rijksuniversiteit groningen

# The Relationship Between Brand Memory, Image Memorability, and Fixation Durations While Viewing Picture Advertisements

Bram Koiter

Master Thesis – Applied Cognitive Neuroscience

S3171248
July 2022
Department of Psychology
University of Groningen
Examiner/Daily supervisor:
Dr. M. R. Nieuwenstein

A thesis is an aptitude test for students. The approval of the thesis is proof that the student has sufficient research and reporting skills to graduate, but does not guarantee the quality of the research and the results of the research as such, and the thesis is therefore not necessarily suitable to be used as an academic source to refer to. If you would like to know more about the research discussed in this thesis and any publications based on it, to which you could refer, please contact the supervisor mentioned.

## Abstract

The purpose of print advertisements is to increase brand recognition. Print advertisements often contain images, and recent research has shown that images differ consistently across individuals in terms of how well they will be remembered. Previous research found a negative correlation between brand recognition and the memorability of images used in self-fabricated simple ads. The goals of this study were to test the replicability of this result and to investigate the relationship between image memorability, viewing behavior, and brand recognition. A sample of 35 participants viewed 40 advertisements of 10 different product types containing either a high (N = 20) or a low (N = 20) memorable image and a brand name while their eye movements were tracked, followed by an unannounced brand recognition test. The results showed no evidence for a relationship between image memorability, the fixation durations for the brand names and images, and brand recognition, thus failing to replicate the earlier finding of a negative effect of image memorability on brand recognition. Taken together, these results suggest that image memorability does not affect brand recognition after viewing print advertisements.


*Keywords:* image memorability, brand memory, eye tracking, fixation durations, picture advertisements

# The Relationship Between Brand Memory, Image Memorability, and Fixation Durations While Viewing Picture Advertisements

It is commonly known that advertising increases the consumer's familiarity with a particular brand (Baker et al., 1986), which is one of the most influential factors contributing to a brand's equity (Amiri & Maroofi, 2016). Therefore, advertising is a crucial component of a brand's marketing strategy in order to increase the brand's equity.

Even though many different digital types of advertising are used nowadays, print advertisements are still very common, with a global spending of 52.7 billion USD in 2021 (Statista, 2022). In these ads, an image is often used to capture the viewer's attention, while the whole ad's purpose is to give a quick impression of the brand (Pieters & Wedel, 2004).

In fact, when viewing a print ad, people are able to identify the brand and its product within 100 ms in 80% of the time (Pieters & Wedel, 2012). However, mere identification of a brand name is not the main goal of advertising, as marketeers are primarily interested in whether advertising influences brand recognition and the consumers' familiarity with a brand (Solomon, 2009).

## Advertisement Viewing Behavior

To improve brand recognition, advertisements should capture and keep the attention of consumers. Therefore, the distribution of visual attention is crucial for the effectiveness of print advertisements, since consumers cannot encode a brand name if they are not aware of it. The distribution of visual attention when viewing ads is influenced by several bottom-up and top-down factors. An example of a bottom-up factor is the complexity of an ad, found by Pieters et al. (2010), who studied the relation between ad complexity and visual attention by monitoring fixation durations on elements of advertisements varying in complexity while the participants viewed the ads at their own pace. They found that a higher feature complexity (more variation in e.g., color, luminance and edges) decreases the visual attention towards the brand name, while an increased design complexity (e.g. increased number, irregularity and detail of objects or irregularity of object arrangement) increased fixation durations on the pictorial elements and the ad as a whole. Additionally, Pieters et al. (2002) found that originality (determined by four independent judges) of an ad is positively related to the brand recognition and visual attention measured by fixation frequency of ad elements while individuals viewed print advertisements at their own pace.

Examples of top-down factors influencing visual attention are the viewer's intention, knowledge, and subjective evaluation of the advertisement. Evidence for a role of the viewer's intention was found by Rayner et al. (2001), who measured visual attention by both duration and frequency of fixations and found that individuals viewed ads longer and with greater fixation frequencies, when they looked at an ad that contained a product that they wanted to buy. Moreover, Rayner et al. (2008) found a difference when participants were instructed to rate the advertisement either on effectiveness or whether they liked the ad. Lastly, people fixate longer on familiar advertisements than on unfamiliar advertisements when they were presented together (Pieters & Wedel, 2004). In short, the distribution of visual attention is dependent on both the composition of the ad and the circumstances under which the ad is viewed.

**Image Memorability**

Whereas the brand recognition is dependent on several factors within the individual and will thus vary between individuals, the memorability of images is rather stable. Additionally, recent research has shown that not all images are remembered equally well, as some are recalled consistently better while others are forgotten more easily across individuals (Isola et al., 2011).

Various studies have investigated which factors are related to memorability. The results showed that some characteristics partly predict an image's memorability, while others did not have a significant effect on memorability. For instance, features of an image like interestingness (Gardezi et al., 2021), saturation and hue do not correlate with its memorability. In contrast, conceptual properties such as the presence of persons, floors and seats in an image have a positive effect on its memorability, while the presence of ceilings, buildings and trees decrease an image's memorability (Isola et al., 2011; Isola et al., 2012). Importantly, however, the predictive value of these conceptual properties is limited, as differences in memorability are also visible within these categories (Bylinskii et al., 2015).

Furthermore, the saliency of elements in an image is positively correlated with image memorability. In more detail, Mancas and Le Meur (2013) approximated the saliency of regions in a natural scene by determining the surface that an individual has fixated on when viewing the scene. Specifically, when only a small proportion of the total surface is viewed, this indicates the presence of salient regions, since the individual did not look at the other elements. The proportional surface viewed of a natural scene was negatively correlated with its memorability, indicating that images are more memorable when they contain salient

regions. Additionally, Dubey et al. (2015) found that image memorability is positively correlated with the maximum memorability score of the objects in an image, which is predicted by the salience of the objects.

In addition to these image characteristics, extrinsic factors such as the context (e.g., the presence and type of other images that are presented in the same sequence) in which the image is presented and eye movements (discussed elaborately below) also influence memory of the image (Bylinskii et al., 2015). On the other hand, Goetschalckx et al. (2019) found a large overlap between intentional and incidental pictorial memory during an unannounced memory test, suggesting that image memorability is independent of instructions given to viewers. Overall, previous research has found ambiguous results regarding the influence of extrinsic factors on image memorability.

**Image Memorability and Eye Movements**

Besides the factors mentioned above, one of the most important factors that relates to image memorability, are the eye movements while viewing the image. Damiano and Walther (2019) performed a study during which eye movements were monitored while the participants viewed images for three seconds and had to report whether they had seen them before or not. Based on the performance of the whole sample, memorability scores were determined for each image. They found no difference in fixation frequency or durations between low and high memorable images, but individuals showed a higher number of fixations for images they remembered correctly as an individual. Thus, fixation frequency while viewing an image is related to remembering an image and not to its intrinsic memorability.

In addition to fixation frequency, image memorability can be predicted by the fixation pattern of an individual. More specifically, images have a higher chance of being recognized when the individual's fixation patterns of the first and second viewing moment match with each other (Bylinskii et al., 2015; Marterelli & Mast, 2013). This effect does not only occur in the immediate recall, but was also found one week later (Marterelli & Mast, 2013).

Even though research has been done on how differences in viewing behavior affect memorability, Kostova and Nieuwenstein (2021) found that memorability also affects viewing behavior. In an advertisement viewing study, they found a negative correlation between the total time that the ad was viewed and the priorly determined memorability of the image included in the advertisement. This finding indicates that memorability is not only related to fixation frequencies, patterns or duration of each fixation apart, but might also be related to absolute viewing durations.

## Image Memorability and Brand Recognition

Although a substantial amount of research has been carried out on brand recognition and image memorability separately, only a few studies have examined the relationship between image memorability and brand memory. In one of the first studies on this relationship, Wit and Nieuwenstein (2020) and Kostova and Nieuwenstein (2021) examined the effect of image memorability on brand recognition by fabricating 100 simple advertisements consisting of a brand name paired with an image from the MemCat database (Goetschalckx & Wagemans, 2019). After viewing the advertisements, brand memory was examined using an unannounced brand recognition test.

The results showed no difference in brand recognition between ads containing either a high or a low memorable image. However, Kostova and Nieuwenstein (2021), who selected 40 advertisements containing the 20 lowest and 20 highest memorable images from Wit and Nieuwenstein (2020), found a negative correlation between brand-name recognition and image memorability. They speculated that the decreased brand recognition with memorable images could be explained by assuming that memorable images attract more attention than less memorable images, causing the viewer to pay less attention to the brand name and therefore leading to a decrease in the chance of encoding it.

Furthermore, Kostova and Nieuwenstein (2021) found a positive correlation between total viewing time and brand recognition. They suggested that memorable images are easier to make sense of, both visually and conceptually, resulting in a shorter viewing duration. In turn, the shorter viewing duration results in a worse encoding and therefore a worse recognition of the brand name.

