PsychNology Journal, 2009
Volume 7, Number 2, 141 – 158

# Predicting preference from fixations

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**ABSTRACT**

We measured the strength of the association between looking behaviour and preference. Participants selected the most preferred face out of a grid of 8 faces. Fixation times were correlated with selection on a trial-by-trial basis, as well as with explicit preference ratings. Furthermore, by ranking features based on fixation times, we were able to successfully predict participants' preferences for novel feature combinations in a two-alternative forced choice task. In addition, we obtained a similar pattern of findings in a very different stimulus domain: mock company logos. Our results indicated that fixation times can be used to predict selection in large arrays and they might also be employed to estimate preferences for whole stimuli as well as their constituent features.

Keywords: *Eye movements, preference, gaze bias, decision making.*

Paper Received 14/11/2008; received in revised form 24/02/2009; accepted 29/04/2009.

## 1. Introduction

Measures of fixation duration and location have proven to be invaluable in the context of human factors, usability engineering, and marketing and advertising research (see Duchowski, 2002 for a recent review). In many real world and computer based applications the user is confronted with a cluttered array of options, in which objects and locations are serially and often repeatedly selected for detailed or attentive processing (e.g. looking through a gallery of image thumbnails). Given that attention moves among the options in a

Cite as:

Glaholt, M.G., Wu. M., & Reingold, E.M. (2009). Predicting preference from fixations. *PsychNology Journal, 7*(2), 141 – 158. Retrieved [month] [day], [year], from www.psychnology.org.

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largely serial fashion, such a process can be slow and effortful. This is especially the case for tasks that require detailed visual comparison between non-adjacent objects (e.g., online shopping, e-learning). Consequently, in the context of visual choice and comparison tasks, monitoring the distribution and duration of eye fixations has the potential to provide an excellent measure of an observer's interests and preferences. This, in turn, would allow the development of smart applications that facilitate and customize information retrieval and inspection based on the users' manifest preferences (e.g., an art image database that learns the user preferences and biases image retrieval accordingly).

The goal of the present research was to examine the usefulness of looking behavior as an indirect measure of the observer's preferences. If shown to be a reliable and sensitive measure of preference, looking behavior would potentially have several advantages over traditional self-report measures of preference (e.g., ratings, questionnaires, interviews). First, current eye movement monitoring systems allow for relatively unobtrusive measurement of looking behavior while the observer is interacting naturally with their visual environment. Thus, unlike overt preference ratings, the observer is not required to produce additional responses to indicate his/her preferences. Second, compared to preference ratings, looking behavior is likely to provide better measurement of unconscious preferences. Third, looking behavior is likely to be less susceptible to attempts on the part of the user to only report socially desirable, appropriate, or justifiable preferences. Finally, measurement of preferences by looking behavior can be obtained quickly and efficiently across multi-element arrays of items.

Given these possible advantages, it is surprising that relatively few empirical studies have examined the relation between preference and looking behavior in adults (but see Isaacowitz, Wadlinger, Goren, & Wilson, 2006; and for a review see Murphy & Isaacowitz, 2008). However, several recent studies suggest that such an effort may be feasible and promising. Specifically, Shimojo, Simion, Shimojo and Scheier (2003) and Simion and Shimojo (2006, 2007) reported a gaze bias that exists during selection between two visually presented items. On each trial, two faces were presented and participants had to select the more attractive face. Gaze was shown to be biased towards the face that was later selected. This gaze bias became evident between 1 and 1.5 seconds prior to the response that marked the overt decision. Building on this finding, Glaholt and Reingold (in press) demonstrated that the bias in looking behavior was particularly robust in eight-alternative forced-choice (8-AFC) decision tasks. These findings indicate that by monitoring eye movements it may be possible to predict the observers' choice or preference prior to the overt response and possibly prior to the point at which the choice is consciously made. Bee, Prendinger, André and Ishizuka (2006) demonstrated the feasibility of using eye movements to predict the visual preference decisions of users in real-time, for the purpose of designing applications that would automatically detect users' visual preferences solely based on eye movements in a two-alternative forced choice (2-AFC) setting. These authors reported that in a pilot study involving the selection of neckties, their system correctly classified participants' choices with an average accuracy of 81% (with 50% constituting chance performance).

Our study aims to extend these prior findings in several ways. Specifically, the present study was designed to provide quantitative estimates for the strength of the association between fixation patterns and observers' preferences. We examined gaze behavior during preference decisions in multi-element arrays. Multi-element arrays mimic the kinds of displays that are present in a variety of applied settings, such as web-based image catalogues where the decision maker searches through a large set of decision alternatives. In addition, we examined the potential for using fixation times extracted during the viewing of multi-element arrays to circumvent the need for overt selection between pairs of items and thereby boost the efficiency of search through large sets of potential alternatives.

