



Quantitative Visual Analytics for Optimizing Brand Identity in Packaging Design

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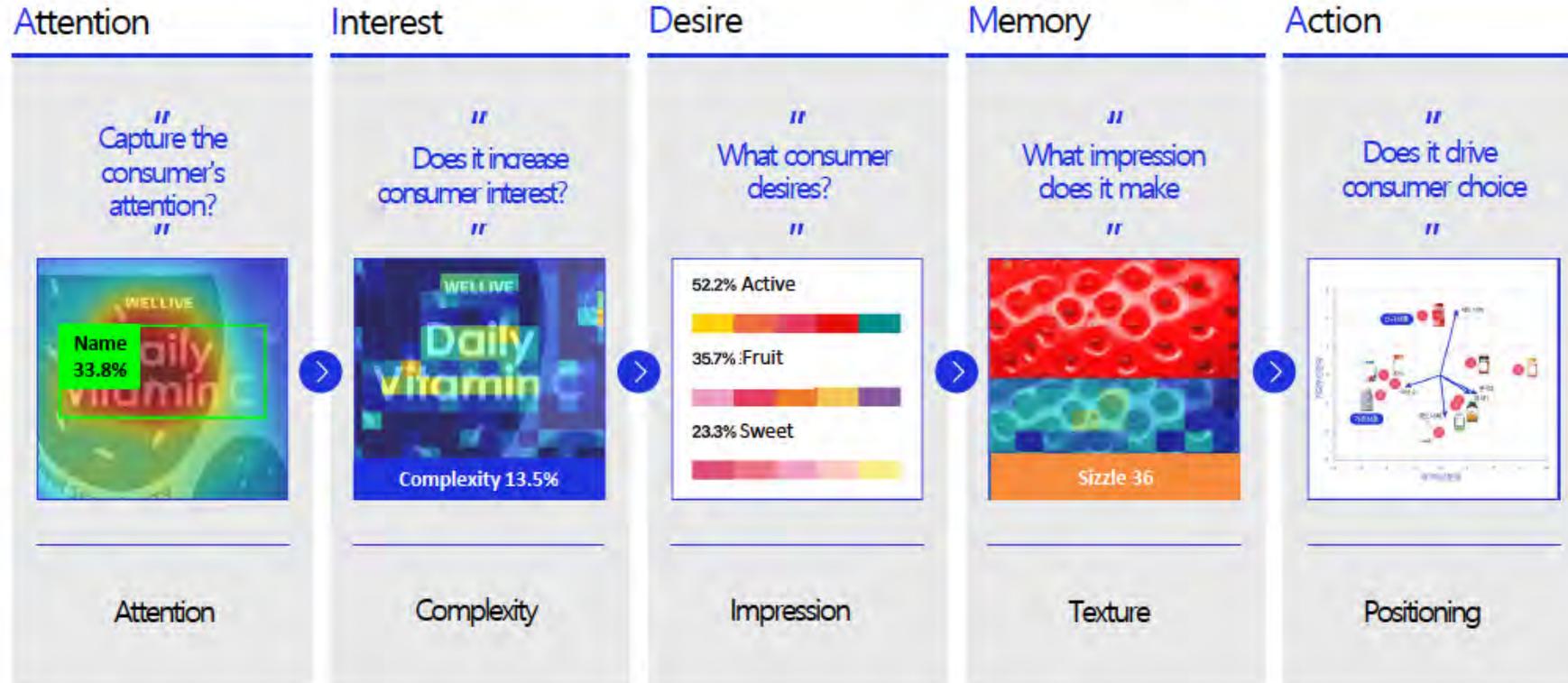
What is the focus of why we do this?



- Product packaging renewal can result in a loss of that product's identity / drop in sales
- Design elements contribute to the identity. Changes to the product design can cause uptick / downtick in sales
- 5 months of design work
 - \$35M marketing investment
 - \$20M sales decline in one month

Looking to understand purchasing behavior

* AIDMA Customer Purchasing Behavior



Part of a much larger project

Scope

- Previous study
 - Recent advancements in AI technology have enabled the creation of CNN (convolutional neural network) models that can learn and classify package images of specific brands
 - Notably, brand identification using CNN has been validated in studies involving brand logos and fashion show runway photos
- Grad-CAM (Gradient-Weighted Class Activation Mapping)
 - To identify CNN visual attention when recognizing the brand of a package
 - In this study, the model used for classification is finally converted into 4,096 features by convolving in 5 layers, so it is difficult for the human eye to know what is contributing to the classification result, The Grad-CAM method makes it somewhat easier for humans to recognize

