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The Effects of Age of Acquisition on Object Recognition.

Abstract

The age at which an item is acquired has been shown to affect naming latency of words, objects and faces. The phonological completeness hypothesis situates the effects of age of acquisition (AoA) at speech output. Ellis and Lambon-Ralph (2000) argue that the effects of age of acquisition result from a 'mapping' between representations of orthography to phonology. However, neither 'phonological completeness' nor 'mapping' of phonological representations can account for the effects of age of acquisition on familiarity decisions to celebrities' faces and names (Moore & Valentine, 1999). This is because a familiarity decision requires a push button response rather than a verbal response. Moore and Valentine argued that exposure to new exemplars of information peg out the parameters of recognition for that type of information that will facilitate subsequent learning. Thus, the prediction is derived that age of acquisition will affect other perceptual classifications of any familiar stimulus class. We report two object classification experiments, where participants were required to decide whether the pictures of objects, presented at brief exposures, were real or not real. Age of acquisition and word frequency were manipulated in separate experiments. An advantage for early-acquired objects was observed, which we argue, cannot be attributable to an effect of word frequency. We further argue, that a phonological locus alone cannot account for the advantage for early-acquired objects in this classification task. The results are discussed in terms of additional multiple perceptual input loci as proposed by the Moore and Valentine (1999) Set up of a Specialised Processing System hypothesis (SSPS).

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Introduction

An extensive literature reports that high frequency words are processed more quickly than are low frequency words (for a review see Monsell, Doyle & Haggard, 1989). For example, people are faster to decide that a high frequency word constitutes an English word than a low frequency word in a lexical decision task (e.g. Scarborough, Cortese & Scarborough, 1977). People are faster to name pictures with high frequency names than pictures with low frequency names (e.g. Oldfield & Wingfield, 1964, 1965). In such studies, measures of word frequency have been derived from published corpora, for example Thorndike and Lorge (1944), Kuèera and Francis (1967) and the CELEX database (Baayen, Piepenbrock & van Rijn, 1993).

An increasing number of studies demonstrate that age of acquisition (AoA) is an important predictor of the speed of lexical processing. That is to say that people are faster to name pictures with names learned early in life than to name pictures with late-acquired names. This effect has been demonstrated in English (Morrison, Ellis & Quinlan, 1992); in Spanish (Cuetos, Ellis & Alvarez, 1999) and in written French object naming (e.g. Bonin, Fayol, & Chalard, 2001; Bonin, Chalard, Méot & Fayol, 2002). An effect of age of acquisition has also been demonstrated in written word production in French (Bonin et al., 2001; Bonin et al., 2002); on English and Dutch word reading and lexical decision tasks (e.g. Morrison & Ellis, 1995; Brysbaert, Lange & Van Wijnendaele, 2000) and on an auditory lexical decision in English (Turner, Valentine & Ellis, 1998). The effects of age of acquisition are not confined to lexical processing. The age at which a celebrity was first encountered has been demonstrated to affect the time taken to name celebrities' faces, read celebrities' names aloud and to decide whether or not a face or name is familiar (Moore & Valentine, 1998; 1999).

In all of the age of acquisition studies cited above the authors controlled word frequency or rated familiarity (that is the cumulative frequency with celebrities) of early- and late-acquired items. However, many past and contemporary studies reporting the effects of word frequency fail to control for the effects of age of acquisition. Some researchers have even argued that the effects of age of acquisition are 'interchangeable' with the effects of word frequency (Seidenberg, Peterson, MacDonald & Plaut, 1996) or re-interpreted the effects of age of acquisition as 'trajectory frequency' (which refers to "how experience with a word is distributed over time", Zevin & Seidenberg, 2002, page 10). This view may be seductive because age of acquisition and word frequency are highly correlated. However, this view can only be maintained if one ignores mounting empirical evidence of the effects of age of acquisition in domains were such correlations are not so strong. For example, these effects have been established in naming and recognising the faces and names of celebrities (Moore & Valentine, 1998). There are also empirical studies that have carefully disentangled the effects of these two variables and demonstrated an effect of age of acquisition in a task that does not show an effect of word frequency (e.g. Turner et al., 1998).

The problems of teasing apart the effects of word frequency and age of acquisition are compounded because some 'objective' measures of word frequency and age of acquisition have been taken from the same source (e.g. Rinsland, 1945: Thorndike & Lorge, 1944). These corpora were designed to advise teachers when children should learn particular words. It has been assumed that because children learn these words early in life, the words will 'naturally' acquire a higher 'cumulative frequency'. However, there has been a consistent failure to find an independent influence of cumulative frequency on lexical processing tasks (Carroll & White, 1973a; Gilhooly &

Gilhooly, 1979; Gilhooly, 1984; Morrison, Chappell & Ellis, 1997; Morrison, Hirsh, Chapell & Ellis, 2002).

Many models of human cognition, especially connectionist models, were designed to account for the effects of word frequency. For example, Seidenberg and McClelland's (1989) network, using backward error-propagation to learn mappings between orthography and phonology has been shown to account for a wide range of effects in normal reading. The model simulates the effects of word frequency on word naming latency. Previously researchers had assumed that backward error propagation networks would not be able to account for the effects of age of acquisition due to catastrophic interference of early learned patterns by later learned patterns. Nevertheless, Ellis and Lambon Ralph (2000) have demonstrated that the effect of age of acquisition can be an 'emergent property' of a backward-error propagation network. Ellis and Lambon Ralph trained a network with a set of 'early' patterns. Later patterns were added so that all of the patterns were trained in an interleaved fashion, that were matched on the cumulative frequency of presentation for each set of patterns. Performance of the network remained superior on the early-learned patterns compared with late-learned patterns even after extensive further training. When activation of the hidden units was analysed, Ellis and Lambon Ralph report that the effects of age of acquisition were caused by a gradual reduction in the network's plasticity. This caused a reduction in the ability of the network to learn later items as effectively as early patterns. The effect cannot be explained in terms of simple differences in the cumulative frequency of presentation, because the number of times each pattern was presented had been equated when the network was tested.

Monaghan and Ellis (2002) argue that the effect of age of acquisition is modulated by the degree of similarity or correlation between early and late learned patterns. When the correlation was low the network structure built up during training on early patterns was generally not helpful for the assimilation of later patterns, which failed to attain representations comparable to those of early patterns. In contrast, when the correlation between early and late patterns was high, the late patterns could take advantage of the network structure established by the early patterns.