We applied the analysis of the within-trial gaze bias reported by Shimojo, Simion, Shimojo and Scheier (2003) to our 8-AFC task and measured the accuracy of the within-trial prediction of selection from gaze data. In order to estimate the strength of the gaze-selection and gaze-preference relationships, measures of fixation duration (see Rayner, 1998 for a review of eye movement measures) were then correlated with both overt choice behavior and explicit preference ratings. For such correlations to be useful they must be reliable and robust at the level of an individual and not just across a group of participants, and consequently we computed correlations separately for each participant. We also wanted to see if, once the individual's preferences for stimulus features are determined, it would be possible to construct novel combinations of these features and accurately predict the pattern of choices among these stimuli. If so, this would demonstrate how fixation times can narrow search for preferred items in a large feature space.

Accordingly, in the first part of the experiment, each participant was asked to select the most attractive stimulus in visual arrays of 8 faces (group 1) or arrays of 8 company logos (group 2) (see the 8-AFC task, Figure 1). Each item in each array represented a unique combination of 3 stimulus dimensions with 8 possible features in each dimension (see Figures 3 & 4). In the second component, participants explicitly rated their preference for each of the stimuli from part 1. These data allowed us to examine the relationship of fixation time to selection (within-trial) and fixation time to overt preference rating. In the final part of the experiment, pairs of novel stimuli were constructed that were expected to constitute easy or difficult preference decisions based on the participant’s fixation patterns from part 1. For each trial of this 2-AFC task, we had a prediction about which of the two stimuli the participant would prefer.

## 2. Method

### 2.1 Participants

One group of eight participants took part in the face version of eight-alternative task and another group of eight participants took part in the logo version. In the second part of the experiment, five participants from each group completed the two-alternative task. All participants were students at the University of Toronto at Mississauga, and each received $10 compensation for their time. All participants provided informed consent, and the reported research was conducted in strict compliance with APA ethical principles.

### 2.2 Apparatus

The eyetracker employed in this research was the SR Research Ltd. EyeLink 1000 system. This system has high spatial resolution (0.005º) and a sampling rate of 1000 Hz (1-msec temporal resolution). By default, only the participant's dominant eye was tracked in our study. In the present study, the configurable acceleration and velocity thresholds were set to detect saccades of 0.5º or greater. Stimulus displays were presented on two monitors, one for the participant (a 19-in. Viewsonic) and one for the experimenter. The experimenter monitor was used to give feedback in real time about the participant's computed gaze position. This feedback was given in the form of a cursor measuring 1º in diameter that was overlaid on the same image being viewed by the participant. This allowed the experimenter to evaluate system accuracy and to initiate a recalibration if necessary. In general, the average error in the computation of gaze position was less than 0.5º of visual angle. The participant used a chinrest with a head support to minimize head movement.

### 2.3 Stimuli

Faces were constructed as unique combinations of 3 stimulus dimensions (eyes, nose, and mouth) with 8 possible features (i.e., exemplars) in each dimension. The features were stored as bitmaps and assembled into faces on each trial (see Figure 3). Of the 512 possible faces in our feature space, we selected a set of 64 in which all pairs of features occurred once, and all individual features occurred eight times. These faces were used in the 8-AFC task and the Preference Rating task. Of the remaining 448 faces, a subset (determined separately for each participant) was used in the two-alternative forced choice task. The logo version of the experiment was analogous to the face version. We constructed logos by combining features from each of three stimulus dimensions: font, shape, and texture (see Figure 4). All the logos were portrayed as possible logos for a fictional company with the initials ‘TEK’.

### 2.4 Procedure

The experiment consisted of three components that were completed by the participant in a fixed order: eight-alternative forced-choice, preference rating, and two-alternative forced choice. Only five of the eight participants in each group were available to complete the 2-AFC task. One group of participants was given the face version of the experiment, and another group was given the logo version. Each participant was given instructions prior to each component of the experiment. In the 8-AFC task, following a 9-point calibration, eye movements were recorded while the participant selected, from each display presented, the most attractive face. All 64 faces (see Stimuli) were presented 8 times, across 64 stimulus displays, where each display contained a unique combination of 8 stimuli (see Figure 1). At the beginning of each trial the display appeared, and the participant decided which of the eight stimuli (faces or logos) was most attractive. To terminate trials, the participant first had to look at the grey dot located in the center of the display and fixate it for 500 ms (the beginning of the saccade preceding this fixation was considered the end of the trial for the purpose of analysis). Following this fixation, the grey center dot turned green indicating to the participant to move his/her gaze to the preferred stimulus in order to select it and terminate the trial.

In the second component, Preference Rating, the participant viewed each of the 64 stimuli from the 8-AFC task, one at a time, and rated the attractiveness of the face or logo on a 300-pixel wide sliding scale anchored by ‘Unattractive’ and ‘Attractive’ on the left and right ends, respectively. On each trial the stimulus appeared in the center of the display and the rating scale appeared horizontally below. The participant responded using the mouse, and the preference rating was recorded as the position of the participant’s mark along the axis of the rating scale.