Investigation overview

- Part 1: Multi-class classification model based on visual geometry group
 - Data collection and preprocessing
 - Model training and validation
 - Performance evaluation
- Part 2: The alignment between human and the model attention regions
 - Psychological experiment for collecting eye-tracking data
 - Heatmap generations
 - Comparison between human and AI visual attention
- Part 3: Filter analysis and ablation study
 - Extracting and analyzing filters
 - Ablation study
 - Analyzing the degree of filter's contribution on model decisions

Model Construction

Data collection and preprocessing

- Collect 6,000 package images from Google for 5 stationery brands
 - Only those works for which the copyright has expired.
 - The brand name were masked

e.g., Brand A's Packages



120 packages

× 5 brands = 6000 packages

- Brand A: Luxury brand
- Brand B: Luxury brand
- Brand C: Mass-market brand
- Brand D: Mass-market brand
- Brand E: lesser-known brand

Model Training and Validation

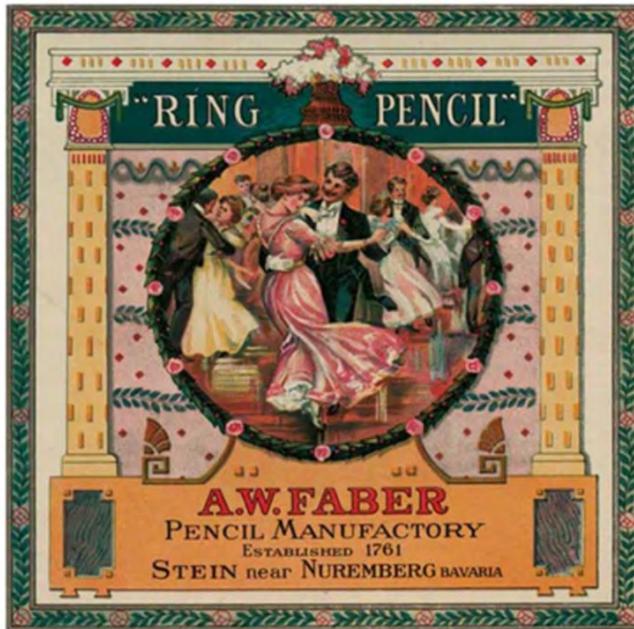
- Model
 - VGG16 pre-trained on ImageNet
 - Output size of the final layer adjusted to 5 to classify brands A through E
- Dataset:
 - 70% of the dataset for training
 - 30% of the dataset for validation
- Training and Validation:
 - Conducted 2,000 times
 - The data was shuffled each time
 - With a batch size of 32 and 10 epochs

→ a validation accuracy of 91%

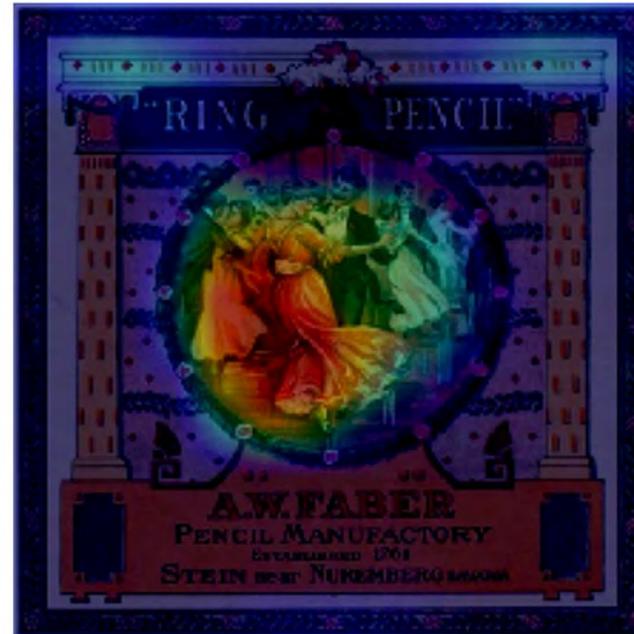
Results from model training and validation