## Current study

The current study replicates the study of Kostova and Nieuwenstein (2021), while using eye tracking to monitor the participants' viewing behavior. The first research question is whether the results of Kostova and Nieuwenstein (2021) can be replicated. If so, we would expect image memorability to correlate negatively with brand-name recognition and total viewing time of the advertisement, while a positive correlation is expected between brand-name recognition and viewing time of the ad.

Additionally, by using eye tracking data, we will try to answer the question whether advertisement viewing behavior is related to the memorability score of the image included in the ad. We expect that individuals will look longer at a memorable image than at a non-memorable image, since image memorability is associated with the presence of more salient

objects or scenes (Dubey et al., 2015; Mancas & Le Meur, 2013). This salience difference may cause the gaze to direct towards the more salient image (Treue, 2003), and would therefore result in less attention being paid towards the brand name, causing a worse encoding resulting in a worse recognition of the brand name (Constant & Liesefeld, 2021).

## Methods

### Participants

Prior to the participant recruitment, ethical approval was obtained from the Ethics Committee. To estimate the sample size needed, an a priori power analysis was performed based on the previous research of Kostova and Nieuwenstein (2021), who found a negative relationship between image memorability and total viewing time of the advertisements. Based on the results of the power analysis, a sample size of N = 32 was found to be sufficient to find a significant negative correlation between image memorability and total viewing time with alpha = .05 and power = .80.

In line with the power analysis, a sample of 35 students at the University of Groningen and Hanze University of Applied Sciences Groningen (15 male, 20 female) participated in this study with a mean age of 21 years (SD = 2). The sample consisted of 22 first-year psychology students at the University of Groningen whose participation was compensated with study credits and 13 volunteers recruited via the social network of the researcher. Participants were assigned to one of the two versions of the experiment depending on their subject number; odd numbers were assigned to the first version, even numbers to the second.

People were not allowed to participate in this study if they wore glasses or were younger than 18 years old.

### Materials

#### *Hardware and Software*

The experiment is almost an exact replica of the experiment of Kostova and Nieuwenstein (2021) and was built and run in OpenSesame version 3.3.11 (Mathôt et al., 2012) using a 27-inch LCD monitor with a resolution of 1024 x 768 pixels and a refresh rate of 100 Hz. The gaze direction was recorded using an EyeLink 1000 desktop mount (SR Research, Mississauga, Ontario, Canada), with a sampling frequency of 1000 Hz. To maximize the stability of the head during the experiment, a head rest was fixated at a distance of approximately 60 cm from the monitor to a height adjustable desk. To ease the integration

of the eye tracker into the OpenSesame experiment, the Python software package PyGaze (Dalmaijer et al., 2014) was used.

***Advertisements***

The first phase of the experiment consisted of the presentation of 40 advertisements that were selected from Wit and Nieuwenstein (2020). The advertisements concerned 10 different categories of products and contained a brand name and an associated image shown below it on a black background. The brand names were presented in a Times New Roman font, with font size 48. The image was centered both horizontally and vertically on the screen, while the brand name was centered horizontally and was vertically located between the top and the center of the screen. An example of the advertisements used for the category of pleasure boats is shown in Figure 1.

**Figure 1**

*Four Advertisements Used in the Pleasure Boat Category*


*Note*. The illustrations of the advertisements are not drawn to scale, but are cropped from full screen

The advertisements were selected from those used in the study of Wit and Nieuwenstein (2020), who used a total of 100 advertisements with 10 advertisements per category. For the current study, four advertisements were selected from each category, namely those with lowest and highest image-memorability scores for each category. In every category, two images had a low memorability score (M = .64, SD = .12), the other two had a high score (M = .88, SD = .06). The images differed in terms of their height (183 to 300 pixels) and width (240 to 384 pixels). The complete overview of memorability scores per advertisement are included in the Appendix.

The images presented in the advertisements were selected from the MemCat database created by Goetschalckx and Wagemans (2019), which contains 10,000 images with a memorability score. In a study with 249 participants, they presented thousands of pictures consecutively, while some pictures were repeated once with a lag ranging from 19 to 149

images. The participants' task was to determine whether they had seen the image before or not. The memorability scores reflect the hit rate, uncorrected for false alarms.

All brand names included in this study were selected from Wit and Nieuwenstein (2020). The brand names that were included in the advertisements, i.e. the target brand names, were selected based on name length and brand familiarity. This way, a memorable and non-memorable image were paired with a brand name of equal length and familiarity. In addition to the target brand names, four non-target brand names were included for each category in an unannounced brand-name recognition test, which had similar lengths as the target brand names within each category.

## Research Design

The study had a within-subjects design with one factor, namely image memorability (high vs. low). The assignment of brand names to memorable and non-memorable images was counterbalanced across participants, so that any difference in the intrinsic memorability of the brand names could not confound the effect of image memorability on brand recognition in the analysis.

## Procedure

Prior to the experimental session, the participant signed a written consent. At the start of the experiment, a thirteen-point calibration and validation were performed for the right eye, after which the experiment consisted of three phases: viewing advertisements (encoding phase), the test for brand recognition (recall phase) and an ensuing brand-name familiarity judgment task. The experiment had a total duration of approximately 30 minutes. To optimize standardization, the instructions for each phase were presented on screen and additional oral instructions were only given when the participant asked for them or when it was clear that the participant did not understand the instructions correctly. For example, when they took over a minute to continue to the next advertisement, they were reminded that they could progress to the next ad by clicking the mouse. Participants were not informed on the presence of the second phase of the experiment, to ensure that the recognition test for brand names would reflect incidental memory.

### *Phase one: viewing advertisements*

During the first phase of the experiment, the participants viewed forty advertisements while their eye movements were tracked. Each advertisement trial contained a single-point recalibration prior to a fixation dot that was displayed for 1500 ms, followed by the

advertisement. The participants were instructed to pay close attention to the advertisements and could view the ads as long as they would like. When they were done viewing the advertisement, they could move on to the next ad by clicking a mouse button. The fixation dot was centered between the brand name and the image of the advertisement to prevent that the participant's gaze direction was towards the image or brand name at the moment the ad was presented.

The advertisements were presented in a fixed order of ten blocks of four trials, one block for each category. In each block, advertisements with memorable and non-memorable images were alternated. At the start of each block, the participants received instructions to pay close attention to the advertisements and they were informed which category of advertisements they were about to see (i.e., 'The next series of advertisements are ads for pleasure boats').

***Phase two: unannounced recognition test***

After the encoding phase, the unannounced recognition phase started, during which the participants' eye movements continued to be tracked. This phase contained eighty trials presented in a random order, containing a single-point recalibration prior to a fixation dot displayed for 1500 ms, followed by a brand name that either did (N = 40) or did not (N = 40) appear in one of the advertisements. The participants were asked whether they recognized the brand name from the advertisements or not and they responded by means of pressing the 'z' or the 'm' key.

***Phase three: brand name familiarity***

In the last phase of the experiment, participants were asked to rate their pre-participation familiarity with the forty brand names that were presented in the advertisements on a 5-point Likert scale (1 = unfamiliar, 5 = very familiar) in a random order. No eye tracking data was collected during this phase.

## Data Analysis

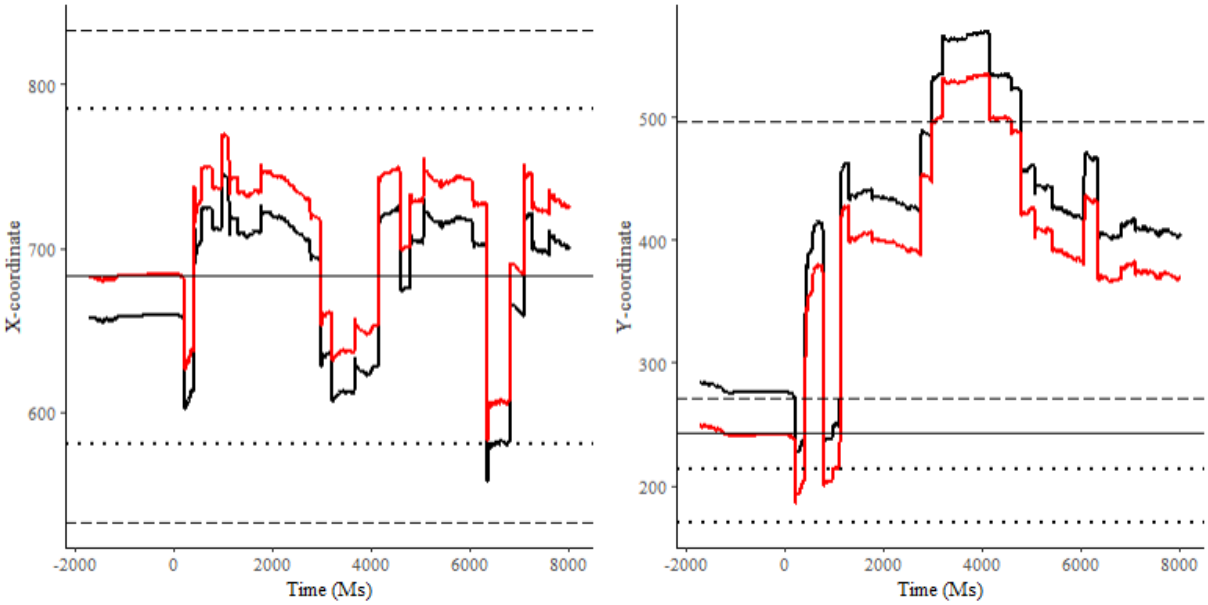
The preprocessing of the data and statistical analysis were performed using R Studio version 2022.02.0 + 443 (Boston, USA). During the preprocessing of the raw eye-tracking data, blinks were removed from the x- and y-coordinate data using the pupilMiner package (van der Mijn, 2022). The analysis of the x- and y-coordinate data consisted of determining the duration for which participants looked at the image, the brand name, or something else while viewing the advertisement in the first phase of the experiment.