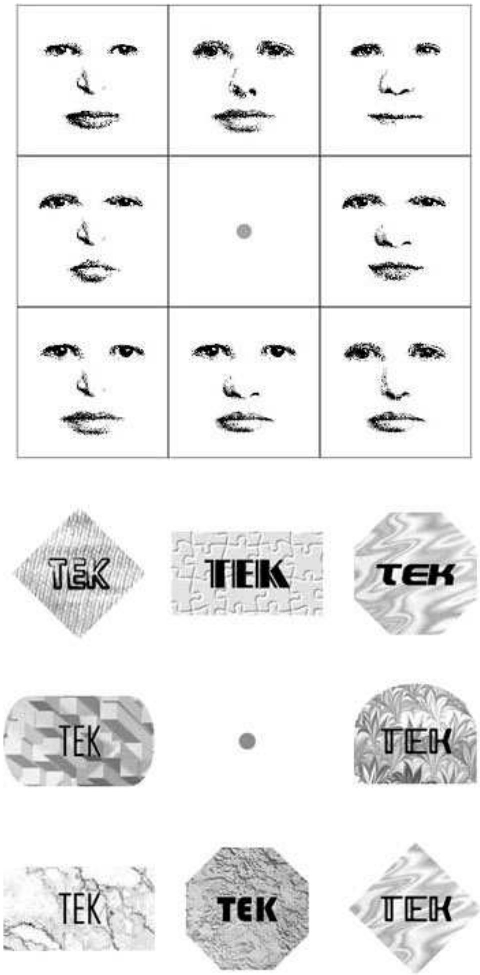


**Figure 1**. Stimulus displays from the 8-AFC task in the face version (top) and the logo version (bottom).

Following the Preference Rating task, there was a short break during which the experimenter analyzed the data from the 8-AFC task. Average total fixation time, across presentations, was computed for each of the 24 features (see Results for feature analysis). For each of the 448 stimuli (logos or faces) not yet seen by the participant, we computed an average total fixation time (i.e., the average of the mean fixation times for its three component features). We then ranked the new stimuli according to total fixation time and selected 'high preference' items from the top quartile 'low preference' items from the bottom quartile. In the 2-AFC component, the participant completed 64 trials, half of which were high-low preference pairs (Easy decision), and the other half were high-high preference pairs (Difficult decision). Importantly, the pairs were selected such that the two stimuli did not share features. The stimulus display was similar to the display in the 8-AFC task, but containing only the middle row of boxes (see Figure 1). Participants were asked to select the stimulus they preferred. For both Easy and Difficult pairs, we recorded both the correspondence between the choice made by the participant and the predicted choice, as well as the response latency for the decision. We expected to find higher prediction accuracy and shorter response latencies for the Easy trials compared to the Difficult trials.

## 3. Results

To analyze the gaze behavior in the 8-AFC task, we defined 8 non-overlapping regions of interest (corresponding to the boxes in Figure 1, top), each of which contained one stimulus. The summed duration of all fixations on a stimulus throughout the trial (i.e., from stimulus onset to the participant's re-fixating the center prior to selection) is referred to as total fixation time. Our analyses were aimed at exploring two different issues: 1) in order to compare the present results to previous investigations, we looked at the association between gaze behavior and preference decisions within a trial, and 2) we examined how total fixation times for individual stimuli and features, averaged across trials, could be used for predicting overt preference decisions, subjective preference ratings, and preference decisions for novel stimuli.

### 3.1 Gaze and Preference Within-trial

Similar to previous research (Glaholt & Reingold, in press, 2009; Shimojo, Simion, Shimojo and Scheier, 2003; Simion & Shimojo, 2006, 2007), we explored the gaze bias toward the chosen item on each trial of the 8-AFC by plotting the proportion of time spent on the chosen item prior to the response. In addition, we ranked each of the items that were not chosen (referred to here as 'distractors') according to their total fixation time for the trial. We then labeled them as the 'top distractor', '2nd distractor', '3rd distractor', and the four lowest-rank distractors were averaged together and labeled 'Last 4'. In Figure 2, for each of forty 50-millisecond time bins (i.e., a 2 second interval) prior to the response, we plot the proportion of time the eye spent on the chosen item, and on each distractor category. Data for the face (Figure 2, top) and logo (Figure 2, bottom) versions of the task were plotted separately, collapsing across all participants and trials. In total, 3% of the trials were excluded because they lasted less than 2 seconds.