- The CNN model identifies the vivid central illustration as a key visual element for brand recognition. Particularly, the colors and dynamic movements of the figures in the illustration serve as crucial visual cues defining the brand's identity

Original Image



Grad-CAM



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Human eye tracking

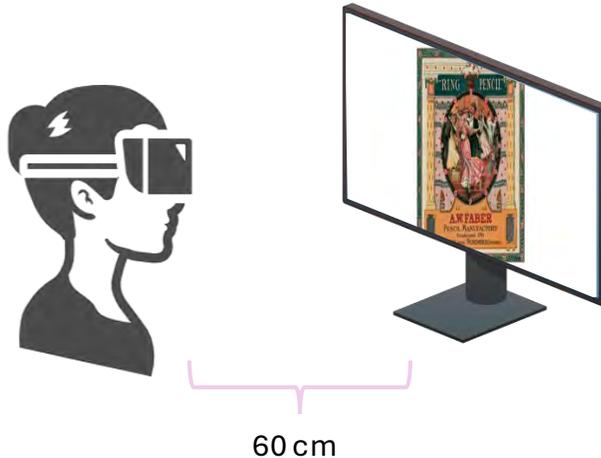
Participants

6 Adults 2 female and 4 males (39.8 ± 7.9 years) having normal visual acuity.

Procedure

Looking at a package, participants:

1. Identified which brand from A to E the package belonged to
2. Rated their confidence level in that classification (0-100%)



× 10 times
for learning each brand's VIs

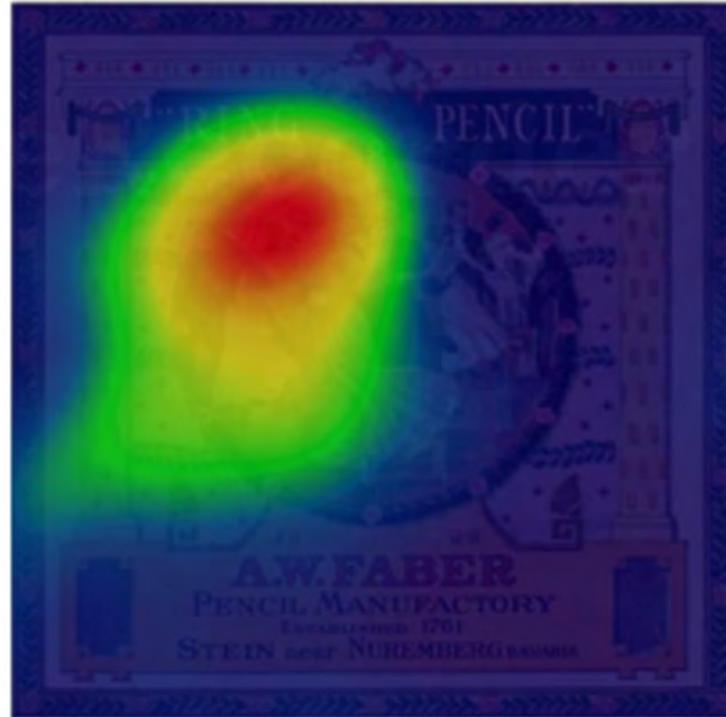
× 20 times
for classifying packages

Eye movements were recorded during only the classification process.

