Cognitive neuronal dynamics of aesthetics: Kawabata and Zeki’s neuroscience on beauty in Paralleli

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Abstract: Artificial Intelligence (AI) is now widely used across a wide variety of fields. Yet, there are so far very few reported in-depth experimental studies utilising artificial intelligence in modelling cognitively of how the brain or mind processes aesthetics. In this paper, we document our study of aesthetical judgements via Artificial Neural Network (ANN). A technology inspired from neuronal processes of the brain is here enabled through training to derive meanings from symbolic designs. The insights gained from our cognitive neurodynamic modelling of the processes are presented. To the best of our knowledge, ours is probably the first prototypical artificial judge of aesthetics ever created: one capable of assessing designs in a human-like fashion.

Keywords: AI; artificial intelligence; logos; aesthetics; machine’s perception; aerospace; artificial judge.


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1 Introduction

For a long time in the business world, corporate logos are seen more as an afterthought or add-on rather than as an absolute necessity. In the schema of corporate strategists, customers are drawn to a business primarily as a consequence of either having competitively lower prices, or having better quality of their products, or the corporation has a dominant position in the marketplace through monopoly. However, corporate identity building through branding necessitated the use of a well-designed logo as trademark (Foo, 2000). Clearly, a well-conceived logo aesthetically pleasing in design can empower customers in remembering and thus later choosing the advertised service, for example as in airline travel. In an intensely competitive market, aesthetically pleasing logos help corporations say, in airline travel industry, to differentiate themselves from the amorphous masses and is thus essential in modelling of corporate identity (Foo and Andy, 1999). Indeed, one may argue that aesthetically designed logos may even help corporations to win the hearts and minds of customers at the early, pre-purchase decision-taking phase. An aesthetically ‘nice’ logo often leaves favourable impressions in the minds of potential customers. Such well-conceived logos even if these may be attractive despite being seen to be visually complex (Foo, 2003a). Also, a logo may often convey the critical message to customers a strong sense of professionalism.

Thus, there is an enhanced role of corporate identity involving use of logo. Corporate identity is to be seen as an integral part of competitive strategy. For this reason, top corporate managers should be allocating adequate resources towards creating a logo (Foo et al., 2002) and then testing the design empirically. The idea is to design a logo that finds favour with as many customers as possible. What is even more surprising is that despite the importance of logo, there is as yet very little, if any, attempt by neuro-dynamical scientists to model algorithmically these cognitive processes: how people respond to stimulus of a logo in reaching to an aesthetic response. Stimulus and response is at the core of what constitutes cognitive psychology. In a growing
attention on economy with the rise of competitive aesthetics (Foo, 2006a), such researches are clearly of practical importance and hence our work in this neglected field of investigation.

2 Theory and model

On the basis of theory, cognitively, our aesthetic judgements can be attributed to a wide range of causes: senses, emotions, intellectual opinions, will, desires, culture, preferences, values, conscious decision, training, instincts, conditionings by societal institutions or some complex, differentially weighted combinations of these (Foo, 2006a). A recent neuro-aesthetic study showed that human perceptions of the different categories of paintings are associated with very distinct and specialised visual areas of the brain. In particular, it is found that the orbito-frontal cortex is differentially engaged during perceptions of both beautiful and ugly stimuli. This is regardless of the category of painting utilised in the experimentations. Also, those perceptions of the stimuli as beautiful or ugly mobilise the motor cortex differentially (Kawabata and Zeki, 2003; Immanuel, 1928). In this intriguing brain mapping study, Functional Magnetic Resonance Imaging (fMRI) techniques were used to discover specifically which areas of the human brain are engaged when subjects are asked to view paintings they already perceived as beautiful regardless of the category of painting.

Our parallel experimental study (hence, the title) employing cognitive neuro-dynamical modelling of human aesthetic judgements is grounded on the above parsimonious model (see Figure 1). The cognitive neuro-dynamical study undertaken here is in very close parallelus with the neuroscience (Kawabata and Zeki, 2003), fMRI brain mapping research.

Figure 1 Parsimonious model of aesthetic cognitive process (see online version for colours)

Through using Artificial Neural Network (ANN) for pattern recognition (Foo and Wong, 2007), neuron-inspired software for modelling aesthetic judgements, we are besides developing a patentable AI tool, also uncovering the underlying algorithmic patterns of the working of the conscious human mind.

The discussion then follows on with the next section detailing the methodological aspects including descriptions of the airline logos being experimented with.
3 Methodology

The design of the experiments consists mainly of four stages, namely acquisition of airline logos, review of human’s perception, features extraction, and application of ANN algorithm.¹

3.1 Standardisation of airline logos

During the collection of airline logos, it was observed that the standard airline company logos, which are readily available on their websites, were not standardised in size, pixels, and resolution.