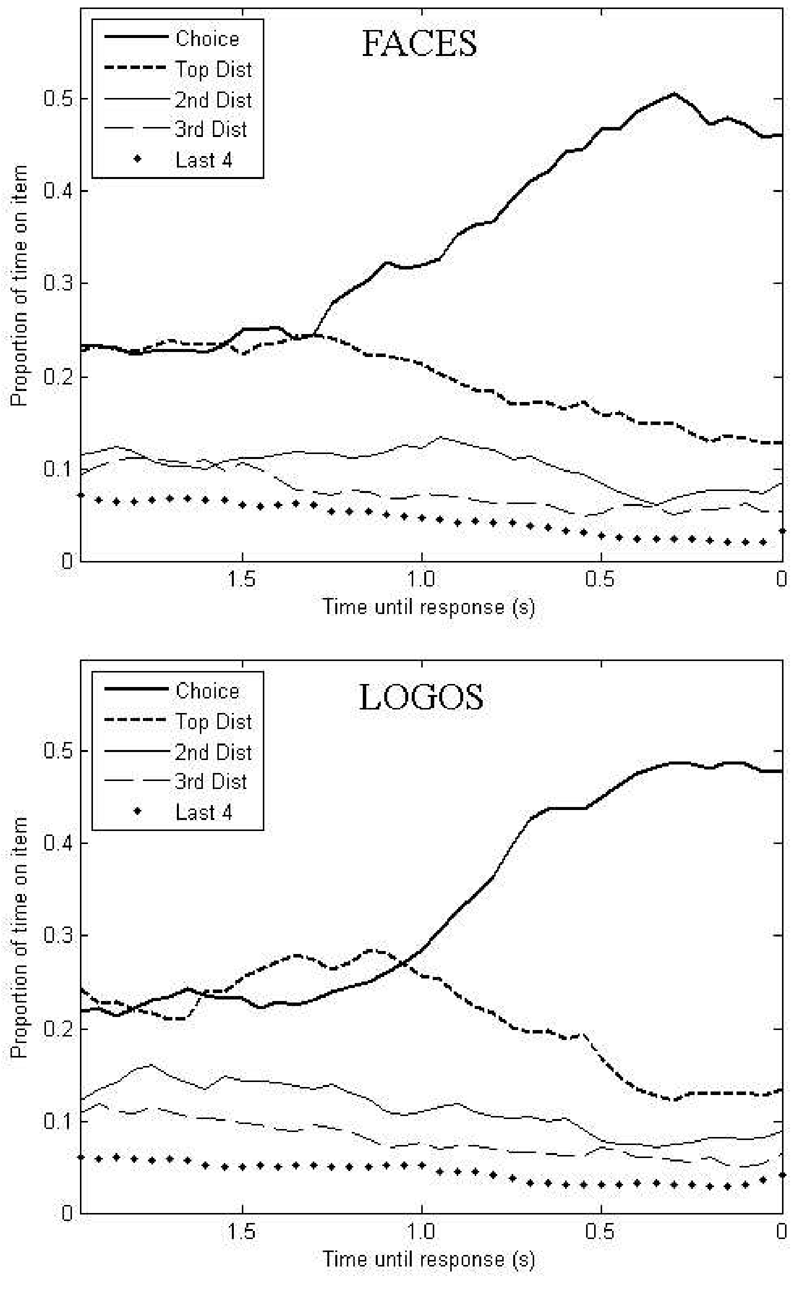


**Figure 2.** Plots of the proportion of time that gaze was directed to the chosen item or distractor items (ranked by total fixation time) over the 2 seconds prior to the response in the 8-AFC task for faces (top) and logos (bottom).

As can be seen in Figure 2, the time course plots for the Face and Logo versions of the experiment are very similar. Replicating previous findings (Glaholt & Reingold, in press, 2009; Shimojo, Simion, Shimojo and Scheier, 2003; Simion & Shimojo, 2006, 2007), gaze was biased towards the chosen item during the last second prior to the decision. The first distractor item seems distinguishable from the other distractors; it enjoyed a similar proportion of the gaze to the chosen item up until approximately a second prior to the decision, after which the chosen item dominated. This may indicate that towards the end of the trial, the participant was choosing primarily between the top two options. The other distractor items received a smaller amount of gaze throughout the interval. Interestingly, the ranking of the other distractors seems stable over the interval, suggesting that gaze duration may provide a stable estimate of the preference ranking of each option.

To quantitatively assess the apparent gaze bias towards the chosen item, we computed the percentage of trials in which the chosen item had the highest total fixation time (chance = 12.5%). We also computed the percentage of trials in which total fixation time for the chosen item was one of the two largest (chance = 25%), or four largest fixation times (chance = 50%). For all of these measures, total fixation time was substantially longer on the selected item than predicted by chance (for all comparisons, $t(7) > 11.85$, $p < 0.001$). Specifically, for faces, the chosen item had the highest total fixation time on 65.2% of the trials, was within the top 2 total fixation times on 85.5% of the trials, and was in the top four total fixation times on 95.3% of the trials. For logos, the chosen item had the highest total fixation time on 67.8% of the trials, was within the top 2 total fixation times on 90.0% of the trials, and was in the top four total fixation times on 97.7% of the trials. Thus, total fixation time within a trial is a powerful predictor of the item chosen, and an even stronger predictor of the active subset of the options from which the participant is choosing.

The time course plots clearly depict a pattern of increasing gaze selectivity throughout the trial. To quantify this narrowing of actively considered items over the course of the trial, we divided the trial into dwells (where a dwell is a run of one or more consecutive fixations on an item). We contrasted the first four dwells (beginning of trial) and last four dwells (end of trial) in each trial (13% of trials had less than 8 dwells and were excluded). Total fixation time on the chosen item and on other items was computed separately for the beginning and the end of the trial, for either the face or logo versions of the task. The result of this analysis is shown in Table 1 and clearly depicts a dramatically stronger gaze bias in the end than in the beginning of the trial (for all comparisons, $t(7) > 4.89$, all $p < 0.01$). The chosen item had the longest total fixation time, and was in the top two total fixation times, more often in the end than in the beginning of the trial. Interestingly, even in the beginning of the trial, the chosen item had the longest total fixation time and was one of the top two total fixation times, more often than chance. This increase in gaze bias toward the end of the trial is also reflected in the fact that the chosen item was more frequently visited and fixated on for a longer duration during the end than in the beginning of the trial.