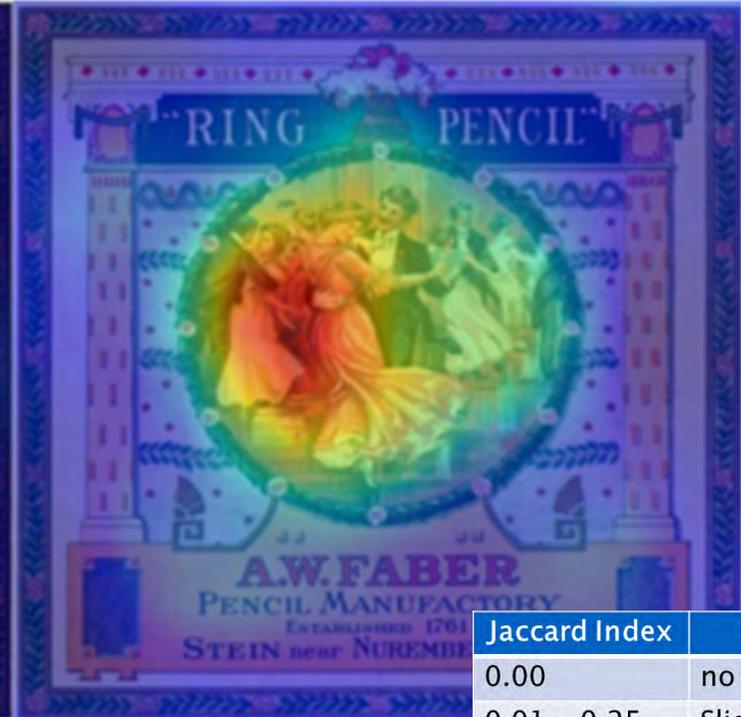
Results from correlation

- Average heatmap agreement between the two exceeds 0.32
- Attention areas of humans and models were found to have moderate similarity
- CNN successfully captured visual features that humans use

Eye-tracking



Grad-CAM



Jaccard Index	Interpretation
0.00	no overlap
0.01 - 0.25	Slight similarity
0.26 - 0.50	Moderate similarity
0.51 - 0.75	High similarity
0.76 - 1.00	almost identical

Investigation overview

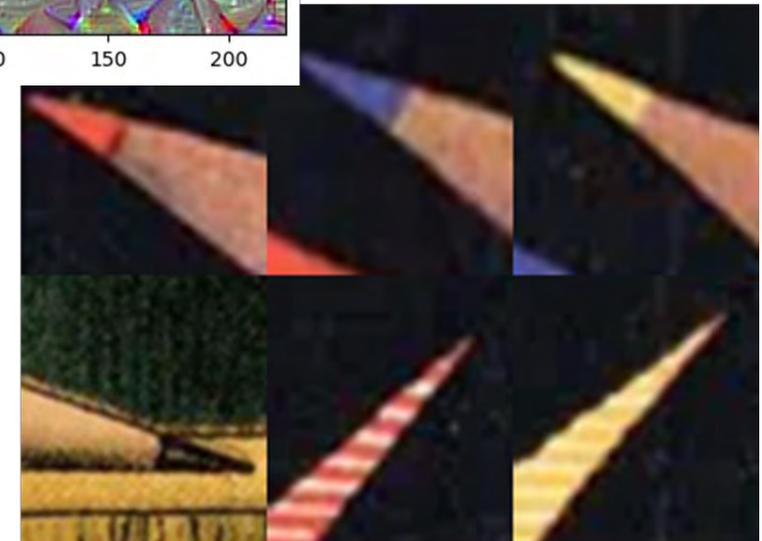
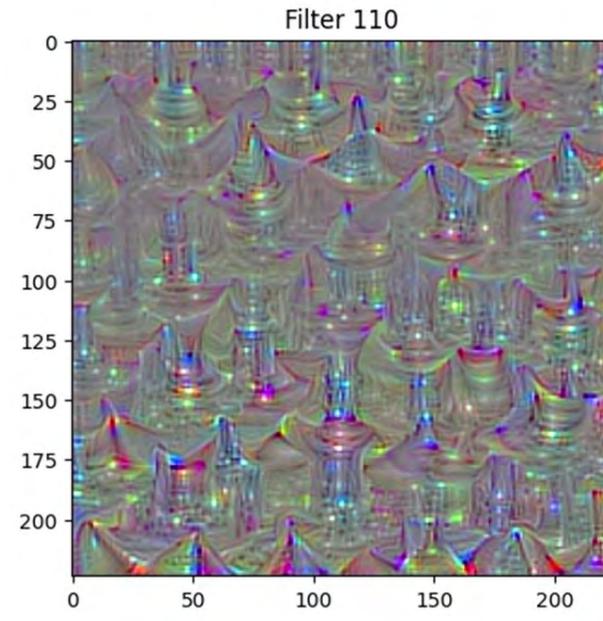
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Model investigation