The locus of the effect of age of acquisition has also been subject to considerable debate in the literature. Early theorists attributed the effect to the phonological representation of words. According to the 'Phonological Completeness Hypothesis' (Brown & Watson, 1987) the phonological representation of early-acquired words should be stored in a more complete form than the representation of later-acquired words. Consistent with this view Morrison et al. (1992) located the effect of age of acquisition on object naming at the speech output lexicon. This locus was supported by the lack of an effect of age of acquisition in a semantic classification task. Morrison and Ellis (1995) report significant effects of age of acquisition in visual lexical decision tasks. They attributed the effect of age of acquisition on lexical decisions to automatic activation of phonology in the output lexicon. Gerhand and Barry (1999) replicated this effect. Furthermore, they report that the use of orthographically illegal non-words and pseudohomophones as non-words failed to remove the effect of age of acquisition. They also found that the use of articulatory suppression as a secondary task (repetition of a nursery rhyme or repetition of the single word "the") while making lexical decisions also failed to extinguish the significant effect of age of acquisition. Notwithstanding this finding, Gerhand and Barry attributed the effects of age of acquisition to an automatic activation of phonology upon seeing the word. The locus of an effect of age of acquisition at the speech output lexicon implies that the effect arises from learning during a 'critical period' during which the representations that underpin speech are acquired.

The observed effects of age of acquisition in face and name processing tasks challenges both the locus of the effect of age of acquisition and the notion of a critical period. Moore and Valentine (1999) report that age of acquisition affected the speed with which participants could decide whether a famous face was familiar or not. Famous faces are notoriously difficult to name (see Valentine, Brennen & Brédart, 1996) and there is further evidence from repetition priming studies to show that names are not automatically activated during a face familiarity decision task (Valentine, Hollis & Moore, 1998). These data are difficult to reconcile with a 'phonological' locus alone because no verbal response was required. Furthermore, famous faces and names are acquired later in life than typical object names, suggesting that age of acquisition influences cognitive processing beyond a 'critical period' of language acquisition. The early-acquired celebrities in these studies were rated as acquired between the ages of six to twelve years.

Moore and Valentine (1999) suggested that the effect of age of acquisition reflects the order of acquisition of items in a specific stimulus domain, rather than the age per se, at which they were acquired. That is to say, initial exemplars of the new type of information would stimulate a physiological, orienting response[1], that would effectively initiate the set up of a specialised processing system (SSPS). In this way, we have argued that age of acquisition should affect any perceptual or lexical processing task for which specialised representations have been established (Moore, 2000).

Effects of age of acquisition have been reported for visual and auditory word recognition, for oral and written production of object names; naming celebrity faces; reading aloud printed words; printed celebrity names and making familiarity decisions to both celebrity names and faces. If age of acquisition affects processing in all perceptual domains, it would be predicted that age of acquisition should affect the speed of recognition of visual objects. The aim of this paper is to test this prediction. Neither the phonological completeness hypothesis (Brown & Watson, 1987) nor a hypothesis that specifically attributes the effects of age of acquisition onto mappings between phonological representations (the 'phonological mapping' hypothesis Ellis & Lambon Ralph, 2000) would predict an effect of age of acquisition in this task.

Vitkovitch and Tyrell (1995) reported a significant correlation between age of acquisition and the speed of classifying stimuli as 'true objects' or 'non-objects'. However, there was also a highly significant intercorrelation between age of acquisition and word frequency (rho = -0.48; $p<.001$). Therefore, the result may be attributable to a shared variance between age of acquisition and word frequency. Intercorrelations between variables can destabilise a stepwise regression model (see Tabachnickk & Fidell, 1996, pp 146-157). Therefore, the shared and unique variance of all variables that significantly correlate with the dependent variables should be examined and reported separately (for discussion see Moore & Valentine, 1998). To avoid

1 Such a response may be that reported as an attentional mechanism. For example, pre-pulse inhibition occurs when a weak non-startle stimulus is presented (30-500ms) before a startle probe and serves to reduce the effect of the probe stimulus (Lang, Bradley & Cuthbert, 1997). Lang et al. (1997) argue that the operation of pre-attentive processes serve to increase vigilance for that type of information.

the problems associated with intercorrelations between variables the effects of age of acquisition and word frequency were investigated in experiments 1 and 2, in which they were manipulated orthogonally, and in which the stimuli were matched on other potentially important variables (see Appendix III). Age of acquisition was manipulated in Experiment 1, while the stimuli were matched on word frequency and other important variables. In Experiment 2, word frequency was manipulated while the stimuli were matched on age of acquisition and other important variables.

In Experiment 1, participants classified pictures of early- and late-acquired stimuli as 'true objects' or 'non-objects'. Because we wanted to exclude intrusion or feedback from an object' name to the decision time, participants were encouraged to respond as fast as possible, while maintaining accuracy. This was achieved in two ways. First, the stimuli were presented briefly between a forward and a backward mask. Second, the instructions emphasised the importance of a fast response. A pilot study (Moore & Valentine, 2001) without these characteristics yielded a significant effect of age of acquisition on object decision times ($F(1,36) = 8.9$, MSE = 19642; $p<.001$). These classification times (mean = 714ms, SEM = 4.16) were faster than those (between means of 790ms to 1263ms) reported by Vitkovitch and Tyrell (1995), however, they were also similar to those reported in object naming studies (Barry et al., 1997; Morrison et al., 1992) with mean latencies ranging between 714ms to 827ms. Therefore, it is possible that the effect of age of acquisition in the pilot study could have been attributable to implicit naming, not perceptual processing.

Experiment 1

In Experiment 1 the emphasis of the instructions encouraged participants to make fast responses. The stimuli were presented between a forward and a backward visual mask. Also, post hoc ratings of familiarity (or cumulative frequency) and age of acquisition were obtained from participants using the procedure used by Moore and Valentine (1999). The post hoc ratings will serve to validate the a priori matching of the stimulus sets[2], with post hoc ratings obtained from the participants in the classification task. The post hoc ratings thus provide a check on the individual differences in AoA and cumulative frequency.

Method.

Participants: There were 39 participants (26 female, 13 male) with a mean age of 28.33 (s.d. = 10.04). The participants were staff and students at two UK universities and were paid for their participation.