| | Dwell set | # of visits to chosen item | Chosen item total fixation time (ms) | Chosen item is top fixation time (prop'n) | Chosen item within top 2 fix. times (prop'n) |
|---|---|---|---|---|---|
| Faces | First 4 | 0.55 | 244 | 0.24 | 0.48 |
| | Last 4 | 1.12 | 763 | 0.56 | 0.87 |
| Logos | First 4 | 0.6 | 301 | 0.27 | 0.53 |
| | Last 4 | 1.07 | 691 | 0.49 | 0.84 |

**Table 1**. Analysis of the first 4 and last 4 dwells in each trial in the 8-AFC task.

### 3.2 Total Fixation Time and Preference Across-trials

Having illustrated the relationship between gaze and preference decisions in the 8-AFC task within-trial, we asked what relationships hold across trials. We examined the correlation between total fixation time and preference, at two levels: 1) at the level of whole stimuli (faces or logos), and 2) at the level of individual features. These analyses are discussed separately below.

*Correlations across stimuli*. Each stimulus (face or logo) was part of the stimulus array in eight trials during the 8-AFC task. Across these eight presentations, we counted the number of times the stimulus was chosen (Selection) and computed the average total fixation time on this item. In addition, for each stimulus we obtained the subjective preference rating (Preference) from the rating task. For each participant, the correlations between total fixation time and Selection, and between total fixation time and Preference, were computed across stimuli and are displayed in Table 2 (faces) and Table 3 (logos). In addition, to measure the strength of the relationship between the three variables we computed the multiple correlation between total fixation time and both the number of times selected and mean preference rating (Selection + Preference). As can be seen in the Tables, for all participants, total fixation time was strongly and positively correlated with Selection (i.e., number of times an item is chosen) and Preference (i.e., subjective preference ratings). Furthermore, taken together both Selection and Preference were highly predictive of total fixation time, reflected in a high multiple correlation.

*Correlations across features*. We derived measures of total fixation time, number of times selected, and preference rating for individual features. Each feature appeared in different stimuli, which allowed us to derive the average contribution of each feature to total fixation time, number of times selected, and preference rating. We assigned the values for these variables from each whole stimulus to its component features. For example, for a given face, the total fixation time, number of times selected, and preference rating were assigned to the eyes, nose, and mouth features that composed that face (font, shape, and texture for logos). For each feature, these values were averaged across 64 occurrences (in 8 different items, each presented 8 times). The correlations, as computed across features, show a particularly strong positive relationship between total fixation time and selection and also between total fixation time and overt preference rating (see Tables 2 and 3). Taken together both Selection and Preference were highly predictive of total fixation time, as reflected in a high multiple correlation.

| | Whole Stimuli (Faces) (Pearson's r) | | | Single Features (Pearson's r) | | |
|---|---|---|---|---|---|---|
| Participant | Selection | Preference | Selection + Preference | Selection | Preference | Selection + Preference |
| 1 | 0.65† | 0.62† | 0.69 | 0.89† | 0.75† | 0.89 |
| 2 | 0.74† | 0.58† | 0.76 | 0.84† | 0.70† | 0.85 |
| 3 | 0.70† | 0.66† | 0.74 | 0.86† | 0.83† | 0.89 |
| 4 | 0.80† | 0.48† | 0.78 | 0.89† | 0.56§ | 0.89 |
| 5 | 0.66† | 0.39§ | 0.69 | 0.81† | 0.56§ | 0.83 |
| 6 | 0.75† | 0.74† | 0.83 | 0.88† | 0.86† | 0.92 |
| 7 | 0.65† | 0.39§ | 0.65 | 0.83† | 0.48§ | 0.84 |
| 8 | 0.70† | 0.39§ | 0.70 | 0.83† | 0.70† | 0.84 |
| Mean | 0.71 | 0.53 | 0.73 | 0.85 | 0.68 | 0.87 |

**Table 2**. 8-AFC with faces. Correlations between total fixation time and number of times selected (Selection), between total fixation time and mean preference rating (Preference), and the multiple-correlation between total fixation time and both the number of times selected and mean preference rating (Selection + Preference), computed across whole stimuli and across single features, for each participant. Note: †: $p < 0.001$, §: $p < 0.01$, *: $p < 0.05$.

| | Whole Stimuli (Logos) (Pearson's r) | | | Single Features (Pearson's r) | | |
|---|---|---|---|---|---|---|
| Participant | Selection | Preference | Selection + Preference | Selection | Preference | Selection + Preference |
| 1 | 0.75† | 0.57† | 0.75 | 0.92† | 0.80† | 0.92 |
| 2 | 0.84† | 0.56† | 0.84 | 0.91† | 0.66† | 0.91 |
| 3 | 0.65† | 0.34§ | 0.66 | 0.83† | 0.44* | 0.84 |
| 4 | 0.74† | 0.57† | 0.76 | 0.86† | 0.65† | 0.86 |
| 5 | 0.87† | 0.60† | 0.88 | 0.95† | 0.71† | 0.96 |
| 6 | 0.81† | 0.67† | 0.81 | 0.91† | 0.76† | 0.91 |
| 7 | 0.74† | 0.88† | 0.91 | 0.96† | 0.88† | 0.97 |
| 8 | 0.71† | 0.65† | 0.76 | 0.89† | 0.81† | 0.90 |
| Mean | 0.76 | 0.61 | 0.80 | 0.90 | 0.71 | 0.91 |