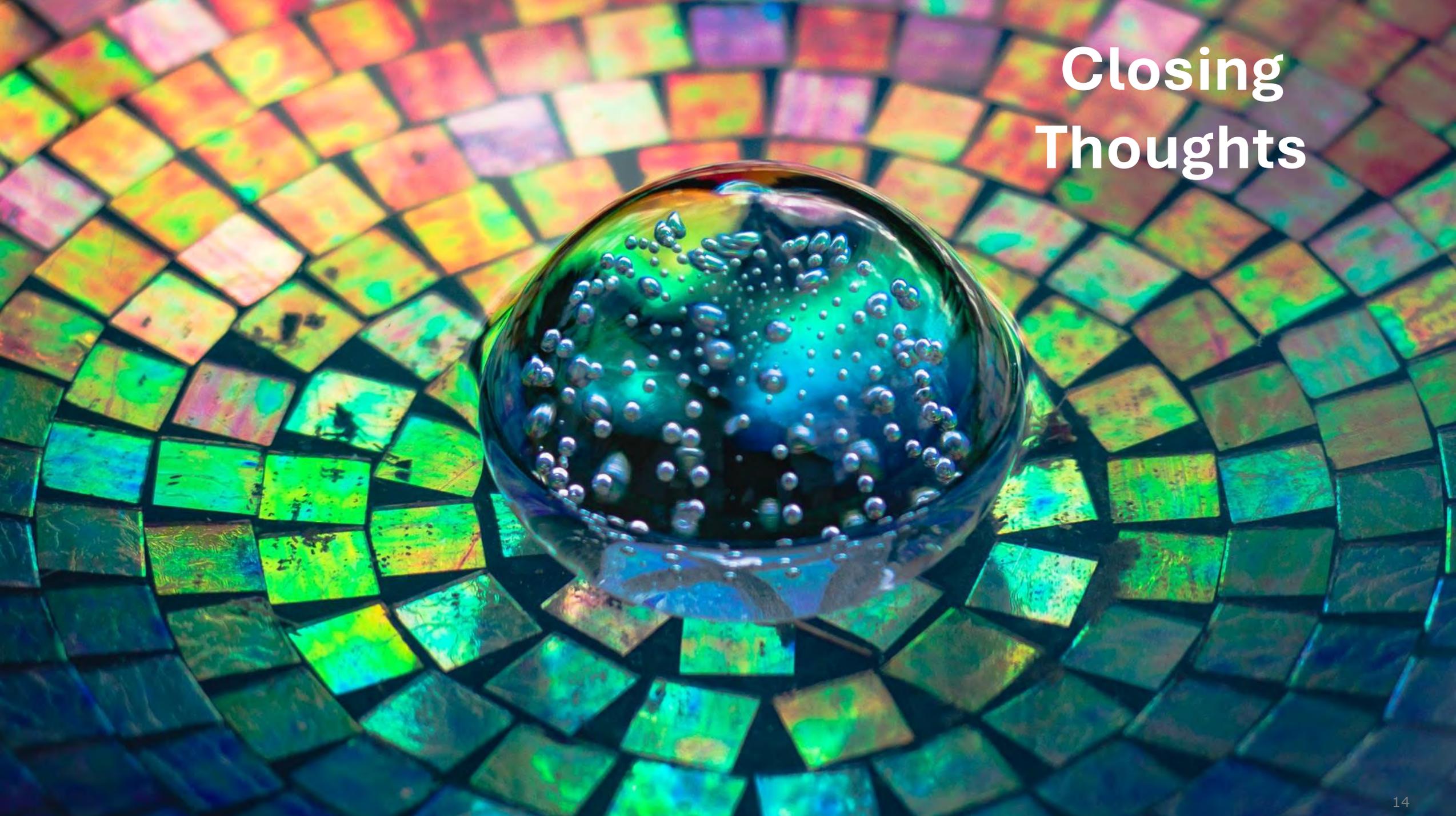
- To analyze the visual information processing of the CNN model and identify design elements that contribute to Brand A's brand identity
- Filter Visualization
 - The filters in the middle layers of the CNN model were visualized to identify the visual elements the model focuses on when recognizing brand A - e.g., particular colors, edges, or shapes
- Ablation Study:
 - An ablation study was conducted to assess the contribution of each filter to the model's performance. This involved systematically disabling individual filters and observing the impact on the model's classification accuracy.