Apparatus: Testing was carried out on an IBM-compatible Viglen 800 MHz Pentium III computer, with 128 Mb RAM. The Micro Experimental Laboratory (MEL Professional) experiment generator software package (Rodgers, Schneider, Pitcher & Zuccolotto, 1995)

2. Note that frequency refers to measures of word frequency from published corpora. Familiarity refers to the rated measure of participants' individual and reflective measure for the frequency of personal encounter with an item (also see Gernsbacher, 1984). Familiarity does not refer to Lewis' (1999) mathematical estimation of the cumulative number of instances of potential exposure to an item. Age of acquisition is a measure of individual participants' reflective estimate of when they personally first encountered an item. Where we refer to objective AoA, this refers to the age at which 75% of children can produce the name of an object (Morrison et al., 1997).

was used to program the experiment, randomise the order of stimulus presentation, record reaction time (with millisecond accuracy) and accuracy of response.

Stimuli: The critical items were 48 pictures from Snodgrass and Vanderwart (1980) and 48 pictures of non-objects as used by Barry, Morrison & Ellis (1997). These pictures were digitally scanned to create high contrast line drawings, 256 x 256 pixels in size. There were 24 pictures with early-acquired names and 24 pictures with late-acquired names. This division was based on a priori age of acquisition ratings taken from Morrison et al. (1997), where adults had estimated the age at which they had learned a word, in either written or spoken form, using scores on a 7-point scale. Early age of acquisition items were selected such that their names were rated as less than 2.25 (mean = 1.95), that is, learned between approximately 2 and 4 years of age. Late AoA items were rated over 2.90 (mean = 3.36), that is, they were rated as learned between approximately 6 and 7 years of age.

The two groups of critical items, early vs. late, were matched on other influential variables, i.e. the number of phonemes, visual complexity, name and image agreement, familiarity and word frequency (list of items, scores and group analyses appear in Appendices I to III). The non-object filler items were created from mixing sections of pictures from the Snodgrass and Vanderwart set, not used in the reported experiments (e.g. a camel with the head of a cat), which were scaled to produce an unbroken contour. All stimuli were 16-bit greyscale images (256 x 256 pixels in size). The pictures were centred on the computer screen and subtended a visual angle of approximately 6 degrees.

In order to drive the rapid perceptual nature of this task, the pictures were presented between forward and backward masks. The masks were created using a montage of overlapping discontinuous Snodgrass and Vanderwart image parts.

Design: The experiment was a within-participant factorial design. The independent variable had two levels (Early AoA vs Late AoA). The dependent variables were speed and accuracy of response.

Procedure: The participants were requested to focus on the centre of the PC screen and to decide as quickly and accurately as possible whether the picture was that of a ‘real’ object or ‘not’ and press the appropriate key on the keyboard, pressing ‘Yes’ or ‘No’ (marked on the ‘z’ and ‘/’ keys respectively). For each stimulus presentation a ‘+’ sign appeared in the centre of the screen for 700ms, followed by a 532 Hz tone (250ms) which was followed by a forward mask (250ms). The mask was replaced by a picture of an object or non-object (200ms) and followed, immediately by the presentation of a backward mask, which remained until participants made their response via the keyboard. The participants were required to respond as quickly and accurately as possible. Latencies above or equal to 2 seconds from the onset of the backwards mask were excluded from the analyses. The classification latencies (with millisecond accuracy) and accuracy of response were automatically recorded by the experimental software.

Instructions to participants emphasised the importance of making rapid responses that is as fast as possible that would allow accuracy to be maintained. These instructions were emphasised during twelve practice trials (comprising 6 objects and 6 non-objects) during which participants were encouraged to respond as quickly as possible. The data from the practice trials were excluded from all analyses.

Following the experiment each participant was required to rate the stimuli for familiarity and age of acquisition using the procedure used in previous studies by Moore and Valentine (1998).

Post hoc Ratings

Familiarity Ratings: The instructions were that the ratings should reflect how many times, prior to the experiment, the object had been encountered by the participant in everyday life, TV, films, newspapers, magazines, posters, etc. Ratings were made on a 7-point scale (1 = completely unknown to 7 = very familiar). Note that this rating could equally well be referred to as an estimate of cumulative frequency rather than familiarity (Moore & Valentine, 1998).

Age of Acquisition Ratings: Ratings of age of acquisition were made on a 7-point scale with 1 representing an unfamiliar item, ratings of 2 – 7 reflected increasing ages at which the items were first encountered. Participants estimated when they "first became aware...." of each object. A score of two related to an object first acquired under 3 years of age; three, to an object acquired under 4 years of age; four, an object acquired under 5 years of age; five, an object acquired under 6 years of age, six; an object acquired under 7 years of age; and seven, an object acquired over 7 years of age. A key to this scale was provided while participants made their ratings. There was no time pressure for ratings to be made. Participants were instructed to make their ratings based on their own experience. It was stated that there "are no right of wrong answers, it is your personal opinion that we value."

Results.

These experiments were designed to take participants as the random factor in a within-participant design. Such an analysis provides an appropriate test of the influence of the manipulated variable, because the stimuli have been matched on other relevant variables. Therefore, an analysis with items as the random factor is unnecessary (see Raaijmakers, Schrijnemakers & Gremmen, 1999). However, even careful control of the stimulus groups cannot control for the variability within each group[3]. Therefore, in addition to the by-participant analysis of variance (ANOVA, F_1) we report a by-item analysis of covariance (ANCOVA, F_2) in which the early and late age of acquisition grouping (AoAGP) forms a single between-items factor. The covariates are variables that significantly correlate with the dependent variable, and significant intercorrelations.

The mean reaction time of correct responses was calculated for objects (mean = 568ms, SEM = 5.38.) and non-objects (mean = 694ms, SEM = 5.90). The participants were significantly faster to recognise objects acquired early in life (mean = 559ms, SEM = 3.74) than late-acquired objects (mean = 583ms, SEM = 4.39) by participants ($F_1(1, 38) = 6.64$, MSE = 1656.03; $p<.02$) and by items ($F_2(7,40) = 6.15$, MSE = 46816.50; $p<.02$). The covariates in the analysis of covariance were post hoc age of acquisition ratings ($F_2(7,40) = 11$, MSE = 83700.38; $p<.01$) and post hoc familiarity ratings ($F_2<1$). Faster classifications were made to those items rated as early-acquired by experimental participants, than the items rated as late- acquired. Analysis of the accuracy data evinced a significant difference between the accuracy to classify early-acquired objects (mean = 22.62, SEM = 0.04) and late-acquired objects (mean = 21.67, SEM = 0.05) by participants (F_1(1,

38) = 10.94, MSE = 1.60; p<.01), but not by items (F_2(6,41) = 2.96, MSE = 38.73; p = .09). The covariates in the analysis of covariance

3. We thank Marc Brysbaert for pointing this out.

were post hoc age of acquisition ratings (F_2(6,41) = 11, MSE = 71.57; p<.03); post hoc familiarity ratings (F_2<1); number of phonemes (F_2<1); image agreement (F_2(6,41) = 2.02, MSE = 26.40, p =.16) and visual complexity (F_2(6,41) = .61, MSE = 7.93, p=.44). The participants were faster and more accurate to classify pictures of early-acquired objects than to classify pictures of late-acquired objects.

