The Effects of Iconicity on Learning Paired Associates

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Introduction

The vast majority of words in natural languages consist of arbitrary relationships between word forms and the meanings that they convey. As an example of this arbitrariness, consider the word dog. The word form in this case is the sound pattern produced when “dog” is spoken, or the visual pattern when the orthographic representation of “dog” is rendered. In contrast, the meaning of dog consists of the class of animals that have four legs, make great companions, and so forth. Clearly, these two things—the sound or visual pattern of the word form and the class of animals to which they refer—have no intrinsic similarities. The word forms are just arbitrary markers, or symbols, that we use to denote their intended meaning. Indeed, when we consider other examples of word forms and the meanings they map to, we find that this pattern of arbitrariness holds for most other words in English, and for the panoply of other natural languages as well.

The view that word forms and meanings have arbitrary relationships traces back to the seminal work of Saussure (1916). Since the time of Saussure’s theorizing, others have argued that the arbitrary relationship between forms and meanings is actually a critical and defining feature of human language (e.g., Hockett, 1960). However, more recent work in cognitive linguistics has shown that systematic relationships exist between forms
and meanings in certain regions of human languages (Bergen, 2004; Gasser, Sethuraman, & Hockema, 2005). The notion of systematic relationships between forms and meanings is known as iconicity.

Bergen (2004) focused on certain sound patterns in words called phonaesthemes, which have long been thought to underly iconic relations between forms and meanings. A phonaestheme is a sound pattern that is shared by a number of words which also ostensibly share certain important aspects of their meanings. For instance, an often cited example is the sound “gl-”, which occurs in a large number of words relating to light or vision, such as “glitter”, “glisten”, “glow”, “glare”, and so on. Bergen used a priming paradigm to show that phonaesthemes in fact have a real psychological basis.

Gasser et al. (2005) developed a novel quantitative measure of the amount of iconicity between a set of forms and their corresponding meanings. Using this measure, the researchers then showed that certain aspects of various languages in fact possess a significant degree of iconicity. In particular, they found the highest amount of iconicity in the lexical category referred to as expressives. These new findings give credence to a novel perspective on language, one wherein form-meaning pairs are not entirely arbitrary, but rather arbitrary and iconic mappings coexist.

Gasser et al. also identify two distinct kinds of iconicity, termed abso-
lute and relative iconicity. Absolute iconicity refers to a form-meaning pair that share some intrinsic similarity. One example of this is onomatopoeia, for which forms are intended as imitations of sounds in nature (e.g., moo, quack, bang). Other examples are ideophones, words that convey vivid impressions of certain sensations associated with their meanings (e.g., bling bling, hippetyhop). Despite their saliency for the speakers of a language, absolutely iconic words are exceedingly difficult to pin down and precisely identify for the purposes of scientific investigation.

Relative iconicity refers to the case where a similar pattern of relationships exists between forms and their respective meanings. Essentially, this means that similar forms map to similar meanings, and vice versa. An example of this kind of iconicity are the phonaesthemes described earlier. Words that begin with “gl-” are similar due to this shared initial sound, and their meanings are also similar because of the common semantic element having to do with light or vision.

In another line of research, language acquisition studies have shown that children are able to learn iconic symbols, including sound symbols and gestures, more easily than arbitrary ones (Morford, Singleton, & Goldin-Meadow, 1995; Brown, 1977). These findings are really not surprising, however, considering the additional information that is available in iconic
symbols relative to arbitrary ones. In iconic mappings, forms possess in-
formation that directly relates to their intended meanings, and this infor-
mation can be effectively exploited in the process of language acquisition.
Considering these findings in light of the observation that most mappings
in natural language are arbitrary immediately prompts a question: Why, if
iconic symbols should in principle be easier to learn and store, do we find a
preponderance of arbitrary symbols in natural language? This question has
motivated several recent investigations (Gasser, 2004; Monaghan & Chris-
tiansen, 2006a; Monaghan & Christiansen, 2006b) and provides the basis
for the work presented in this paper.