Analysis overview

- Why use these?
 - Clearly identifying specific visual elements constituting brand identity
 - Allowing companies to protect essential visual features during redesign, reducing risks associated with changing package designs
 - Objectively manage and preserve the visual elements crucial for brand recognition
- Sample results
 - 20 of the filters worked well for brand A
 - From 512
 - For instance, one filter worked on the sharp tips of pens and filters
 - Eliminating this resulted in 20% loss of recognition accuracy

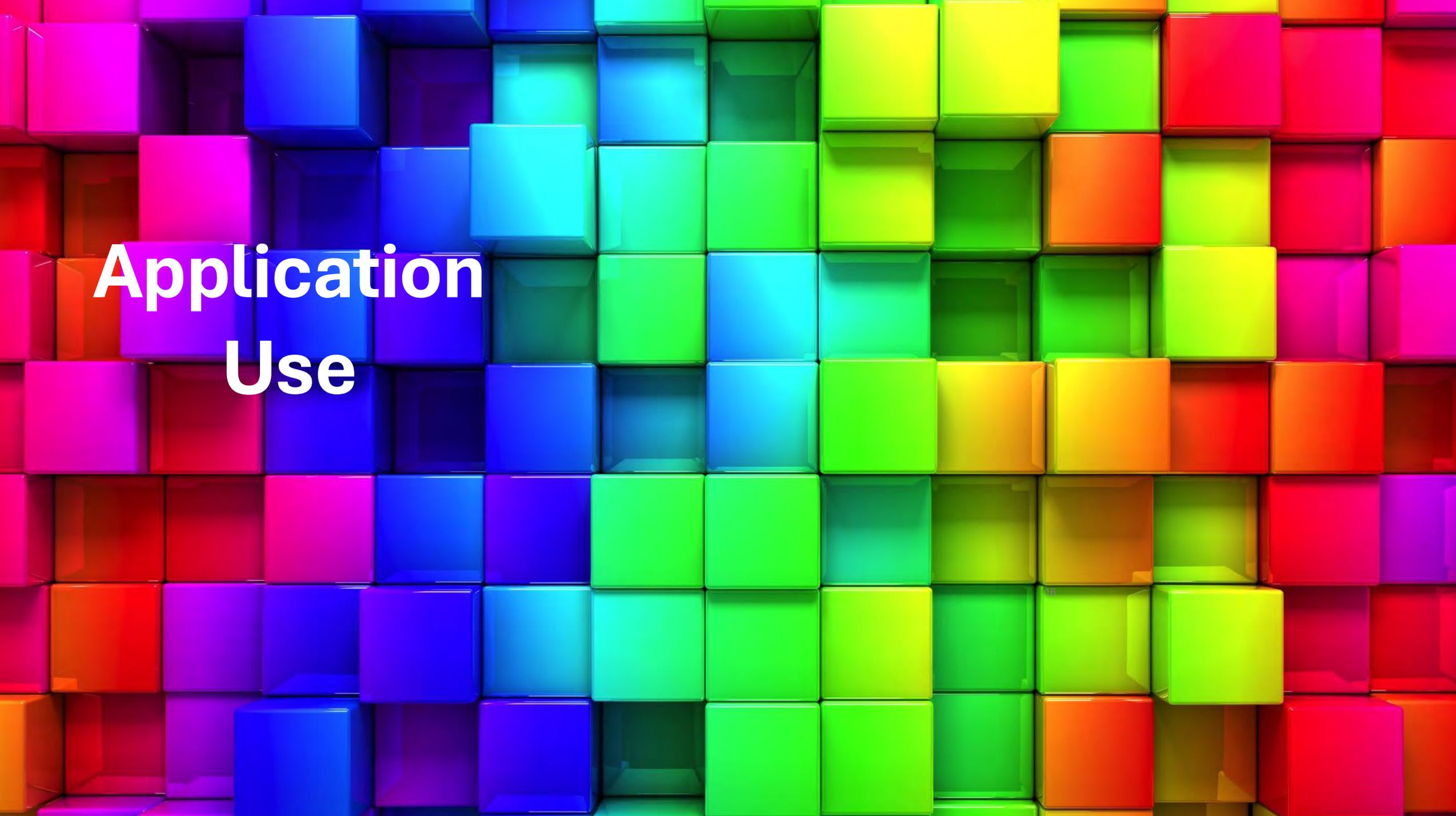


Closing Thoughts



Some closing thoughts on the model

- The machine learning model can identify important design elements in brand recognition
- Visualization using Grad-CAM showed partial agreement between the visual recognition of humans and machine learning models
- This will contribute to the quantitative management of brand identity and the development of effective packaging design strategies
- While Grad-CAM is an effective method of highlighting important areas, it tends to be biased toward visually prominent areas
- Further experimentation and expansion of the data set are needed to generalize the results



Application Use

What does this translate to? Which is most memorable?