**Table 3**. 8-AFC with logos. Correlations between total fixation time and number of times selected (Selection), between total fixation time and mean preference rating (Preference), and the multiple-correlation between total fixation time and both the number of times selected and mean preference rating (Selection + Preference) computed across whole stimuli and across single features, for each participant. Note: †: $p < 0.001$, §: $p < 0.01$, *: $p < 0.05$.

*Correlations across participants*. In order to evaluate the consistency of preferences across participants, we computed between-participant correlations across features for average total fixation time, number of times selected (Selection), and preference rating (Preference). For both faces and logos, these correlations were quite variable, often low, and sometimes negative. For faces, total fixation time: range = -0.11 to 0.84, mean = 0.43; Selection: range = -0.02 to 0.89, mean = 0.51; Preference: range = -0.08 to 0.78, mean = 0.48. For logos, total fixation time: range = -0.27 to 0.64, mean = 0.11; Selection: range = -0.37 to 0.57, mean = 0.07; Preference: range = -0.46 to 0.54, mean = 0.13. This indicates that, at least for the stimuli used in this experiment, individual differences in preference are substantial, and consequently preference predictors should be derived separately for each participant. Note that the correlations across participants tended to be higher for faces than logos (for each measure), and hence the consistency of preference across participants may depend strongly on the stimulus domain. Nevertheless, it is of interest to portray the central tendency of preference for a group of participants. To demonstrate this, we normalized the average total fixation time for each feature for each participant by converting it to a z-score, and we then ranked each feature according to its mean z-score across participants (see Figures 3 and 4).