In order to systematically study iconicity, it is first necessary to formalize
somewhat what is meant by words, or form-meaning mappings. We can
think of forms as points in a high-dimensional feature space, where, for
example, each dimension represents some aspect of the sound form for a
spoken word. Similarly, we can think of a meaning as a point in a high-
dimensional feature space, where each dimension is some semantic attribute.
A word is an association between a point in the form space and a point in
the meaning space. Then, relative iconicity is the situation where points
that are close together in the form space are associated with similarly close
points in the meaning space.
The present study is designed to explore a hypothesis about why arbitrariness might be better than relative iconicity for words, and thus why arbitrariness predominates in natural language. The hypothesis is that arbitrariness is better for words because it forces the learner to attend to forms and meanings independently, rather than focusing on higher-order correlations between them. This means that with arbitrary mappings forms, meanings, and the associations between them all need to be learned separately. This learning task is presumably more difficult than one in which iconic relationships hold, and thus learning should take longer. However, the advantage is that once all three components—forms, meanings, and their associations—have been learned, there will be less tendency for the learner to confuse individual forms or meanings, as they will all be stored separately in the learner’s memory. Clearly, this is a desirable attribute for natural languages, where it is essential that speakers distinguish between different word forms and different semantic concepts.

In order to explore the effects of relative iconicity on learning associations, the present study addresses the phenomena in “form” and “meaning” spaces of drastically reduced dimensionality. In particular, forms and meanings each vary along two perceptual dimensions. Subjects are presented with the task of learning pairs of associations between the forms and meanings
in one of two conditions: either the forms and meanings are given arbitrary pairings, or the forms and meanings are paired iconically, such that similar forms are associated with similar meanings. We are then interested in two questions about this learning task. The first question is whether subjects learn the associations better in the iconic condition than in the arbitrary, which is our prediction based on previous findings in the literature. The second question is whether perceptual discrimination of the forms and meanings is affected by the task of learning associations, and, if so, whether this effect differs for the iconic and arbitrary conditions. Our prediction is that perceptual discrimination will be better in the arbitrary condition relative to the iconic condition, because the arbitrary condition requires subjects to individually attend to and store each of the forms and meanings independently.

**Method**

**Participants**

Fourteen graduate students (6 female) participated on a volunteer basis with informed consent. All had normal or corrected-to-normal vision.
Stimuli

The stimuli consisted of two sets of seven images each, which were created using the Microsoft Paint drawing program. The first set of images, henceforth referred to as the forms, were blue circles of various diameters and hues. The second set of images, henceforth the meanings, were line drawn figures that resembled human forms. The meanings were generated from an initial line drawn figure which was deformed to produce a set of pictures of various widths and heights. Figure 1 shows examples of the form and meaning stimuli. Stimuli were presented on a 19-inch computer monitor at a normal viewing distance.

Design and Procedure

Subjects were randomly assigned to one of two conditions: either an arbitrary learning condition or an iconic learning condition. In both conditions, the subjects were to learn associations between form-meaning pairs, with each of the forms paired with exactly one of the meanings. In the arbitrary learning condition, the forms and meanings were paired randomly. In the iconic learning condition, forms and meanings were paired such that forms that are closest together in the form space (the two-dimensional color/diameter space) are paired with meanings that are closest together.
in the meaning space (the two-dimensional height/width space).

In both conditions, subjects were first administered a pair of pre-tests to assess perceptual discrimination of the form and meaning stimuli, respectively. Each pre-test proceeded as follows. First a fixation cross was displayed in the center of the monitor for 1000 ms. Then one of the seven test images (either one of the forms or one of the meanings, depending on the pre-test) was displayed for 100 ms followed by another fixation cross for 500 ms. All seven test images were then displayed and the subject was instructed to select the image that he or she had just seen. The subject responded by using the mouse to select one of the seven images and then clicking on a button to confirm the selection. This procedure continued for all seven test images in each set, which were presented in random order.

After completing both pre-tests, subjects were then trained on the associations for their respective experimental conditions. Training trials proceeded as follows. First a fixation cross was displayed for 1000 ms. Then one of the forms was displayed for 2000 ms, followed by a display of the corresponding meaning for another 2000 ms. Subjects were instructed to learn each of these form-meaning pairs, so that later they would be able to recall the appropriate meanings when prompted with the forms alone. The presentation of fixation cross, form, and meaning repeated for all seven
of the form-meaning pairs, constituting one training epoch. This process then continued several times over so that each subject received 10 training epochs. The order of presentation was randomized in each epoch.

