., Terpak, L., Graves, J.M., 2021. Edible cannabis exposures among children: 2017-2019. Pediatrics 147 (4).