The participants made post hoc ratings of the critical stimuli to verify the validity of the a priori stimulus grouping. These data appear in Table 1. The post hoc ratings were subjected to a battery of t tests. There was no significant difference between the familiarity ratings of early-acquired and late-acquired items, t(46) = 1.77, SED = 0.18, p<.08. There was a highly significant difference between ratings for early-acquired and late-acquired stimuli, t (46) = 10.81, SED = 0.01, p<.001.

Table 1: Showing the mean *a priori* and *post hoc* familiarity and age of acquisition ratings from Experiment 1.

	Early AoA Ratings		Late AoA Ratings	
	a priori	*post hoc*	*a priori*	*post hoc*
Familiarity	**2.93**	**6.11**	**2.82**	**5.80**
	(0.77)	(0.58)	(0.80)	(0.64)
AoA	**1.91**	**2.58**	**3.36**	**3.66**
	(0.26)	(0.27)	(0.34)	(0.41)

Note: Standard deviations in parentheses. A priori ratings taken from Morrison et al. (1997). Post hoc ratings from those participating in Experiment 1.

There was a significant difference between a priori and post hoc ratings of familiarity, t(46) = 55.40, SED = 0.006, p<.001. This result demonstrates that the items were rated as significantly more familiar to participants whose data contributed to the analyses, than to participants who gave the a priori ratings to Morrison et al. (1997). This difference may reflect differences in the instructions between the studies. There was a significant difference between a priori and post hoc ratings of age of acquisition, t(47) = 10.30, SED = 0.005; p<.001. The objects used in the experiment were rated as being acquired at a significantly earlier age in the a priori ratings than by the participants in the present experiment.

Discussion

In comparison to the pilot data, it is clear that when participants are encouraged by instruction and practice to respond quickly, it is possible to reduce their response latencies considerably, without affecting the response accuracy in this task. The mean classification latencies for objects in Experiment 1, was 568ms compared to 714ms in the pilot study. The significant advantage for faster classification of early-acquired objects than of late-acquired objects that was observed in the pilot study was replicated in Experiment 1. Early-acquired objects were classified more accurately in Experiment 1. The significant advantage for early-acquired objects to be classified more accurately than late-acquired objects confirmed that a speed-accuracy trade off had not occurred. The post hoc ratings of familiarity and age of acquisition confirmed the a priori selection of stimuli. It is important to note that the advantage for early-acquired items cannot be attributed to any confounding influence of familiarity of with the critical items, as confirmed by the analyses of covariance.

The finding that an advantage for early-acquired objects was observed when participants responded more quickly is consistent with a perceptual locus for the effect of age of acquisition. However, it could be argued that the early stages of lexical selection in implicit naming are fed back to the perceptual levels of processing. Therefore, it could be argued that the effect is attributable to automatic activation of lexical representations, perhaps including phonological representations. Such an interpretation would imply that attributes, other than age of acquisition, that are known to affect object naming latency would also influence object classification latency. To test this hypothesis we manipulated word frequency and matched age of acquisition in Experiment 2. If the effect of age of acquisition on object classification is attributable to implicit naming there should be an effect of word frequency (i.e. faster response times to high frequency items) on the task when age of acquisition is controlled.

Experiment 2

Method.

Participants: There were 38 participants (33 female, 5 male; mean age = 20.75 yrs, s.d. = 4.82 yrs). The participants were staff and students at two UK Universities and were paid for their participation.

Materials and Apparatus: These were identical to those described in Experiment 1 with the following exceptions. The stimuli were regrouped to create orthogonal sets for pictures with high or low frequency names and were matched on other attributes (see Appendix II). The stimuli consisted of 48 pictures of real objects and 48 pictures of non-objects. There were 24 line drawings of objects with high frequency names (e.g. bottle, box, table) and 24 line drawings of objects with low frequency names (e.g. kite, owl, pram). The selection of stimuli was based on those used by Barry et al. (1997). Four frequency measures were used to group the stimuli into high and low frequency groups, namely Celex written and Celex spoken (1993), Kuèera and Francis (1967) and Hofland and Johansson (1982). The items had non-overlapping distributions the means on these measures are given in Barry et al. (2001). The familiarity and AoA of the stimuli were matched across the two groups of objects using Barry et al.'s ratings.

Design: There was a single within-participant factor of word frequency with two levels (high vs low frequency). The dependent variables were speed and accuracy of responses.

Procedure: The experimental procedure and post hoc ratings were as described for Experiment 1.

Results and Discussion

The mean latency scores were derived for objects (mean = 543ms, SEM = 5.92) and non-objects (mean = 683ms, SEM = 6.34). The participants were significantly faster to classify pictures of objects with low frequency names (mean = 532ms; SEM = 3.21) than they were to classify pictures of objects with high frequency names (mean = 555ms, SEM = 3.55) by participants (F_1(1, 37) = 8.18, MSE = 1176.17; p<.01) but not in the items analysis (F_2<1). The covariates in the analysis were post hoc age of acquisition ratings ($F_2(4,43) = 13.20$, MSE = 67832.84; $p<.001$); image agreement ($F_2(4,43) = 16.50$, MSE = 84644.42, $p<.001$) and post hoc familiarity ratings ($F_2<1$). Participants were faster to classify low frequency items than they were to classify high frequency items. This demonstrates that post hoc age of acquisition ratings, when given by the same participants making the classification responses, significantly influenced the classification latencies. The significant contribution made by image agreement suggests that objects representing a prototypical image (high image agreement score) were classified faster than those that were not typical of the objects (low image agreement score).