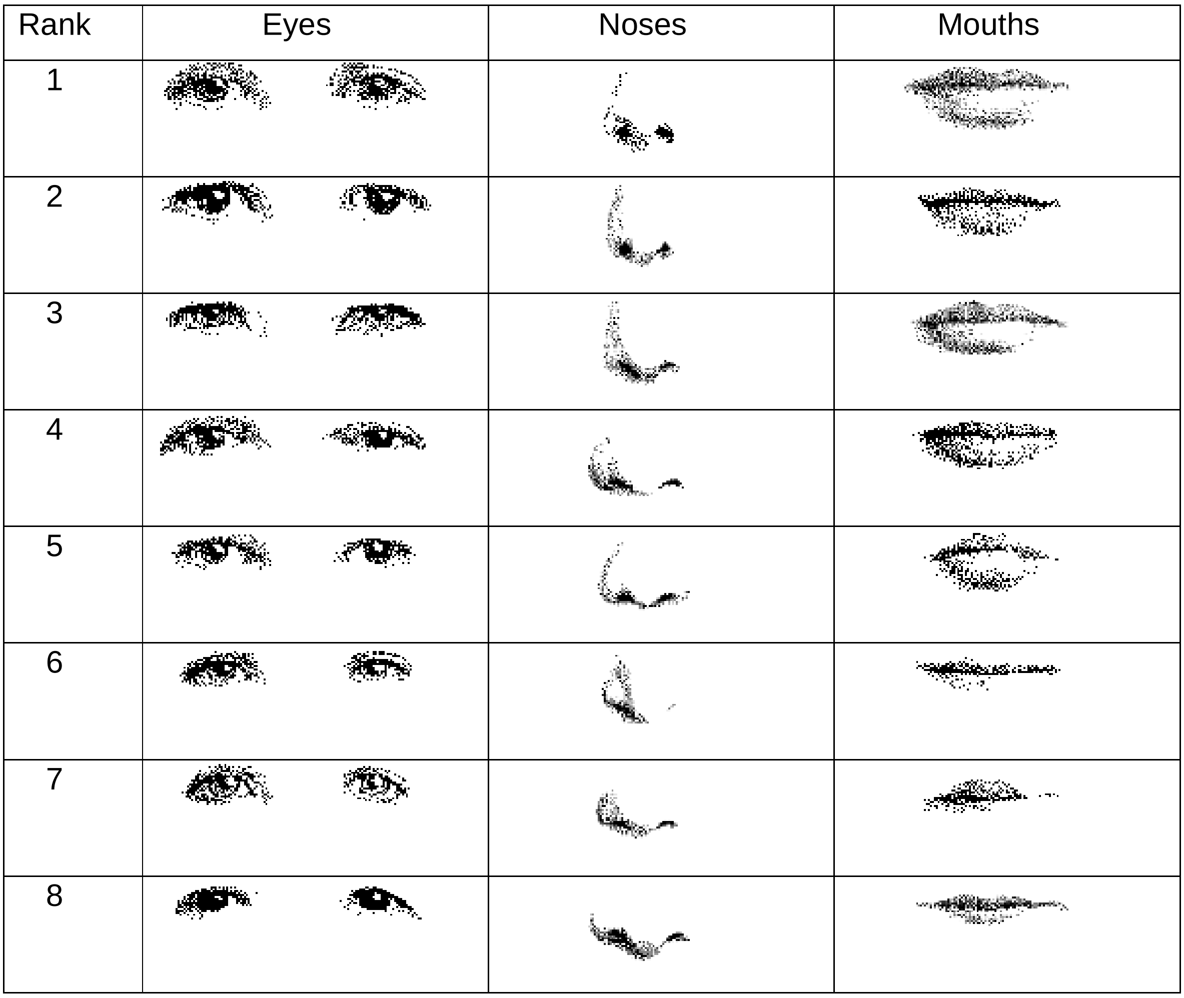


**Figure 3.** Face features in rank order (from highest-1 to lowest-8) according to normalized average total fixation time across participants.

### 3.3 Predicting Preference Decisions for Novel Stimuli

To further establish the usefulness of fixation information across trials, we used average total fixation time on individual features to rank the expected preference for stimuli other than the 64 that were used in the 8-AFC task (i.e., the 448 combinations of features that were not used in the 8-AFC task). High-high preference pairs (Difficult trials) and High-Low preference pairs (Easy trials) were then used in a 2-AFC preference decision task. For each pair of stimuli, we predicted which of the two items would be preferred based on the average total fixation time for individual features obtained from the 8-AFC task.

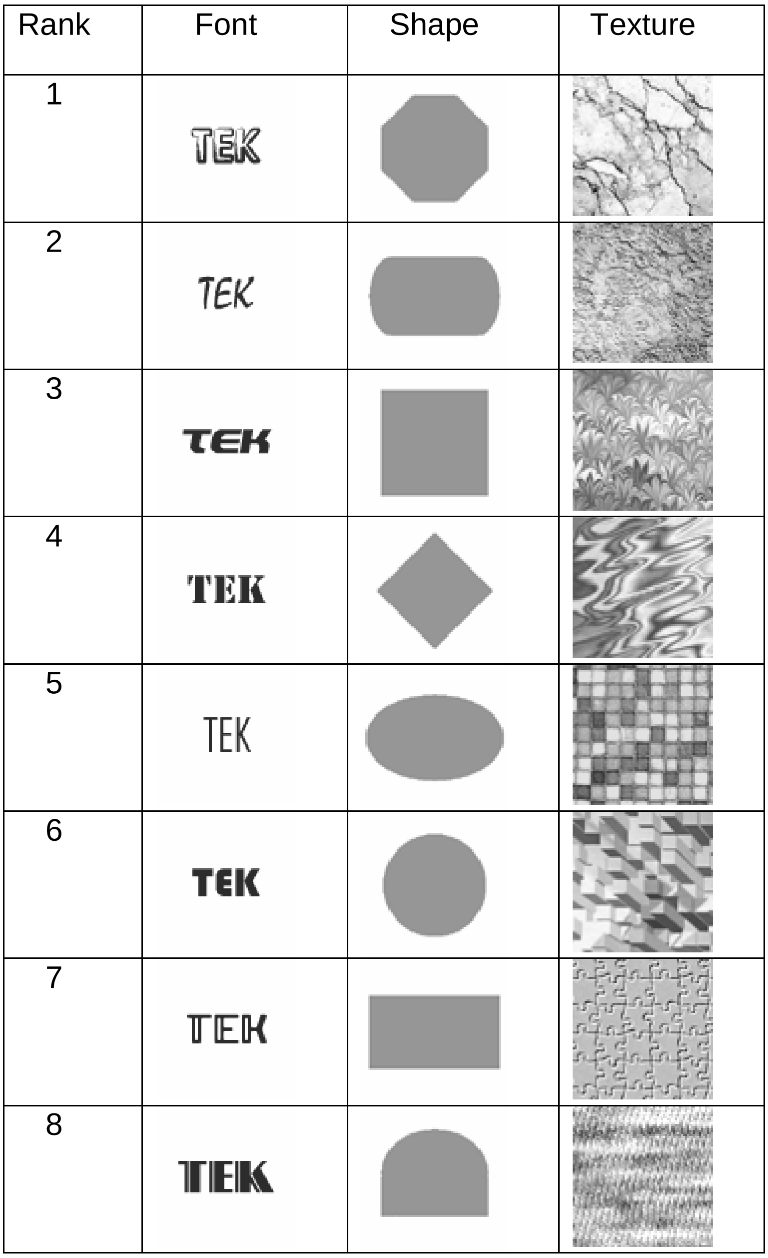


**Figure 4.** Logo features in rank order (from highest-1 to lowest-8) according to normalized average total fixation time across participants.