Participants were removed from the study when they performed at chance, defined as a false alarm rate that was equal to or greater than their hit rate or when they did not complete the experiment. Trials were excluded from the data analysis when the total viewing duration was three or more standard deviations above or below the mean viewing duration of that participant. Additionally, trials were removed when a consecutive period longer than 500 ms had to be interpolated for the eye-tracking data.

A visual inspection of the eye-tracking data of phase one showed deviations in the gaze direction from the fixation dot during the fixation phase. Since it was assumed that participants looked at the fixation dot during the fixation phase, a linear correction was performed for the x- and y-coordinates of the gaze direction data based on the difference between the mean of the data during the fixation phase and the coordinates of the fixation dot. An example of a trial with the uncorrected and the corrected data is shown in Figure 2.

**Figure 2**

*Example of the Linear Correction Based on the Fixation Phase*




*Note.* The left and the right figure show the x- and y-coordinates of the gaze direction of the uncorrected (black) and corrected (red) data. Time = 0 represents the onset of the presentation of the advertisement. The solid black horizontal line represents the coordinates of the fixation dot and the broken lines represent the borders of the image (dashed) and the brand name (dotted). Note that the (0;0) coordinate was located at the top left of the screen, which is why the brand name is below the fixation dot and image in the right plot.

After the correction for the fixation phase, it appeared that participants often fixated just below the brand name, resulting in 331 trials during which the participant did not look at the brand name. Therefore, the bottom of the brand name's region of interest was expanded to

the mean of the y-coordinate of the brand name's bottom and the y-coordinate of the fixation dot. This correction decreased the number of trials during which the participant did not look at the brand name to 191. The results of the statistical analyses, reported below, did not depend on whether this correction was applied. We therefore decided to report the results for the uncorrected regions of interest in the Results section below.

## Statistical Analysis

### *Packages*

The correlations and t-tests were done by calculating Bayes Factors (BF) using the BayesFactor package (Morey et al., 2021) and interpreted following the guidelines of Wetzels et al. (2014)**.** The linear mixed effect models were performed using the lme4 package (Bates et al., 2015) and their fits were compared by computing the BF using the flexplot package (Fife, 2019). The ggplot2 package (Wickham, 2016) was used to visualize the data.

### *Correlations*

To determine the relation between the memorability scores of the images, the viewing behavior of the participant, and whether the participant recognized the brand name or not, correlations coefficients were estimated following the Bayesian Approach. Specifically, we examined the correlations between the average hit rate per image (i.e., the proportion of times the brand name was recognized correctly), the average total viewing time of the advertisement (T-TOT), the memorability score of the image shown in the advertisement, the average fixation duration on the brand name (T-BN), and the average fixation duration on the image (T-IMG).

### *Comparing Advertisements With Low and High Memorable Images*

To test the difference between advertisements with images with low and high memorability scores, Bayesian paired t-tests were performed on the participants' mean hit-rate, T-TOT, T-IMG, T-BN, mean 'proportion of the total time spent viewing the image' (P-IMG), and mean 'proportion of the total time spent viewing the brand name' (P-BN).

### *Linear Mixed Effect Models*

**Predicting Brand Recognition.** A generalized linear mixed effect model was computed to determine whether the recognition of a brand name could be predicted by fixation durations and advertisement characteristics. The null model contained brand recognition accuracy as dichotomous dependent variable, no fixed effects and participant as random effect to take the individual differences into account. Variables were added to the null model on a theoretical basis and the fits of the models were compared using the Bayesian

Information Criterion (BIC) and the BF of the model. To compare the individual models with the model of the sample as a whole, a logistic model was fitted to the sample data.

We included the following predictors of brand recognition as fixed effects in the model: T-TOT, image-memorability, T-IMG, T-BN, P-IMG, P-BN, 'total duration fixating on the brand name and the image' (T-BN-IMG) and 'proportion of the total viewing time spent fixating on the brand name and the image' (P-BN-IMG), brand name size and image size.

**Image Memorability as Predictor of Fixation Durations.** Furthermore, linear mixed effect models were performed to determine the influence of memorability on the viewing behavior per participant. The null model only included participant as a random effect. In the other models, 'memorability' was included as predictor and the various indices of viewing behavior were included as the dependent variable. A linear model was fitted to the sample data to compare the individual models with the model of the sample as a whole.

The indices of viewing behavior that were included as dependent variables were: T-TOT, T-BN, T-IMG, T-BN-IMG, P-BN, P-IMG and P-BN-IMG. Since the analysis involved comparing models with different fixed effects, the ordinary likelihoods were used instead of the restricted maximum likelihood estimation, which is the default in RStudio (Oehlert, 2012).

## Results

### Data Exclusion

One participant was removed from the analyses because the experiment was not completed due to technical issues. In addition, 49 trials of 13 different participants were excluded as a result of a too long interpolation period and 15 trials of 15 different participants were removed due to a too large deviation (z-score > 3) from the participant's mean for the presentation duration of the advertisements. Furthermore, two trials of one participant were removed because the experiment had to be restarted after trial one and as a result these trials were seen twice. No participants were removed due to performing below chance.

### Correlations

The correlation coefficients are described together with their $BF_{10}$ in Table 1. The hit rate is negatively correlated with memorability, T-TOT and T-IMG and positively correlated with T-BN, while memorability is negatively correlated with T-TOT. However, the BF's show that the data provide anecdotal evidence against the presence of these correlations ($0.3 > BF_{10} < 1$). The scatterplots of the correlations are shown together with their fitted linear model in Figure 3.

**Table 1**

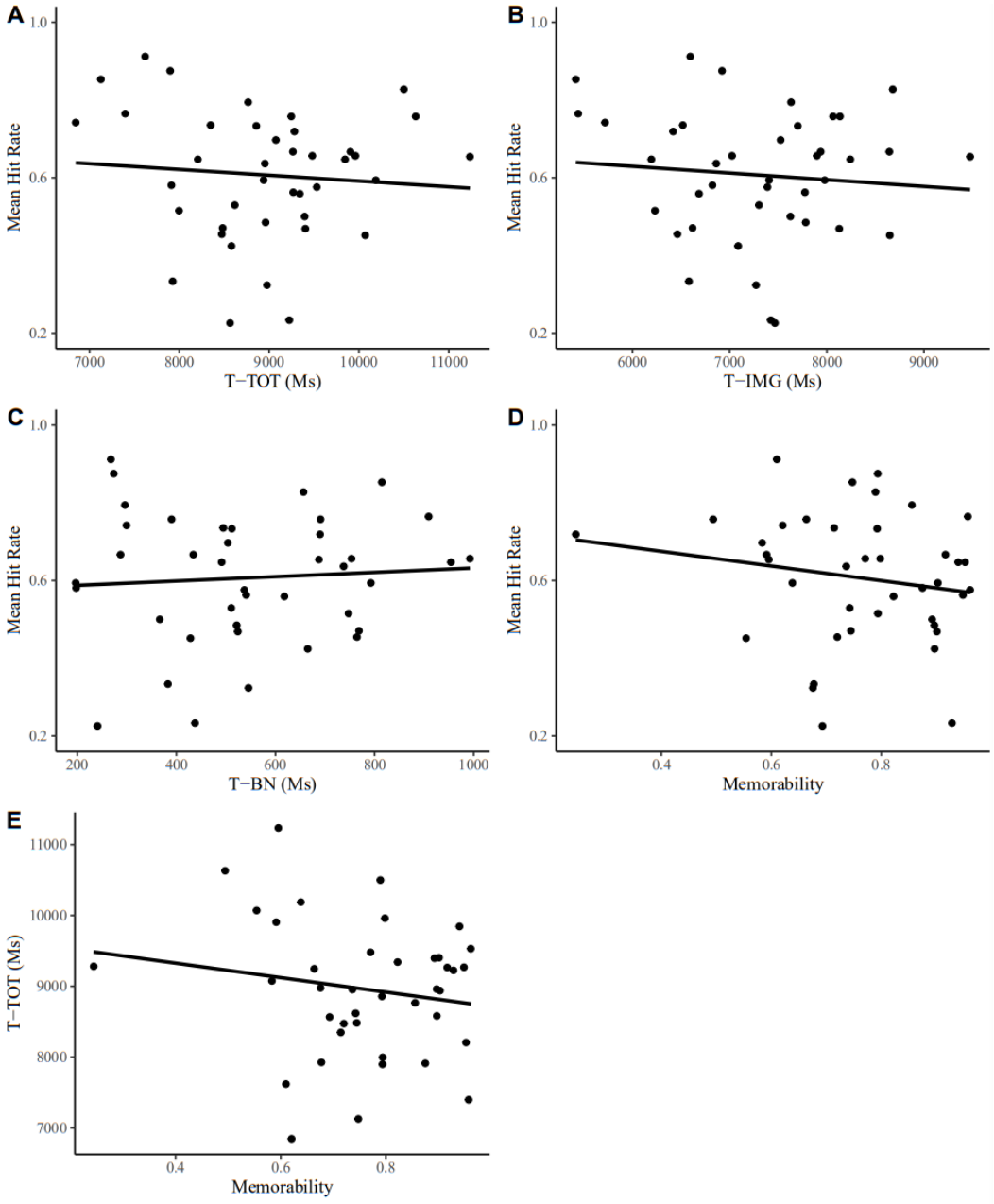
*Correlation Coefficients and Their Bayes Factors*