The accuracy of response was derived for objects (mean = 45.55, SEM = 0.11) and non-objects (mean = 41.87, SEM = 0.09). The participants were more accurate to classify pictures of objects with low frequency names (mean = 23.08, SEM = 0.03.) than pictures with high frequency names (mean = 22.47, SEM = 0.03) by participants ($F_1(1,37) = 6.05$, MSE = 1.15; $p<.02$) but not by items ($F_2(6,41) = 2.19$, MSE = 18.86, $p<.15$) There were no significant correlations in the accuracy data. More low frequency items were correctly classified than high frequency items, although not significantly so.

The post hoc ratings of stimuli were subjected to a battery of t tests. The mean scores appear in Table 2. There was a significant differences between the high and low frequency items in rated familiarity, $t(46) = 2.63$, SED = 0.12; $p<.02$, or on rated age of acquisition, $t(46) = 0.91$, SED = 0.14; $p=.36$. A comparison of a priori and post hoc familiarity ratings revealed a significant difference between a priori (mean = 3.20) and post hoc (mean = 6.29) ratings, $t(47) = -36.81$, SED = 0.008; $p<.001$. The stimuli were rated as significantly more familiar to the experimental participants (i.e. whose data contributed to the analyses) than participants who provided the a priori ratings (Barry et al., 1997). A comparison of a priori and post hoc ratings of age of acquisition revealed a significant difference (a priori mean = 2.34; post hoc mean = 2.89), $t(47) = -12.81$, SED = 0.004; $p<.001$. The items were rated as being acquired at a significantly earlier age a priori than by the participants in Experiment 2. These differences show the same trend as was apparent for Experiment 1.

Table 2: Showing the mean a priori and post hoc familiarity and age of acquisition ratings from Experiment 2.

	High Frequency		**Low Frequency**	
	a priori	*post hoc*	*a priori*	*post hoc*
Familiarity	**3.58**	**6.45**	**2.82**	**6.13**
	(0.83)	(0.37)	(0.81)	(0.45)
AoA	**2.40**	**2.96**	**2.28**	**2.83**
	(0.42)	(0.54)	(0.30)	(0.44)

Note: Standard deviations in parentheses. The a priori ratings taken from Barry et al. (2001). Post hoc ratings from those participating in Experiment 2.

Discussion

If the latency of object classifications was affected by word frequency, decisions should have been made faster to pictures of objects with high frequency names than to those with low frequency names. This was not the case, instead objects with low frequency names were classified faster.

There was no evidence of a speed accuracy trade-off as the responses were both faster and more accurate to low frequency items. The two sets of objects were matched a priori on measures of familiarity, age of acquisition, visual complexity, image and name agreement, and the number of phonemes in the name. However, the analysis of covariance revealed that early-acquired items were classified faster than later-acquired. Therefore, the influence of age of acquisition is significant, especially when the post hoc ratings are provided by the experimental participants. The Tables in Appendix III reveal that post hoc age of acquisition ratings for low frequency objects (mean = 2.83) were rated as earlier-acquired than the ratings for high frequency objects (mean = 2.96). However, this explanation for the 'reverse frequency effect' may appear parsimonious, therefore we investigated this effect further by scrutinising the stimulus sets. This revealed that the two sets might not have been matched on the 'structural similarity' of the categories from which the stimuli were drawn. Humphreys, Riddoch and Quinlan (1988) showed structural similarity of object categories affected naming latencies. They demonstrated that objects from structurally dissimilar categories in which the exemplars are visually dissimilar from each other (e.g. furniture) are, under some circumstances, named faster than objects from structurally similar categories (e.g. fruits, animals). Inspection of the stimuli in Experiment 2 (Appendix II) shows that there were 16 objects from structurally similar categories (fruit, vegetables, animals) in the set of low frequency objects but only 3 items from these categories in the high frequency set of items. Therefore, it was possible that word frequency may have been confounded with structural similarity. We investigated the possibility of a structural similarity confound in Experiment 2 and whether the effect of age of acquisition from Experiment 1 could have been due to a structural similarity confound in the classification data. The effect of structural similarity on classifications was investigated in both Experiments 1 and 2 seperately[4].

It should be noted that Humphreys et al. found an advantage for naming structurally distinct objects. Naming required a different response for each exemplar of a category. In contrast, deciding whether an object is 'real' is a decision requiring the same response for each member of any category, indeed, for all 'real' objects. Therefore it could be argued that performing this task to structurally similar objects may be faster, because participants can identify the object category faster when it is shared with other, similar looking objects. Such an effect of structural similarity on object decision is consistent with our hypothesis that object decision speed is affected by factors that influence visual processing and not by factors that affect name retrieval. This interpretation is supported by the significant contribution of image agreement in the analyses of covariance. For a post hoc analysis of the effects of structural

4 Structural similarity was investigated separately. Experiment 1: There were 8 structurally distinct and 16 were structurally similar early-acquired objects. There were 18 structurally distinct and 16 structurally similar late-acquired objects. The dfference in classification latencies was not significant between structurally distinct (mean = 571ms, SEM = 17.23) and structurally similar objects (mean = 580ms, SEM = 21.09), $t(46)=3.18$, SED = 30.38, $p=.75$. The difference in classification accuracy was not significant between structurally distinct (mean = 36.89, SEM = 0.43) and structurally similar (mean = 35.43, SEM = 0.94) objects $t(46) = 1.15$, SED = 1.26, $p = .25$.

Experiment 2: There were 21 structurally distinct and 3 were structurally similar high frequency objects. There were 8 structurally distinct and 16 structurally similar low frequency objects. Although there was a difference of 32ms in the mean classification latency between structurally distinct (mean = 561ms, SEM = 25.41) and structurally similar objects (mean = 529ms, SEM = 64.54) this was not significant in a t test ($t(46) = 1.28$, SED = 25.41, $p = .21$). The difference in classification accuracy was not significant between structurally distinct (mean = 35.90, SEM = 3.75) and structurally similar (mean = 36.32, SEM = 1.46) objects ($t(46) = 0.46$, SED = 0.90, $p = .65$).

similarity in both experiments 1 and 2 see footnote 4. The results of Experiment 2 clearly demonstrate that the predicted advantage for objects with high frequency names in an object decision task was not observed.

General Discussion.