Generally, these predicted choices corresponded quite well to the actual choices in the 2-AFC task. For faces, on 93.8% of the Easy trials and 65.6% of the Difficult trials, the predicted item was chosen by the participant. Both of these values differ significantly from chance (Easy: $t(4) = 43.95$, $p < 0.001$; Difficult: $t(4) = 4.58$, $p < 0.05$). Logos showed a similar pattern of results, with the predicted item being chosen on 98.8% of the Easy trials and 63.8% of the Difficult trials, again both values differing from chance (Easy: $t(4) = 64.21$, $p <$

0.001; Difficult: $t(4) = 3.43$, $p < 0.05$). In addition, participants took longer to make Difficult decisions than Easy decisions (2387 ms vs. 1758 ms for faces; 2409 ms vs. 1748 ms for logos), though the difference was only significant for logos ($t(4) = 3.51$, $p < 0.05$).

## 4. Discussion

We examined the relationship between eye movements and selection during preference decisions. Consistent with previous findings (Ford, Schmitt, Schechtman, Hults, & Doherty, 1989; Glaholt & Reingold, in press, 2009; Lohse & Johnson, 1996; Pieters & Warlop, 1999; Rosen & Rosenkoetter, 1976; Russo, 1978; Russo & Dosher, 1983; Russo & Leclerc, 1994; Russo & Rosen, 1975; Shimojo, Simion, Shimojo and Scheier, 2003; Simion & Shimojo, 2006, 2007), the present results clearly demonstrate the usefulness of eye movement measurements for the study of visual decision making. In the present study, we found that during 8-AFC preference decisions, the amount of time the eye spends on a particular stimulus is positively related to the likelihood of that stimulus being selected and preferred. These results confirm and extend previous findings of a bias in looking behavior towards the item-to-be-chosen prior to the response in preference decisions (Glaholt & Reingold, in press, 2009; Shimojo, Simion, Shimojo and Scheier, 2003; Simion & Shimojo, 2006, 2007). Specifically, the selected item was substantially more likely than chance to be the item with the longest total fixation time, to be among the top two total fixation times, and to be among the top four total fixation times. In addition, the 8-AFC task revealed a clear differentiation among the items that were not chosen. Consequently, gaze behavior prior to decision can potentially provide a sensitive moment-by-moment indication of the relative strength (i.e., activation) of the items and as such may be very useful in the investigation of the time course of preference decisions in large arrays of items. For example, we speculated that there was a narrowing of the ‘active’ options considered by participants over the course of the trial, and we explored this by contrasting gaze bias in the beginning versus the end of the trial. Consistent with this idea, gaze bias was substantially stronger in the end than the beginning of the trial. Interestingly, and consistent with previous findings (Glaholt & Reingold, in press, 2009), gaze bias was also evident early in the trial.

From an applied perspective, our results suggest a possible extension to the ideas of Bee, Prendinger, André and Ishizuka (2006), who implemented an auto-selection mechanism by monitoring the emerging gaze bias. Specifically, in large arrays such as the ones used here, although gaze bias is a reasonable predictor of the chosen item, it is probably not accurate enough to substitute for overt selection. However, gaze bias clearly contains information concerning the subset of items that are being actively considered by the participant at a particular time period during the trial. This suggests that gaze bias may be useful in identifying an active subset of the items competing for choice, and providing a graded measure of the preference ranking of items. Future studies are required to explore the use of eye movement recordings in real-time to aid selection among alternatives in large arrays of items such as web-pages and image arrays. Monitoring of cumulative fixation times could be applied in order to gradually and dynamically reduce the number of alternatives in a large array, potentially assisting the decision process. However, note that in pursuing such an application, one should consider the potential obstacles that could arise due to known effects of display changes on low-level visual processing (Pannasch, Dornhoefer, Unema, & Velichkovsky, 2001; Reingold & Stampe, 2002, 2004).

Furthermore, the present results indicate that fixation times are also able to convey stable preference information about stimuli and individual features. This is shown by the strong positive correlations, shown in each participant, between fixation time and selection, and between fixation time and overt preference rating. To demonstrate the power of this technique, we created new combinations of features with high and low expected preference. The results of the 2-AFC task showed that these predictions were very accurate for coarse differences between stimuli (Easy trials). Fine differentiation (Difficult trials) was less robust, but yet consistently above chance. This demonstrates that the fixation times collected ‘passively’ during preference decisions in large arrays can provide a particularly accurate appraisal of a person’s preference along elementary feature dimensions, and this could be used to constrain a preference-search through a large set of stimuli generated from these features. We also documented large individual differences in preference. Further research is required to explore whether with large samples, it is possible to derive stable estimates of central tendency or identify clusters of individuals who share preferences.

Together with prior work (Bee, Prendinger, André and Ishizuka, 2006; Glaholt & Reingold, in press, 2009; Shimojo, Simion, Shimojo and Scheier, 2003; Simion & Shimojo, 2006, 2007), the present results convincingly demonstrate the usefulness of monitoring gaze selectivity during preference decisions. Theoretically, gaze bias may be a valuable tool for exploring the time course of preference decisions and informing the development of qualitative and quantitative models in this area. From an applied perspective, gaze bias may be exploited in applications that attempt to facilitate users’ selection among items in a complex visual display, and in devising smart applications which are able to extract information about users' preferences and customize their visual environment accordingly.

## 5. Acknowledgments

We thank Jiye Shen for essential technical assistance in these experiments. This research was funded by an NSERC research grant to Eyal M. Reingold.

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