| | **Correlation Coefficient** | **$BF_{10}$** |
|---|---|---|
| Mean Hit rate X Total Viewing Time | -.07 | 0.40 |
| Mean Hit rate X Image Viewing Time | -.08 | 0.41 |
| Mean Hit rate X Brand Name Viewing Time | .06 | 0.38 |
| Mean Hit rate X Memorability | -.15 | 0.59 |
| Memorability X Total Viewing Time | -.14 | 0.56 |

*Note.* $BF_{10}$ = Bayes Factor giving evidence for $H_1$ over $H_0$.

**Figure 3**

*Scatterplots of the Correlations With Their Fitted Linear Models*




Notes. The correlations of mean hit rate with A: total viewing time (T-TOT), B: image fixation duration (T-IMG). C: brand name fixation duration (T-BN) and D: image-memorability. Plot E presents the correlation between image memorability and the total viewing time (T-TOT).

## Differences Between Advertisements Containing Low and High Memorable Images

Table 2 contains the descriptive statistics of the participants' performance on the brand recognition test and their viewing behavior. Moderate evidence was found against the hypothesis that there would be a difference between both memorability categories in hit rate ($BF_{10}$ = 0.22), T-BN ($BF_{10}$ = 0.19) or P-BN ($BF_{10}$ = 0.28). Furthermore, anecdotal evidence

was found against an effect of memorability on T-TOT ($BF_{10}$ = 0.34), T-IMG ($BF_{10}$ = 0.43) and P-IMG ($BF_{10}$ = 0.82).

**Table 2**

*Means and Standard Deviations of the Hit Rate and Fixation Durations for Both Memorability Categories*

| | Hit Rate | T-TOT (s) | T-IMG (s) | T-BN (s) | T-OTH (s) | P-IMG | P-BN | P-OTH |
|---|---|---|---|---|---|---|---|---|
| High Memorable | .61 ± 13 | 8.92 ± 4.34 | 7.29 ± 3.90 | 0.54 ± 0.36 | 1.10 ± 0.71 | .80 ± .07 | .07 ± .05 | .13 ± .05 |
| Low Memorable | .60 ± .17 | 8.72 ± 4.20 | 7.05 ± 3.68 | 0.55 ± 0.40 | 1.13 ± 0.81 | .79 ± .06 | .07 ± .05 | .13 ± .05 |

*Note.* Hit rates are the mean hit rates per image (calculated by 0 = incorrect and 1 = correct). T-TOT is the mean duration that the advertisement was presented, T-IMG, T-BN and T-OTH are the mean durations fixated on the image, brand name or somewhere else respectively. P-IMG, P-BN and P-OTH represent the proportion of the total presentation duration that the participant looked at the image, brand name or somewhere else respectively. Note that the proportional values of the low memorable categories do not add up to 1 due to rounding of the values.

**Brand Recognition Predicted by Viewing Behavior and Advertisement Characteristics**

Table 3 contains the generalized mixed effect models ordered from lowest to highest BIC. It can be seen that the null model is the best fitting model based on BIC, followed by the intrinsic advertisement characteristics, absolute viewing times and proportional viewing times.

**Table 3**

*Generalized Mixed Effect Models with Brand Recognition Accuracy as Dependent Variable and their BIC Statistics*

| Model | BIC |
|---|---|
| Correct ~ (1\|pp) | 1724.8 |
| Correct ~ Brand name size + (1\|pp) | 1725.3 |
| Correct ~ Image size + (1\|pp) | 1725.7 |
| Correct ~ Memorability + (1\|pp) | 1727.5 |
| Correct ~ Total viewing time + (1\|pp) | 1728.7 |
| Correct ~ Image and brand name viewing time + (1\|pp) | 1729.1 |
| Correct ~ Image viewing time + (1\|pp) | 1729.5 |
| Correct ~ Brand name viewing time + (1\|pp) | 1731.6 |
| Correct ~ Proportional brand name viewing time + (1\|pp) | 1731.8 |
| Correct ~ Proportional image viewing time + (1\|pp) | 1731.8 |
| Correct ~ Proportional image and brand name viewing time + (1\|pp) | 1732.0 |

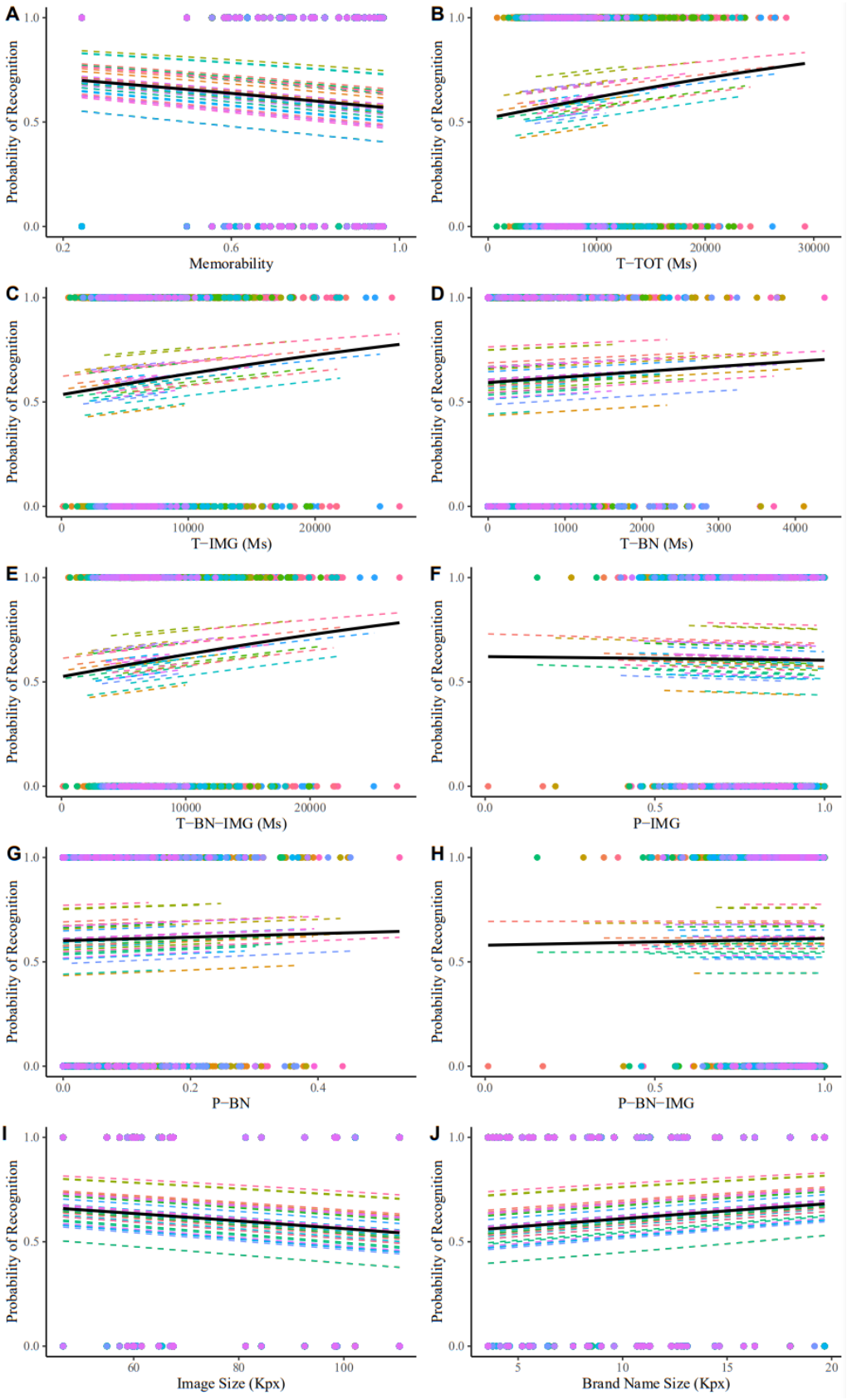
*Note*. The models are ordered based on their Bayesian Information Criterion (BIC), with a lower BIC indicating a better fitting model. In the models, (1|pp) represents the participants as a random effect.