The experiments reported here have shown that an effect of age of acquisition was observed in a decision that requires line drawings of familiar objects to be distinguished from non-objects (comprising two halves of different objects). Objects acquired early in life were classified as objects faster than later-acquired objects. This effect of age of acquisition was observed when the stimulus sets were matched on word frequency, familiarity, image and name agreement, visual complexity and the number of phonemes in the name. The effect of age of acquisition was found when instructions are used to speed the decision, reducing the mean latencies from around 700ms in the pilot study, to around 550ms. The aim of speeding participants' responses was to limit the possibility of any influence of retrieval of the object's name on that response. Experiment 2 explored whether a lexical factor known to influence object naming latency would affect the object decision latency. If lexical factors influenced the classification reaction times, it would be expected that object decisions would be made more quickly to objects with high frequency names when age of acquisition was controlled. No such effect was found. Indeed, object decisions were made more quickly to objects with low frequency names, an effect that we have demonstrated to be an artefact of age of acquisition.

To summarise, the empirical effects of age of acquisition evince a robust advantage for early-acquired stimuli on visual and auditory lexical decision tasks (e.g. Morrison & Ellis, 1995; Turner et al., 1998); also, for both object naming (Morrison, et al., 1992) and word naming in English (Monaghan & Ellis, 2002), in Dutch (Brysbaert et al., 2000) in French (Bonin et al., 2001; Bonin et al., 2002) and in Spanish (Cuetos et al., 1999). The same pattern of results were also reported for naming both celebrities' faces and reading the printed names of celebrities (Moore & Valentine, 1998). Contrary to the sole locus of age of acquisition being at the 'phonological output' stage of processing, age of acquisition also affects the speed of making familiarity decisions to celebrities' faces and to celebrities' printed names (Moore & Valentine, 1999). The data presented here clearly demonstrate the same pattern of results on a perceptual object recognition task, demonstrating that age of acquisition affects both input as well as output processing tasks. Therefore, it is concluded that effects of age of acquisition are observed in speeded decisions on tasks that require a response based on either the mental lexicon or perceptual register for any class of stimuli.

The data reported here refute a single locus for the effects of age of acquisition at the phonological output lexicon. Instead, the data are consistent with the view that the effects of age of acquisition are the result of the neural representation of any class of perceptual or lexical information. This, in turn, may reflect a general property of the mental representation of perceptual information both visual and lexical. Moore (1998; 2000) argued that all new patterns of information are processed in a fundamentally different way to later-acquired related material. It was argued that initial encounters of exemplars from any new class of information, of any type and at any age, could begin to establish a new principle for organising and processing the relevant information. If enough exemplars of a class are encountered, that are of sufficient significance to the observer, then a specialised processing system would become established. Later-acquired, related information would be represented in a different manner from early items. This is because the early exemplars were actively involved in setting up, or pegging out the parameters for a dedicated processing mechanism. Under this view the 'phonological mapping' hypothesis may well be one such dedicated system. However, this effect arises because of the active involvement where initial exemplars 'configure' the system. There is some evidence for such facilitation in the Ellis and Lambon-Ralph model, as reported by Monaghan and Ellis (2002). Monaghan and Ellis demonstrated that late-learned patterns could take advantage of the network's configuration, but this was only when a high degree of correlation existed between early and late-learned patterns. The evidence for the distinction between network configuration and reduced plasticity may be seen by the fact that while later-learned patterns are often more difficult, they are indeed learned. Furthermore, people can become proficient and even expert in specific fields where the information that has been learned later in life. This has been demonstrated in the way specialist expertise can be acquired. For example taxi drivers were found to have superior navigational skills and their knowledge correlated with neural structures in the posterior hippocampi (Maguire, Gadian, Johnsrude, Good, Ashburner, Frackowiak, & Frith, 2000). This proficiency has been also been demonstrated in the special expertise of learning a second language (Pernani, Paulesu, Galles, Dupoux, Dehaene, Valentino, Cappa, Fazio & Mehler, 1998; Flege, Yeni-Komshiam & Lui, 1999; Birdsong & Molis, 2001). The challenge presented to neural networks researchers is the question of how the network comes to be established in the first place, and to account for developing expertise after substantial learning has already taken place, as in the case of navigational skill and second language learning.

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Appendix I: Showing the groups of critical items (early AoA vs. late AoA) and variable measures:- phoneme length, visual complexity, name and image agreement, familiarity and word frequency. Words in parentheses are the Snodgrass & Vanderwart (1980) names of the items given different names by British participants.

Early AoA.						**A Priori Rating**		**Pilot Study**		**Experiment 1**		**Post Hoc Ratings**	
	Phon	**ImAg**	**Freq**	**OAoA**	**VCom**	**Fam**	**AoA**	**RT**	**Acc**	**RT**	**Acc**	**Fam**	**AoA**
Balloon	5	4.33	10	22.1	1.25	2.86	1.85	657	35	560	38	6.54	2.19
Banana	6	4.42	4	23.4	1.25	3.71	1.80	639	37	488	38	6.72	2.23
Butterfly	7	3.92	2	23.4	4.05	2.73	2.20	607	29	458	37	6.36	2.56
Cake	3	3.45	13	23.4	2.80	3.32	1.90	694	36	580	39	6.62	2.23
Carrot	5	4.50	1	25.1	2.65	4.23	2.05	739	35	558	38	6.69	2.74
Coat	3	2.59	43	68.5	2.45	3.77	1.85	670	37	457	38	6.85	2.28
Comb	3	3.78	6	39.5	2.00	3.68	2.10	806	30	661	36	6.56	2.64
Doll*	2	2.28	10		4.12	2.50	1.60	717	37	593	36	6.13	2.18
Drum	4	3.71	11	50.5	2.65	2.41	2.00	733	34	609	36	5.54	2.92
Duck	3	3.85	9	22.1	3.05	2.59	1.05	723	38	496	39	6.08	2.59
Elephant	7	3.85	7	23.4	4.12	2.18	2.05	753	37	494	37	5.10	2.92
Frog	4	3.60	1	23.4	3.60	2.38	2.10	652	34	576	38	5.85	2.92
Leaf	3	3.88	12	25.1	2.75	3.41	2.05	693	35	487	37	6.79	2.38
Lion	4	3.88	17	23.4	3.25	1.91	1.75	866	28	709	31	5.03	2.65
Lorry (truck)	4	2.80	0	44.5	2.25	3.41	2.10	728	38	538	38	6.21	2.79
Mouse	3	4.22	10	23.4	3.00	2.59	2.05	657	37	522	37	5.79	2.87
Orange	5	4.00	23	38.5	2.12	3.73	1.85	752	38	674	38	6.64	2.38
Pear	2	4.62	6	44.5	1.20	3.23	2.16	582	37	437	39	6.26	2.74
Pig	3	3.62	8	23.4	2.70	2.36	1.80	696	36	580	32	5.92	2.59
Pram (baby carriage)	4	3.65	1	38.5	3.55	2.27	1.75	727	35	633	38	5.33	2.41
Shoe	2	3.02	14	22.1	3.20	4.68	1.50	622	34	470	38	6.90	2.18
Snail	4	3.33	1	44.5	2.70	2.45	2.20	812	29	605	35	5.79	3.03
Snowman	6	4.00	0	23.4	2.45	2.18	1.95	735	35	590	36	5.79	2.64
Tiger	4	3.82	7	44.5	4.35	1.77	2.10	662	34	583	33	5.15	2.85
Mean	**5.09**	**3.71**	**9.00**	**32.20**	**2.81**	**2.93**	**1.95**	**690**	**34.80**	**556.40**	**36.75**	**6.11**	**2.58**
SD	**0.70**	**0.58**	**9.30**	**12.60**	**0.89**	**0.77**	**0.19**	**124**	**1.52**	**73.42**	**2.13**	**0.58**	**0.27**