Following training, subjects were tested to see how well they had learned the form-meaning associations. On each learning test trial, a fixation cross was presented for 1000 ms and then a form was presented for 2000 ms. All seven meanings were then displayed and the subject was instructed to select the meaning associated with the form they had just seen. This procedure repeated for all seven of the form-meaning pairs, which were displayed in random order for each subject.

Finally, after completing the learning test, subjects were given two post-tests to again assess perceptual discrimination of the forms and meanings. The post-test procedure was identical to that of the pre-test procedure.

Results

Learning Performance

The first question of interest is whether learning performance differed between the arbitrary and iconic conditions. Subjects in the iconic condition correctly recalled more of the seven training pairs (M=2.86, SD=1.35) than
did subjects in the arbitrary condition (M=1.14, SD=1.07). The difference in performance between the two conditions was significant, $t(12)=2.64$, $p<.05$, two-tailed.

**Perceptual Discrimination Before and After Training**

Next we examine whether perceptual discrimination was affected by either of the two training conditions. In order to do this, we consider the two conditions separately, and within each condition we consider performance for the forms and meanings separately. This amounts to four repeated-measures $t$-tests to account for each condition and stimuli set.

First we consider results from the arbitrary condition. For the set of forms, subjects identified the correct probe more often in the post-test ($M=4.43$, $SD=.98$) than in the pre-test ($M=2$, $SD=1.29$). This difference in performance was significant, $t(6)=3.23$, $p<.05$, two-tailed. For the set of meanings, subjects identified the correct probe slightly more often in the post-test ($M=4.57$, $SD=.53$) than in the pre-test ($M=4.29$, $SD=.76$), but the difference was not significant, $t(6)=0.68$, n.s.

In the iconic condition, subjects identified the correct probes from the set of forms more often in the post-test ($M=4.14$, $SD=1.22$) than in the pre-test ($M=3.29$, $SD=1.11$), but the difference was not significant, $t(6)=1.16$, n.s.
Subjects in the iconic condition also identified the correct probes from the set of meanings more often in the post-test (M=4.43, SD=.98) than in the pre-test (M=2.71, SD=1.11). The difference in performance in this case was significant, $t(6)=3.03$, $p<.05$, two-tailed.

The Effect of Training Condition on Perceptual Discrimination

Finally, in order to determine whether perceptual discrimination differed after training between the two conditions, two independent-measures $t$-tests were performed on the post-test results from the iconic and arbitrary conditions. Perceptual discrimination for the set of forms did not differ significantly between the two conditions, $t(12)=.25$, n.s. Perceptual discrimination for the set of meanings also did not differ significantly between the two conditions, $t(12)=.85$, n.s.

Discussion

One significant result was the finding that learning performance was better in the iconic condition than in the arbitrary condition. This result was predicted based on previous findings in the literature, and is what one should expect considering the additional information available in iconic mappings.
Nevertheless, it is good to see that this prediction bears out within this experimental set-up, and the finding goes some way to validating the experimental design as a viable means of studying questions about the relative merits of iconic versus arbitrary mappings.

In terms of the results regarding the effect of learning on perceptual discrimination, the findings were considerably less noteworthy. In particular, we would have liked to have seen significantly better performance after training in the arbitrary condition relative to the iconic condition, which would have supported our earlier hypothesis about why arbitrary mappings may be better than iconic mappings. However, this result turned out to not be significant. On the other hand, there were some findings from the tests of perceptual discrimination that are at least promising for future work. Namely, we found that perceptual discrimination did improve after training in both conditions, and a couple of times significantly so. These findings suggest that the training conditions did affect perceptual discrimination, so more extensive experimentation in the future may be able to exaggerate these effects in order to identify their underlying causes.

Probably the biggest impediment to finding more significant results in this study was the small number of subjects. Given the few significant results that were found, and the various other results that were suggestive, it
seems possible that a similar study with considerably more subjects may find the predicted effects. Another possible explanation for the less than stellar findings was the fairly brief amount of training that subjects received in the learning phase of the experiment. Due to time considerations, subjects were only presented with ten training epochs, and based on the learning performance results for both conditions it is apparent that this was not nearly enough for successful learning. It seems quite possible that more training could serve to further distinguish the results from the two training conditions. However, overall, the results did support one of our initial predictions and provided some suggestive fodder for future work.
References


Figure 1: Sample stimuli