The BF's computed through model comparison yielded very strong evidence for a better fitting null model in comparison to the models with P-IMG ($BF_{10}$ = 0.03) and P-BN-IMG ($BF_{10}$ = 0.03) as predictors and strong evidence for a better fitting null model for T-IMG ($BF_{10}$ = 0.10), T-BN ($BF_{10}$ = 0.04) and P-BN ($BF_{10}$ = 0.04) included as fixed effects. Moreover, moderate evidence was found for a better fit of the null model in comparison to the models containing the following fixed effects: memorability ($BF_{10}$ = 0.26), T-TOT ($BF_{10}$ = 0.15) and T-BN-IMG ($BF_{10}$ = 0.12). Lastly, anecdotal evidence was found for a worse fit of the models containing brand name size ($BF_{10}$ = 0.78) and image size ($BF_{10}$ = 0.65) as fixed effect compared to the null model. These results indicate that none of the variables that were added as fixed effect predicted brand-name recognition.

The generalized linear mixed effect models with participant as random effect are visualized in Figure 4 together with the logistic models. Although the plots look like they are linear where an S-shape would be expected, the full range of the models are too broad, which is expected due to the evidence for the null effects. It can be seen that there are differences in the intercepts of the participants, indicating that there is a difference in probability of recognizing the brand name between subjects. Additionally, the slope of the participants' models are almost equal to the logistic model fitted for the data, meaning that there is no 'clustering' within the data, where the trend of the sample does not follow the trend of the majority of the participants.

**Figure 4**

*Plots of the Generalized Linear Mixed Effect Models with Participant as Random Effect and the Logistic Models Fitted on the Data*



*Notes*. Every plot contains scatter plots of each trial (colored per participant), the models fitted for each participant (colored dashed lines), and the fitted logistic model (solid black line). The Y-axes represent the probability of a correct (represented by 1) brand recognition. Plot B shows the time the advertisement was presented (T-TOT), while C, D and E show the absolute fixation durations of the image (T-IMG), the brand name (T-BN) and the brand name and image combined (T-BN-IMG) in milliseconds (ms). Plot F, G, H show the proportion of the total time spent fixating on the image (P-IMG), the brand name (P-BN) and the brand name and image combined (P-BN-IMG). Plot I and J show the relation between correct brand-name recognition and the size of the image and the brand name in kilopixels (kpx).

**Viewing Behavior Predicted by Image Memorability**

Table 4 contains the null models with their BIC for the viewing behavior together with the models with memorability as fixed effect. The table shows that adding memorability to the null models is only useful for predicting the P-BN-IMG according to the BIC's.

**Table 4**

*Linear Mixed Effect Models That Predict Viewing Behavior by Memorability*

| Model | BIC |
|---|---|
| Total viewing time ~ (1\|pp)* | 24117.9 |
| Total viewing time ~ Memorability + (1\|pp) | 24122.3 |
| Image viewing time ~ (1\|pp)* | 24067.5 |
| Image viewing time ~ Memorability + (1\|pp) | 24074.6 |
| Brand name viewing time ~ (1\|pp)* | 20282.4 |
| Brand name viewing time ~ Memorability + (1\|pp) | 20289.5 |
| Image and brand name viewing time ~ (1\|pp)* | 24109.1 |
| Image and brand name viewing time ~ Memorability + (1\|pp) | 24116.2 |
| Proportional image viewing time ~ (1\|pp)* | -1793.3 |
| Proportional image viewing time ~ Memorability + (1\|pp) | -1790.5 |
| Proportional brand name viewing time ~ (1\|pp)* | -2962.2 |
| Proportional brand name viewing time ~ Memorability + (1\|pp) | -2956.5 |
| Proportional image and brand name viewing time ~ (1\|pp) | -2213.6 |
| Proportional image and brand name viewing time ~ Memorability + (1\|pp)* | -2217.6 |

*Note*. In the models the (1|pp) represents the participants functioning as a random effect. *Indicates the better fitting model for that dependent variable based on Bayesian information criterion (BIC) and Bayes Factor.

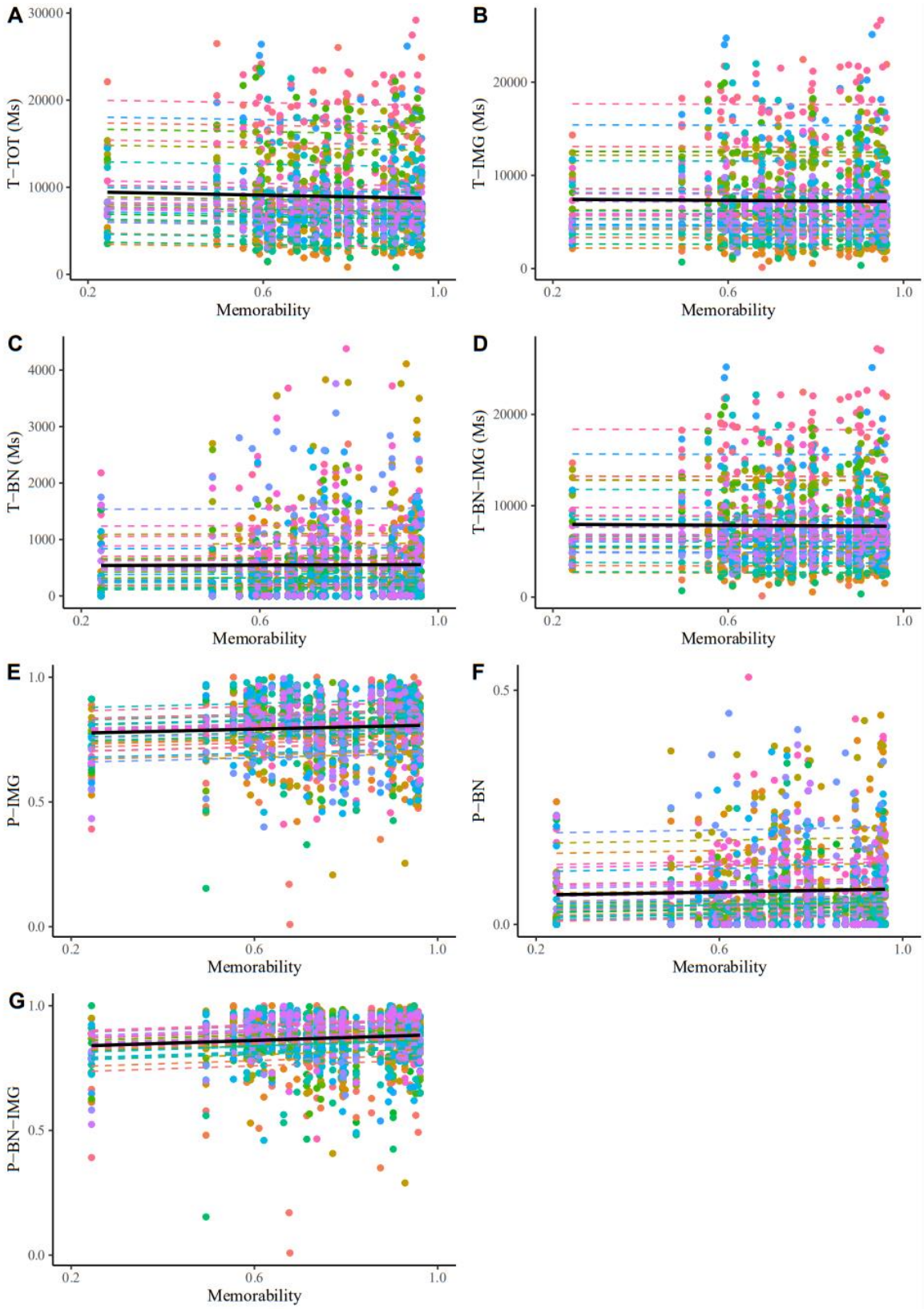
BF's computed for model comparisons yielded moderate evidence for a better fitting model with memorability as fixed effect with P-BN-IMG as dependent variable ($BF_{10}$ = 7.2), with a coefficient of 0.06. This indicates that participants tended to look more at the elements of the advertisement than something else, when the image in the ad had an increased memorability. Furthermore, very strong evidence is found for worse fitting models when memorability is included in the models with T-IMG ($BF_{10}$ = 0.03), T-BN ($BF_{10}$ = 0.03), T-BN-IMG ($BF_{10}$ = 0.03) and strong evidence for P-BN ($BF_{10}$ = 0.06) as dependent variable.