*Objective AoA 75% rating and phonemes for the picture with the doll (n=23).

Key: Phon. = Number of phonemes. ImAg = Image agreement. Freq = Word frequency. OAoA = Objective AoA scores from Morrison et al. (1997)
VCom. = Visual complexity. Fam = Rated familiarity (cumulative frequency). AoA = Rated AoA scores. RT = Reaction Times. Acc = Accuracy.

Late AoA.						**<u>A Priori</u> Rating**		**Pilot Study**		**Experiment 1**		**<u>Post Hoc</u> Rating**	
	Phon	**ImAg**	**Freq**	**OAoA**	**VCom**	**Fam**	**AoA**	**RT**	**Acc**	**RT**	**Acc**	**Fam**	**AoA**
Anchor	4	4.32	15	102.5	2.30	1.73	3.35	855	38	687	33	4.74	3.96
Arrow	3	2.27	14	62.5	1.60	3.27	3.25	799	32	554	38	5.28	3.56
Ashtray	5	3.20	0	140.0	2.25	3.50	3.35	757	37	686	33	6.26	3.82
Belt	4	4.05	29	50.5	1.70	3.81	3.00	684	29	508	39	6.33	3.23
Bow	2	2.67	15	56.5	2.15	2.36	3.25	685	35	495	37	5.69	3.10
Cigar	4	2.75	10	126.5	3.58	2.23	3.90	1063	22	861	17	5.10	4.44
Cigarette	7	4.65	25	86.5	2.10	3.86	3.35	893	32	785	31	6.62	3.67
Envelope	7	4.70	21	68.5	1.40	4.27	3.45	662	36	467	37	6.62	3.51
Flag	4	3.22	16	38.5	2.00	2.22	3.20	706	37	529	39	5.59	3.36
Flute	4	3.41	1	92.5	4.15	1.91	3.65	1018	24	750	25	5.15	4.23
Guitar	4	4.20	19	62.5	3.10	3.00	3.35	617	37	522	39	5.85	3.64
Kangaroo	7	4.30	0	44.5	3.70	1.41	3.05	822	36	647	38	4.69	3.56
Lamp	4	3.26	18	74.5	1.90	3.73	2.95	682	35	474	39	6.69	3.05
Light-bulb	7	4.42	0	102.5	3.25	3.41	3.20	723	37	493	38	6.79	3.00
Pineapple	6	4.60	9	74.5	3.60	2.36	3.05	686	36	460	39	5.64	3.46
Pliers	5	4.22	1	126.5	2.30	2.24	4.35	709	37	542	37	5.10	4.38
Ruler	4	3.98	3	62.5	2.40	3.82	3.20	633	38	474	37	6.49	3.15
Screw	4	3.67	21	80.5	2.90	2.77	3.42	801	36	709	26	5.76	4.08
Screwdriver	9	4.30	0	68.5	1.90	2.73	3.45	715	34	562	38	6.15	3.77
Spanner (wrench)	5	2.51	0	102.5	1.85	2.55	4.10	722	27	829	32	5.51	4.13
Toaster	5	3.92	0	50.5	3.50	3.86	3.45	741	37	621	38	6.44	3.64
Trumpet	7	2.89	7	56.5	3.15	2.05	3.10	656	35	543	39	5.13	3.79
Vase	3	2.72	4	62.5	3.40	2.50	3.25	764	35	610	37	5.95	3.51
Violin	6	4.18	11	62.5	3.75	2.14	2.95	652	27	513	39	5.59	3.77
Mean	**4.90**	**3.68**	**9.90**	**77.31**	**2.66**	**2.82**	**3.36**	**724**	**33.70**	**596.68**	**35.21**	**5.80**	**3.66**
SD	**1.70**	**0.76**	**9.20**	**27.30**	**0.81**	**0.80**	**0.35**	**136**	**3.19**	**120.74**	**5.57**	**0.65**	**0.41**

Key: Phon. = Number of phonemes. ImAg = Image agreement. Freq = Word frequency. OAoA = Objective AoA scores from Morrison <u>et al.</u> (1997)
VCom. = Visual complexity. Fam = Rated familiarity (cumulative frequency). AoA = Rated AoA scores. RT = Reaction Times. Acc = Accuracy.

Appendix II: Showing stimuli and mean scores from Experiment 2 where Word Frequency was manipulated.