Example with shampoo

Concept design >>> Generate images >>>

POP display design 3 patterns



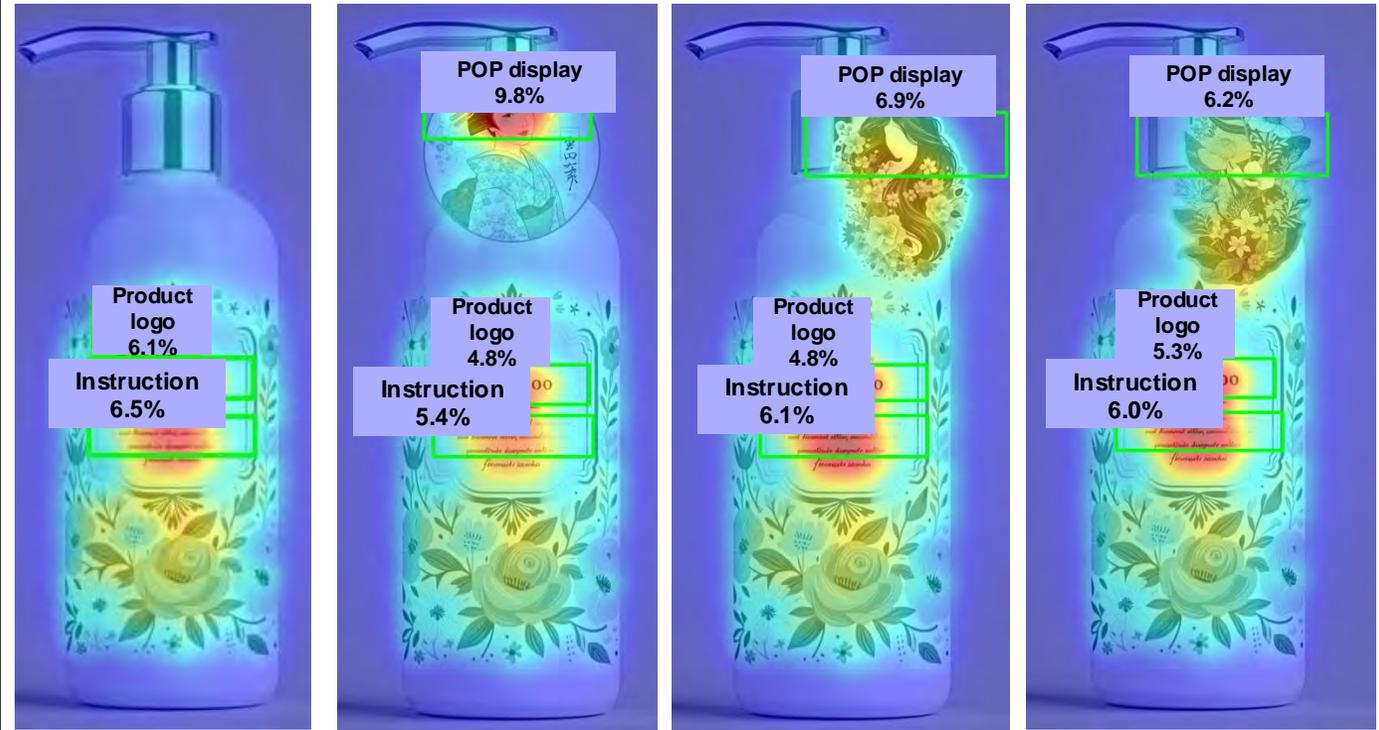
Bottle of shampoo sample



Analysis results/Interpretation



As a human instinct, illustration/image with eyes tends to grab attention the most. Shampoo bottle without POP display earns less than 7% of attention. Statistically speaking, A part where earns more than 7% of attention is easily remembered of 80% of people.



Let's finish with a beer!

- Suntory released their new brand line in April 2023, but the design planning began over a year prior
 - Image renew, brand-new concept of design although, a hint of following industry style...
- Their new concept of the package design is based on *Beer Barrel Image*
- Narrowing down to three package designs and analyze those using software
- The current package's impression was shown the most "clear message" "Easy to recognize"
- Their new design was finalized by attention analysis and impression analysis results



Suntory's other brand lines have been tended to highlight "name of product"



New product line contrastingly highlight company name & New approach of package design by imaging of beer barrel

Thank you



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