Furthermore, the null models of T-TOT ($BF_{10} = 0.11$) and P-IMG ($BF_{10} = 0.24$) were found to fit better with moderate evidence compared to memorability included as fixed effect.

Figure 5 shows the linear mixed effect models together with the linear models. The figure shows that both the individuals´ models and the linear models' slopes are close to zero, indicating no effect of memorability on those variables. However, Figure 5J shows a gentle positive slope, which supports the result that P-BN-IMG is predicted by image memorability.

**Figure 5**

*Plots of the Linear Mixed Effect Models That Predict Fixation Durations With Memorability as Fixed Effect*



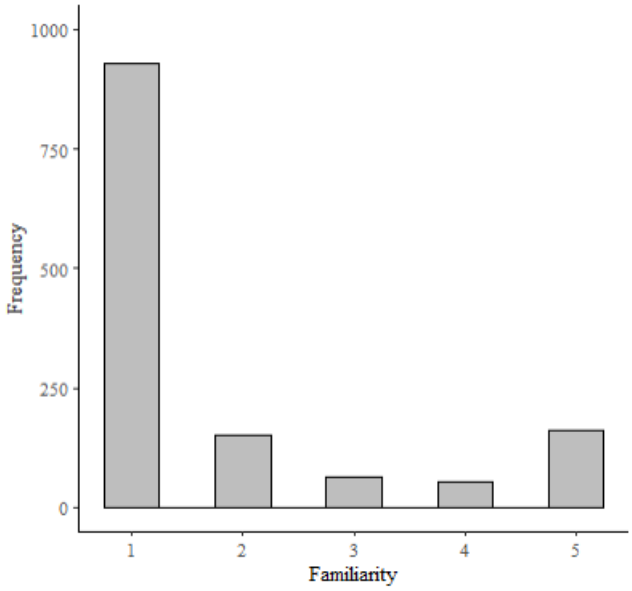
*Notes*. Scatterplots of each trial together with the fitted model for each participant (colored dashed lines) and the linear model (solid black line), fitted to the data. The Y-axes represent the following: plot A presents the time the advertisement was presented (T-TOT), and B, C, D show the absolute fixation durations of the image (T-IMG), the brand name (T-BN) and the brand name and image combined (T-BN-IMG) in milliseconds (ms). Plot E, F, G show the proportion of the total time spent fixating on the image (P-IMG), the brand name (P-BN) and the brand name and image combined (P-BN-IMG).

### Familiarity

The results of the familiarity ratings are shown in Figure 6. As expected, the participants were not familiar with the brand names that were used in this experiment on average (Mean = 1.8 ± 1.1). However, participants considered the brand names as ‘very familiar’ 160 times.

### Figure 6

*Frequencies of the Given Responses in the Familiarity Phase of the Experiment*




*Note.* 1 = 'unfamiliar', 2 = 'slightly familiar', 3 = ‘somewhat familiar’, 4 = ‘moderately familiar’, 5 = ‘very familiar’.

## Discussion

The aim of this study was to test the replicability of the findings of Kostova and Nieuwenstein (2021), who found evidence for a negative relationship between image memorability and brand memory, and to investigate whether this relationship can be explained by how participants view advertisements with memorable and non-memorable images. We hypothesized that image memorability would be negatively correlated with brand recognition and the time participants viewed an advertisement, and we expected to see a

positive correlation between viewing duration and brand recognition. Secondly, we hypothesized that participants would fixate longer on the image while viewing the ad, and therefore a shorter fixation duration on the brand name, when the image had a high memorability score, which would explain the negative correlation between brand recognition and image memorability found by Kostova and Nieuwenstein (2021).

The results yielded evidence against the hypothesized correlations between hit rate, total viewing duration and memorability and we therefore failed to replicate the results of Kostova and Nieuwenstein (2021). In addition, we found no evidence for the presence of correlations between brand recognition and the fixation durations for both the brand names and images in the advertisements. Furthermore, no differences were found in brand recognition and fixation durations between advertisements with low and high-memorable images. Lastly, the image memorability did not predict fixation durations, and fixation durations did not predict brand recognition. Summarizing, we did not replicate the findings of Kostova and Nieuwenstein (2021), we found no effect of viewing behavior on brand recognition and no effects of image memorability on advertisement viewing behavior or brand recognition.

**Comparison of the Current Methods and Results with those of Kostova and Nieuwenstein (2021)**

The current study found no relation between image memorability and brand recognition and no difference in viewing behavior for advertisements with low and high-memorable images. Therefore, our results are not in line with those of Kostova and Nieuwenstein (2021) while they are in line with Wit and Nieuwenstein (2020), who did not find a significant relationship between image memorability and brand recognition.

The difference in conclusions drawn in the relation between memorability and total viewing duration, in the current study and Kostova and Nieuwenstein (2021), might be explained by the inclusion of the eye tracker in the experiment. More specifically, we found substantially longer viewing times than Kostova and Nieuwenstein (2021), which might be caused by the Hawthorne effect (Wei-Xia, 2021), which causes participants to act differently because they know they are being observed. This effect might be enhanced by the difference in location, since the experiment of the current study took place in a lab while that of Kostova and Nieuwenstein was performed at home.

The difference in relations between memorability and brand recognition we found in comparison with Kostova and Nieuwenstein (2021), has several possible explanations. First,

since increased viewing times are associated with an increased brand recognition (Kostova & Nieuwenstein, 2021; Pieters &Wedel, 2004, Pieters et al., 2002), we would expect to find better brand recognition than Kostova and Nieuwenstein (2021). However, we found lower hit rates than Kostova and Nieuwenstein (2021), indicating a worse brand memory in the current study. A possible explanation for the lower hit rates might lie in the duration of the current experiment, which took about twice as long as the experiment of Kostova and Nieuwenstein (2021). The increased duration of the experiment resulted in a longer retention interval, which leads to a worse recognition of words (Oliviera et al., 2013). The increased duration of the experiment is, besides the longer viewing durations discussed above, probably caused by the inclusion of the eye tracker in the experiment, since drift corrections and fixation phases were added before each trial in the encoding phase and brand recognition test. Secondly, Goetschalckx et al. (2018), found that high-memorable images decline less in their absolute memorability score over time than low-memorable images. This means that low-memorable images are more sensitive to an increased retention interval than high-memorable images. We speculate that, if associative encoding exists for the images and the brand names (as suggested in Kostova and Nieuwenstein (2021)), an increased retention interval results in a decrease in the effect of memorability on brand recognition. Since low-memorable images are associated with better brand recognition (Kostova and Nieuwenstein, 2021), the associative encoding might also be sensitive for an increase in retention interval for the brand name paired with low-memorable images. Therefore, an increase in retention interval could decrease the effect of image memorability on brand recognition, explaining the null-effects found in the current study and Wit and Nieuwenstein (2020). However, it is important to note that retention intervals of Goetschalckx et al. (2018) were in terms of days, which is considerably longer than the difference of retention interval between the current study and Kostova and Nieuwenstein (2021). In short, the difference in results we found compared to Kostova and Nieuwenstein, might be explained by the longer duration of the experiment and therefore a longer retention interval, resulting in a worse brand recognition and a reduced effect of memorability on brand recognition.

While we did not obtain statistically significant results for the relationship between image memorability, viewing behavior, and brand recognition, the direction of these relationships did converge with those found by Kostova and Nieuwenstein (2021). Arguably, the difference in statistical significance might be explained by a difference in statistical analysis, as Kostova and Nieuwenstein (2021) performed Pearson correlations, with null-hypothesis significance testing, while we used the stricter Bayesian analyses. However,

besides similar trends, we found some striking similarities in the distribution of viewing times and brand recognition scores per image in a post hoc analysis. In more detail, when we analyzed the brand recognition scores and viewing times for each image for both studies, we found a correlation of .64 for brand recognition ($BF_{10} > 1,000$) and .41 for the total viewing time ($BF_{10} = 22.6$) of the advertisements across the different images. In other words, the images that yielded a relatively high hit rate for brand recognition in the study of Kostova and Nieuwenstein (2021), also yielded a relatively high viewing duration and hit rate in the current study. Crucially, however, these associations were found irrespective of the memorability of the images, indicating that some images yielded longer viewing times or higher hit rates independently of their memorability. Taken together, despite the different conclusions drawn in both studies, the data show similar patterns in the relation of images, brand recognition and viewing times.