Moreover, some of the logos are merely the company name of the airlines, but not the official logo that represents the aircraft or the airline company. Figure 2 shows some examples of the official airline company logos.

Figure 2 Official airline company logos (see online version for colours)

![Official airline company logos](image)

The inconsistency of these logos will affect not only human’s perception on these logos, but also the data from feature extraction would be biased. To ensure uniformity, only aircraft tail logos from the airline industry are used. It was observed that most of the aircrafts have distinctive pictures painted on their aircraft tail. Pictures of the aircraft tail logos were collected and edited with Adobe Photoshop to fit into a standard frame. Figure 3 shows the aircraft tail logos corresponding to the official airline company logos in Figure 2.

Figure 3 Aircraft tail logos (see online version for colours)

![Aircraft tail logos](image)

A total of 101 airline logos were acquired for this experiment.
3.2 Human’s perception

In this study, surveys were carried out to 65 people of age ranging from 12 to 65. The logos in the survey questionnaire were shown to the respondents without displaying the full name of the airline companies to minimise biased responses owing to personal opinion for the company or the country that the airlines belong to.

For example, logos with distinctive symbols, abbreviations and clear indication that they belong to certain company that the respondents are fond of usually receive higher rating from the survey respondents. In this case, the aesthetic factor of the logos will be overpowered by personal preference, which is not aligned with the objective of this survey.

In this study, respondents were advised to rate the logos into three categories, namely Nice, Not Nice and Cannot Decide. The reason for limiting the range of rating into three simple categories is to simplify the respondents thinking process. Each and individual logo has their own uniqueness in terms of complexity, colour combination, symbol used, geometrical shapes, etc. The combinations of these features generally give an overall impression to the respondents. Therefore, respondents were advised to rate the logos based on their first impression, without considering what are the features in each logo that attract them.

The survey results were compiled by calculating the number of response for each category. For example, if a logo receives more than 50\% of ‘Nice’ response out of the total number of responses, the logo is concluded to be ‘Nice’. Likewise for logos that are rated as ‘Not Nice’. If there is no indication of ‘Nice’ or ‘Not Nice’, the logo is put under the category of ‘Cannot Decide’.

Out of the 101 logos surveyed, 25 were rated as Nice, 49 rated as Not Nice, while 27 falls in the Cannot Decide category. The results collected from the respondents were then used to train the ANN system.

3.3 Features extraction

To gather the information for the experiments, the variables of interest within each logo must be identified. The features extracted from the logos were factors that possibly influence the aesthetics of the logos. To prepare the data for ANN algorithm, the variables extracted from the features must be quantified. The features identified from the logos and the values assigned to the respective variables are listed here.

1. Does the logo include any lettering?
   - Represented by 1 for yes, and 0 for no

2. Does the logo include familiar object such as animal, or plant?
   - Represented by 1 for yes, and 0 for no

3. Does the logo resemble any animal? This includes birds and all other animals, including legendary animals such as dragon.
   - Represented by 1 for yes, and 0 for no

4. Does the logo resemble a bird or flying object?
   - Represented by 1 for yes, and 0 for no
5 Does the logo include any geometrical shape such as circle, square, or triangle?
   • Represented by
   • 0 – Circle
   • 1 – Triangle
   • 2 – Square
   • 3 – Rectangle

6 Is the background white or coloured?
   • Represented by 1 for yes, and 0 for no

7 What is the perceived number of colours?
   • Numerical values >1

8 Is the logo colourful? (Include 3 or more contrasting colours)
   • Represented by 1 for yes, and 0 for no

9 Is there a series of lines in the logo?
   • Represented by 1 for yes, and 0 for no

10 What is the percentage of the total area occupied by the picture?
    • The area of the major picture in the logo, in percentage

11 Number of corners.
    • Numerical values >1, excluding the four corners of the frame

12 Is there any symmetrical pattern?
    • Represented by 1 for yes, and 0 for no

13 Is the background light or dark?
    • Represented by 1 for yes, and 0 for no

14 Is the logo meaningful? Can the logo be associated to anything significant such as country flag, national animal or plant, or able to give a clear indication that it is associated to airline industry.
    • Represented by 1 for yes, and 0 for no

15 Is the logo complex or simple? Complexity depends on the quality of being intricate and compounded
    • Represented by 1 for yes, and 0 for no

These variables can be further categorised as ‘objective’ and ‘subjective’ features. The first 12 features (1–12) are ‘objective’ features, while the last three on the list (13–15) are considered as ‘subjective’ features.

Table 1 shows an example of the features extracted from one logo.
3.4 Application of ANN algorithm

In this paper, ANN is used to study the possibility of machine learning the method of aesthetical judgement. ANN consists of an interconnected group of artificial neurons that have the ability to process information using a connectionist approach to computation. Figure 4 shows a simple neural network with input layers, one hidden layer, and one neuron output.