The only significant effect of memorability in the current study was a positive effect of memorability on the proportional brand name and image viewing time. This result suggests that including an image with a higher memorability score is associated with a higher sustained attention towards the ad, since the individual looked proportionally less at something else. However, the effect we found was minimal and although literature suggests no effect of image memorability on selective attention during a visual search task (Bainbridge, 2020), no literature has studied the effect of image memorability on sustained attention. We therefore suggest that further research is needed before a decisive conclusion can be drawn. Indeed, our results showed that image memorability is not a significant predictor for fixation durations, which is not in line with our hypothesis that stated that memorable images might attract more visual attention while viewing the ad since they might be more salient. Previous literature found that saliency of an image is associated with its memorability and the maximum salience of an object in it (Dubey et al., 2015; Mancas & Le Meur, 2013), but this correlation decreases when the number of objects in the image increases. Although the images used in this study mainly consist of one object, the maximum actual salience scores of the objects are not identified, and some categories, e.g., winter holidays destinations, did contain multiple objects. This indicates that the memorability might not correlate with visual salience in the sample of images used in this study, which might explain the null effects found in fixation durations for the brand name and image. Moreover, Goetschalckx and Wagemans (2019), who created the database from which the images are selected in this study, did not mention the role of visual salience in their data base. Taken together, while image memorability might enhance sustained attention towards an advertisement, the null-effects of memorability on

fixation durations, might be explained by the fact that the images' memorability scores do not correlate with their visual saliences.

Summarizing, the current study failed to replicate the effects found by Kostova and Nieuwenstein (2021). Although similar trends were found, the current study's effects were smaller, and no statistical evidence was provided for the presence a relation between memorability, total viewing time and brand recognition. However, the viewing times and brand recognition per image found in both studies correlated significantly, implying a consistency in the relation between image memorability, total viewing times and brand recognition. Additionally memorability might be associated with sustained attention towards the ad, while the null effects of image memorability on fixation durations might be explained by an absence of a relation between saliency and memorability in the current study.

**Brand Recognition Not Predicted by Fixation Duration and Advertisement Characteristics**

Besides the null effect of memorability on total viewing time and brand recognition, we did not find an effect of the fixation behavior or ad-element sizes on brand recognition. These findings are not in line with the results of Pieters and Wedel (2000), who found that an increased element size led to increased fixation frequencies on that particular element, which in turn lead to an increased brand recognition, with an increase in brand name having the largest effect. This difference can be explained by the fact that Pieters and Wedel (2000) used real advertisements, which assumably have a higher effectivity than the ads in the current study. In our study, the brand names were viewed not at all or substantially shorter than the images, while this difference was considerably smaller in Pieters and Wedel (2004), who also used real ads. Additionally, Rayner et al. (2001) found that people tend to look at the brand name prior to fixating on the image. Furthermore, participants on average looked at anything else twice as long as at the brand name. Taking these results and comparisons into account, we speculate that our brand names were not visually attractive, and therefore, the difference in size of the brand names used in our study might not have influenced brand recognition. However, it should be noted that people are able to read words in the peripheral visual field (He et al., 2013), and they might thus encode the brand name while they do not fixate on it. Although this might be another possible explanation for the short fixation durations on the brand name, it is less likely since the participants were instructed to 'pay close attention' to the advertisements. To conclude, the null effects of fixation durations and ad characteristics

on brand recognition might be caused by the simple layout of the brand names in the advertisements, resulting in less visual attention towards it and therefore a worse encoding.

**Limitations**

The current study has various limitations in the set-up of the experiment. First, the advertisements have certain limitations. In more detail, the surface of the images varied from approximately 52,000 to 110,000 pixels, which is a huge difference. Although the current study and has not found a relation between brand recognition and image size, image size does relate to visual attention when viewing advertisements according to the results of Wedel and Pieters (2004). Goetschalckx et al. (2019) reported that image memorability is robust against shrinkage of an image, which might be a possible solution to tackle this problem. However, the images used in their study were of equal size and had an equal shrinkage factor. This robustness can therefore not be assumed when one image is shrunken by a factor of two while the other is kept at its original size and this is therefore not an applicable solution for this problem in the current study. It is therefore recommended to select new images of approximately equal sizes in future research.

Additionally, the experiment's ecological validity is limited for two reasons. First, the advertisements we used have various issues. In more detail, the current ads are substantially simpler than real advertisements, which are graphically designed by professionals. However, since the layout of an ad influences brand recognition (Aribarg et al., 2010), the ads used in this study should be kept as simple as possible in order to isolate the effect of memorability of the image. Secondly, some brand names were incongruent with the product's brand in the image. For example, the car brand name 'A' was paired with an image of a car of brand 'B'. This incongruence can confuse participants, which might affect their viewing behavior or interpretation of the ad.

Furthermore, participants considered the brand names that were used in the ads as 'very familiar' 160 times in spite of the low average familiarity. A post hoc analysis showed that 93 'very familiar' responses were given for brands in the category 'cars', which had an average familiarity of $4.5 \pm 0.8$. Since brand familiarity is related to brand recognition (Aribarg et al., 2010; Kostova & Nieuwenstein, 2021), the purpose of the ads was to contain unfamiliar brand names and the current study failed to do that for this category. For future research, it is recommended to change the brand names for this particular category. In short, the advertisements used should be revised, by using images of equal size, unfamiliar brand

names and the pairing with a brand name should not only be congruent on category, but on brand as well.

Lastly, the eye tracker was used in the brand recognition test for an exploratory analysis for pupil size. However, these data are not used in the current study, but did cause the experiment to take longer than expected due to fixation periods and drift corrections which might have decreased the motivation, concentration and memory of the participants during the recognition test.

**Practical Implications**

Our results can be applied by marketeers in their search for an increased brand recognition as effect of static advertising. This study found evidence for a null effect between fixation durations, image memorability and brand recognition. It is therefore suggested, contrary to Kostova and Nieuwenstein (2021), that it does not matter whether a memorable or non-memorable image is used in the advertisements to increase brand recognition. However, when the goal of the marketeer is to keep the consumer's attention on the ad, it is advised to include memorable images, although further research is needed.

**Future Research**

Although we failed to replicate the correlation of Kostova and Nieuwenstein (2021) between brand recognition and image memorability, we found similar trends. Also, the evidence for a null effect was not convincing and evidence was found for a correlation between the data sets of both studies. Therefore, additional research is needed to get a better understanding of the relation between image memorability and brand-name recognition. For future studies to this topic, it is recommended to select images of approximately equal sizes, matched with unfamiliar brand names.

Furthermore, we propose to perform a post hoc analysis on our data set to obtain fixation frequencies, since Damiano and Walther (2019) found a difference in number of fixations of forgotten and remembered images, but not in high or low memorable. Also, fixation frequencies on the brand or image were found to relate to the brand recognition when viewing advertisements by Pieters et al. (2002). Furthermore, fixation maps might provide valuable information, since Bylinksii et al. (2015) found that fixation maps are a better predictor whether an image will be remembered than the memorability score of the image on an individual trial level. It might therefore be interesting to analyze whether frequency and locations of the fixations are related the memorability of the image or brand recognition.

Lastly, to optimize the reliability of the eye tracker data, the participants were instructed to rest their head in a head-rest, which caused an unnatural posture for viewing ads, since ads are often viewed in a position in which the viewer can move freely. It is therefore suggested that future research could use a head-mounted eye tracker.

## Conclusion

This study partly replicated the results of Kostova and Nieuwenstein (2021) by finding similar but non-significant trends for image memorability correlated with viewing time and brand recognition and evidence for correlations between both data sets. Furthermore, no relations were found between fixation durations on various elements of advertisements, image memorability and brand recognition except for the fact that proportional true advertisement fixation duration (P-BN-IMG) is predicted by the memorability of the image, which might indicate an increased sustained attention towards the advertisement if it contains a higher memorable image. Further research should be done in order to get a better understanding of the relation between brand recognition and the memorability of an image used in the advertisement. In addition to the fixation durations, it is recommended to analyze the fixation frequency since previous literature found a relation between image remembrance and fixation frequencies.

**References**

Ahmad, F.N., Moscovitch, M. & Hockley, W.E. Effects of varying presentation time on long-term recognition memory for scenes: Verbatim and gist representations. *Mem Cogn* **45,** 390–403 (2017). https://doi.org/10.3758/s13421-016-0672-1

Aribarg, A., Pieters, R., & Wedel, M. (2010). Raising the BAR: Bias adjustment of recognition tests in advertising. *Journal of Marketing Research*, *47*(3), 387-400.

Amiri, S., & Maroofi, F. (2016). The relationship between brand awareness, market outcome, brand equity, and the marketing mix. *International Journal of Markets and Business Systems*, *2*(1), 68-84.

Bainbridge, W. A. (2020). The resiliency of image memorability: A predictor of memory separate from attention and priming. *Neuropsychologia*, *141*, 107408.

Baker, W., Hutchinson, J., Moore, D., & Nedungadi, P. (1986). Brand familiarity and advertising: effects on the evoked set and brand preference. *ACR North American Advances*.