In this study, Feed-forward Back-propagation ANNs were used. This network allows signals to travel from input to output, without feedback loops. In this case, the output of any layer does not affect that same layer. Feed-forward ANNs tend to be straightforward networks that associate inputs with outputs, which are extensively used in pattern recognition.
The values representing the features of a logo are used as input to the ANN. The performance of an ANN depends on both the weights and the transfer function that is specified for the units. The transfer function used in this network was the hyperbolic tangent sigmoid transfer function shown in Figure 5. The sigmoid transfer function takes the input, which can have any value between plus and minus infinity, and squashes the output into the range of 0–1. This transfer function is commonly used in back-propagation networks, in part, because it is differentiable.

**Figure 5** Hyperbolic Tangent Sigmoid Transfer Function (TANSIG)

When the numerical data collected from the logos were transferred into the algorithm in vectors, a number of ‘Nice’ and ‘Not Nice’ logos were selected to train the system. Next, a set of logos were input to the system for testing. The test results were reviewed by evaluating how closely the actual output of the network matches the desired output.

### 4 Experimental results

Three types of experiments were carried out in this study.

#### 4.1 Training and testing: all features

In this experiment, 20 ‘Nice’ and 25 ‘Not Nice’ logos were selected for the training. 5 ‘Nice’ and 10 ‘Not Nice’ logos were selected for testing. All 15 variables from features extraction were used in this experiment.

In this research, the network is not assigned a desired weight or bias parameter. The network is allowed to adjust these parameters by itself. Hence, the results vary slightly in every run. To obtain the average value, the experiment was carried out repeatedly to collect 50 sets of readings.

The similarity of the result of the network and human’s perception is about 76% accurate. Figure 6 shows an example of test result.

**Figure 6** Example of test result (see online version for colours)
The red circles in Figure 6 represent the desired value for each output. Table 2 shows the numerical results obtained from this test result.

<table>
<thead>
<tr>
<th>Logo no.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired value</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ANN readings</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.9</td>
<td>0.95</td>
<td>0</td>
<td>0.5</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

From Table 2, ANN perceives logo number 1, 9, 10 and 13 differently from human’s perception.

4.2 Training and testing: ‘objective’ features

The set of logos used in this experiment was the same as is described in Section 4.1. The only difference is the variables used as input to the network. In this experiment, only 12 ‘objective’ features instead of 15 were used in this experiment.

The reading of the experiment concluded that more than 86% of the time, the network gives aesthetic judgement, which is similar to human’s perception.

4.3 Performance of the system on ‘Cannot Decide’ data

The system was implemented on the logos, which are under the ‘Cannot Decide’ category, to give estimation of their aesthetical rating.

In this experiment, all 101 logos were used. 25 ‘Nice’ and 49 ‘Not Nice’ logos, as concluded from the survey result, were used for training, and the remaining 27 logos, which belong to the ‘Cannot Decide’ group, were used for testing.

The programme was repeated to collect 50 sets of readings. Result shows that the ANN managed to categorise all logos into ‘Nice’ or ‘Not Nice’ categories. Figures 7 and 8 show some examples of the machine’s aesthetical judgements.

Figure 7  Sample of ‘Nice’ logos determined by ANN (see online version for colours)
5 The artificial judge

Logos are designed to give an attractive first impression, and if perceived to be impressive, they may just make a difference in customer’s buying decision. In this paper, a machine-based methodology, in this case, an Automatic Neural Network (ANN), is applied (‘trained’) to make aesthetic judgements of airline logos. By embedding through weights upon an AI system the human’s perceptions of airline logos, we are able to demonstrate how a machine-based, ‘artificial judge’ may function in determining what is beautiful and what is not. An 86% parallel with human perceptions as scored by our creation of the artificial judge is highly significant. We achieve this by modelling a given set of features as input parameters to the ANN. From these experiments, we may begin to unfold at least via modelling of what happens inside the ‘brains’ of human respondents in the process of making their subjective judgements. This AI system when fully developed into an operational ‘artificial judge’ can then be used in so many ways yet to be imagined but including to ‘test’ if the existing or newly designed logos are up to a defined set of aesthetic benchmarks. This may possibly lead to the creation of an entirely new industry or professionals related to the artificial judging of aesthetics. In the future age of the internet where every child is exposed at early age to a vast array of imagery (Foo, 2003b), the task of assessing aesthetics, at least in the preliminary stages, may be AI technology driven. Perhaps, we may see the birth of a cyber-psychology of aesthetics as a result of our research endeavours. The greater challenge remains for us to develop through cognitive neurodynamics research (using ANN, possibly back-propagation methodology (Foo, 2002)) artificial court judges to deliver justice (e.g., in cases of personal injury cases) globally for human society (Foo, 2006b). As much as we as human beings yearn for beauty, we too are longing to be living in a fair and just world.

References


**Note**

¹Explored conceptually in *Foo and Wu (2007).*