Bates D, Mächler M, Bolker B, Walker S (2015). "Fitting Linear Mixed-Effects Models Using lme4." *Journal of Statistical Software*, **67**(1), 1–48. doi: 10.18637/jss.v067.i01.

Boucart, M., Lenoble, Q., Quettelart, J., Szaffarczyk, S., Despretz, P., & Thorpe, S. J. (2016). Finding faces, animals, and vehicles in far peripheral vision. *Journal of vision*, *16*(2), 10. https://doi.org/10.1167/16.2.10

Bylinskii, Z., Isola, P., Bainbridge, C., Torralba, A., & Oliva, A. (2015). Intrinsic and extrinsic effects on image memorability. *Vision research*, *116*, 165-178.

Constant, M., & Liesefeld, H. R. (2021). Massive Effects of Saliency on Information Processing in Visual Working Memory. *Psychological science*, *32*(5), 682–691. https://doi.org/10.1177/0956797620975785

Dalmaijer, E. S., Mathôt, S., & Van der Stigchel, S. (2014). PyGaze: an open-source, cross-platform toolbox for minimal-effort programming of eyetracking experiments. *Behavior research methods*, *46*(4), 913–921. https://doi.org/10.3758/s13428-013-0422-2

Damiano, C., & Walther, D. B. (2019). Distinct roles of eye movements during memory encoding and retrieval. *Cognition*, *184*, 119–129. https://doi.org/10.1016/j.cognition.2018.12.014

De Keyzer, F., Dens, N., & De Pelsmacker, P. (2021). The processing of native advertising compared to banner advertising: an eye-tracking experiment. *Electronic Commerce Research*, 1-20.

Dubey, R., Peterson, J., Khosla, A., Yang, M. H., & Ghanem, B. (2015). What makes an object memorable?. In *Proceedings of the ieee international conference on computer vision* (pp. 1089-1097).

Fife, D. (2019, October 16). Flexplot: graphically-based data analysis. https://doi.org/10.31234/osf.io/kh9c3

Gardezi, M., Fung, K. H., Baig, U. M., Ismail, M., Kadosh, O., Bonneh, Y. S., & Sheth, B. R. (2021). What Makes an Image Interesting and How Can We Explain It. *Frontiers in psychology*, *12*, 668651. https://doi.org/10.3389/fpsyg.2021.668651

Goetschalckx, L., & Wagemans, J. (2019). MemCat: a new category-based image set quantified on memorability. *PeerJ*, *7*, e8169. https://doi.org/10.7717/peerj.8169

Goetschalckx, L., Moors, J., & Wagemans, J. (2019). Incidental image memorability. *Memory (Hove, England)*, *27*(9), 1273–1282. https://doi.org/10.1080/09658211.2019.1652328

He, Y., Legge, G. E., & Yu, D. (2013). Sensory and cognitive influences on the training-related improvement of reading speed in peripheral vision. *Journal of vision*, *13*(7), 14. https://doi.org/10.1167/13.7.14

Isola, P., Parikh, D., Torralba, A., & Oliva, A. (2011). Understanding the intrinsic memorability of images. *Advances in neural information processing systems*, *24*.

Isola, P., Xiao, J., Parikh, D., Torralba, A., & Oliva, A. (2013). What makes a photograph memorable?. *IEEE transactions on pattern analysis and machine intelligence*, *36*(7), 1469-1482.

Kostova, L., Nieuwenstein, M. R. (2021). Can image memorability influence brand memory in picture advertisements? A comparison of self-paced and short viewing times. Unpublished manuscript.

Mancas, M., & Le Meur, O. (2013, September). Memorability of natural scenes: The role of attention. In *2013 IEEE international conference on image processing* (pp. 196-200). IEEE.

Martarelli, C. S., & Mast, F. W. (2013). Eye movements during long-term pictorial recall. *Psychological research*, *77*(3), 303–309. https://doi.org/10.1007/s00426-012-_0439-7

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: an open-source, graphical experiment builder for the social sciences. *Behavior research methods*, *44*(2), 314–324. https://doi.org/10.3758/s13428-011-0168-7

Morey, R. D., Rouder, J. N., Jamil, T., Urbanek, S., Forner, K., Ly, A. (2021). Computation of Bayes Factors for Common Designs https://richarddmorey.github.io/BayesFactor/

Mijn, van der, R., (2021).Parse, Process and Analyze Pupil Data in R. https://github.com/robbertmijn/pupilMiner/

Oehlert, G. W. (2012). A few words about REML. *Stat 5303, University of Minesota*.

Olejarczyk, J. H., Luke, S. G., & Henderson, J. M. (2014). Incidental memory for parts of scenes from eye movements. *Visual Cognition*, *22*(7), 975–995. https://doi.org/10.1080/13506285.2014.941433

Oliveira, J., Perea, M. V., Ladera, V., & Gamito, P. (2011). Hemispheric asymmetry in recognition memory: effects of retention level on the recognition of Portuguese words. *International journal of psychology : Journal international de psychologie*, *46*(2), 119–126. https://doi.org/10.1080/00207594.2010.519770

Parikh, D., Isola, P., Torralba, A., & Oliva, A. (2012). Understanding the intrinsic memorability of images. *Journal of Vision*, *12*(9), 1082-1082.

Peltier, J. W., & Schibrowsky, J. A. (1994). Need for cognition, advertisement viewing time and memory for advertising stimuli. *ACR North American Advances*.Pieters et al 2002

Pieters, R., & Wedel, M. (2004). Attention capture and transfer in advertising: Brand, pictorial, and text-size effects. *Journal of marketing*, *68*(2), 36-50.

Pieters, R., & Wedel, M. (2007). Goal control of attention to advertising: The Yarbus implication. *Journal of consumer research*, *34*(2), 224-233.

Pieters, R., & Wedel, M. (2012). Ad gist: Ad communication in a single eye fixation. *Marketing Science*, *31*(1), 59-73.

Pieters, R., Wedel, M., & Batra, R. (2010). The stopping power of advertising: Measures and effects of visual complexity. *Journal of Marketing*, *74*(5), 48-60.

Rayner, K., Rotello, C. M., Stewart, A. J., Keir, J., & Duffy, S. A. (2001). Integrating text and pictorial information: eye movements when looking at print advertisements. *Journal of experimental psychology. Applied*, *7*(3), 219–226. https://doi.org/10.1037//1076-898x.7.3.219

Rayner, K., Miller, B., & Rotello, C. M. (2008). Eye Movements When Looking at Print Advertisements: The Goal of the Viewer Matters. *Applied cognitive psychology*, *22*(5), 697–707. https://doi.org/10.1002/acp.1389

Rosbergen, E., Pieters, R., & Wedel, M. (1997). Visual attention to advertising: A segment-level analysis. *Journal of consumer research*, *24*(3), 305-314.

Solomon, M. (2009) Consumer behavior: Buying, having and being. *Prentice-Hall, Upper Saddle River*.

Statista. (2022). Print Advertising. https://www.statista.com/outlook/amo/advertising/print-advertising/worldwide#ad-spending

Treue S. (2003). Visual attention: the where, what, how and why of saliency. *Current opinion in neurobiology*, *13*(4), 428–432. https://doi.org/10.1016/s0959-4388(03)00105-3Wedel en Pieters 2000

Wei-xia, C. U. I. (2021). A Critique of Eye-Tracking Approach in Translation Process Research. *Journal of Literature and Art Studies*, *11*(3), 190-195Wickham 2016

Wickham H (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. ISBN 978-3-319-24277-4,

Wit, L., Nieuwenstein, M. R. (2020) Does Image Memorability Enhance Brand Memory in Advertisements? Unpublished manuscript.

Wetzels, R., van Ravenzwaaij, D., & Wagenmakers, E. J. (2014). Bayesian analysis. *The encyclopedia of clinical psychology*, 1-11.

# Appendix

*Memorability Scores For the Advertisement Categories*

| **Advertisement Category** | **Memorability Category** | **Memorability Scores** | |
|---|---|---|---|
| Pleasure Boats | Low | .60 | .64 |
| | High | .79 | .80 |
| Exotic Holiday Destinations | Low | .24 | .49 |
| | High | .77 | .82 |
| Cat Food | Low | .74 | .79 |
| | High | .92 | .96 |
| Winter Holiday Destinations | Low | .55 | .68 |
| | High | .89 | .90 |
| Dog Food | Low | .71 | .74 |
| | High | .94 | .95 |
| Scooters | Low | .68 | .74 |
| | High | .90 | .90 |
| Coffee | Low | .72 | .75 |
| | High | .95 | .96 |
| Sportswear | Low | .59 | .69 |
| | High | .90 | .93 |
| Cars | Low | .61 | .66 |
| | High | .86 | .88 |
| Airlines | Low | .58 | .62 |
| | High | .79 | .79 |