High Frequency						***A Priori* Ratings**		**Experiment 2**		***Post hoc* Ratings**	
	Phon	**ImAg**	**Freq**	**OAoA**	**VCom**	**Fam**	**AoA**	**RT**	**Acc**	**Fam**	**AoA**
Bottle	4	2.85	76	38.5	1.68	4.41	2.10	484	36	6.84	2.24
Box	4	2.90	70	38.5	1.38	3.64	2.00	571	38	6.82	2.11
Chain	4	4.46	50	56.5	2.55	2.57	3.25	595	36	5.97	3.42
Church	5	2.98	348	44.5	3.28	3.09	2.70	605	36	6.21	2.92
Cigarette	7	4.65	25	86.5	2.25	3.86	3.35	648	37	6.11	3.92
Desk	4	3.18	65	86.5	3.05	4.09	2.80	571	38	6.71	3.24
Dress	4	2.30	67	38.5	2.65	3.14	2.05	588	34	6.53	2.18
Glass	4	4.40	99	44.5	1.82	4.45	2.35	439	38	6.68	2.79
Gun	3	3.82	118	44.5	3.52	2.00	2.75	505	37	5.32	3.95
Hat	3	3.65	56	23.4	2.35	2.59	2.10	452	38	6.26	2.45
Heart	3	4.49	173	50.5	1.00	3.09	2.45	440	38	6.42	3.26
Horse	3	4.20	117	23.4	3.82	2.82	1.85	479	35	6.16	2.74
Iron	3	4.08	43	44.5	3.25	3.05	2.90	763	22	6.16	3.63
Key	2	4.58	88	23.4	1.92	4.68	2.35	548	37	6.76	3.42
Knife	3	3.25	76	23.4	1.92	4.82	2.10	546	36	6.55	2.92
Moon	3	3.15	60	25.1	1.02	3.32	2.10	617	36	6.68	2.92
Mountain	6	3.52	33	62.5	2.80	2.41	2.95	894	24	6.00	3.62
Ring	3	3.08	47	50.5	2.55	3.82	2.30	633	35	6.35	3.19
Table	4	3.42	198	22.1	1.72	4.50	1.85	427	38	6.81	2.24
Telephone	7	4.28	76	23.4	3.52	4.36	2.20	467	38	6.84	2.59
Train	4	3.20	82	25.1	4.32	3.64	2.40	611	36	6.54	2.78
Watch	3	3.18	81	38.5	3.40	4.27	2.60	583	38	6.68	3.03
Wheel	3	3.48	56	25.1	2.42	2.68	2.16	498	38	6.46	2.97
Window	5	3.25	119	25.1	3.18	4.64	2.00	592	35	6.81	2.38
Mean	**3.92**	**3.60**	**92.63**	**40.19**	**2.56**	**3.58**	**2.40**	**564.85**	**35.58**	**6.45**	**2.96**
SD	**1.28**	**0.65**	**67.89**	**18.65**	**0.89**	**0.83**	**0.42**	**106.95**	**4.07**	**0.37**	**0.54**

Key: Phon. = Number of phonemes. ImAg = Image agreement. Freq = Word frequency. OAoA = Objective AoA scores from Morrison et al. (1997)
VCom. = Visual complexity. Fam = Rated familiarity (cumulative frequency). AoA = Rated AoA scores. RT = Reaction Times. Acc = Accuracy.

Low Frequency						**A Priori Ratings**		**Experiment 2**		**Post Hoc Ratings**	
	Phon	**ImAg**	**Freq**	**OAoA**	**VCom**	**Fam**	**AoA**	**RT**	**Acc**	**Fam**	**AoA**
Ant	3	2.92	6	62.5	3.92	2.81	2.55	643	34	6.71	2.29
Axe	3	4.50	12	62.5	2.48	2.14	2.95	521	37	5.68	3.63
Banana	6	4.42	4	23.4	1.32	3.71	1.80	447	37	6.89	2.08
Carrot	5	4.50	1	25.1	2.95	4.23	2.05	517	37	6.74	2.58
Cown	4	3.25	3	38.5	4.50	2.09	2.35	597	37	5.79	2.79
Comb	3	3.78	6	38.5	2.38	3.68	2.10	620	37	6.58	2.74
Duck	3	3.85	9	22.1	3.32	2.59	1.95	480	37	6.32	2.29
Frog	4	3.60	1	23.4	3.42	2.38	2.10	506	37	5.92	2.76
Glove	3	3.65	9	44.5	3.02	2.91	2.25	471	37	6.47	2.53
Hammer	4	4.10	9	25.1	2.60	2.82	2.45	528	38	5.66	3.42
Kite	3	4.10	1	38.5	2.85	2.14	2.60	492	37	5.79	3.26
Owl	2	4.10	2	38.5	4.22	2.18	2.45	594	33	5.59	3.22
Peach	3	3.28	3	102.5	2.55	3.01	2.45	632	35	5.95	3.27
Pear	2	4.62	6	44.5	1.15	3.23	2.16	465	38	6.08	3.14
Pram	4	3.65	1	38.5	3.42	2.27	1.75	584	34	5.86	2.24
Scissors	5	4.40	1	23.4	2.15	3.91	2.65	437	38	6.54	3.05
Snail	4	3.33	1	44.5	3.40	2.45	2.20	575	37	6.24	2.59
Sock	3	3.72	4	23.4	1.62	4.73	1.80	507	36	6.86	2.11
Spider	5	2.95	2	25.1	3.68	3.09	2.26	534	37	6.49	2.46
Stool	4	4.12	8	50.5	2.32	3.50	2.35	496	38	6.27	3.00
Swan	4	3.69	3	62.5	3.05	2.23	2.50	504	37	5.89	2.92
Tiger	4	3.82	7	44.5	4.62	1.77	2.10	540	36	5.41	3.08
Whistle	4	4.55	4	50.5	2.55	2.45	2.45	560	37	6.00	3.22
Zebra	5	4.05	1	44.5	4.55	1.41	2.50	510	36	5.41	3.14
Mean	**3.75**	**3.87**	**4.33**	**41.54**	**3.00**	**2.82**	**2.28**	**531.55**	**36.54**	**6.13**	**2.83**
SD	**0.99**	**0.50**	**3.28**	**18.40**	**0.96**	**0.81**	**0.30**	**57.75**	**1.32**	**0.45**	**0.44**

Key: Phon. = Number of phonemes. ImAg = Image agreement. Freq = Word frequency. OAoA = Objective AoA scores from Morrison et al. (1997)
VCom. = Visual complexity. Fam = Rated familiarity (cumulative frequency). AoA = Rated AoA scores. RT = Reaction Times. Acc = Accuracy.

Appendix III: Stimuli Groups Statistics

Early vs Late AoA	**Variables**	**Mean Difference**	**Significance Level**	**AoA Mean scores Early**	**Late**
“	Phoneme	0.19	.63	5.09	4.90
“	Image agreement	0.003	.88	3.71	3.68
“	Frequency Measure	0.96	.72	9.00	9.96
“	Objective AoA	45.11	.0001	32.20	77.31
“	Visual Complexity	0.15	.55	2.81	2.66
“	A priori Familiarity Ratings	0.11	.63	2.93	2.82
“	A priori AoA Ratings	1.45	.0001	1.95	3.36
“	Post hoc Familiarity Ratings	0.31	.08	6.11	5.80
“	Post hoc AoA Ratings	1.08	.0001	2.58	3.66

High frequency vs low frequency	**Variables**	**Mean Difference**	**Significance Level**	**Frequency Mean scores High**	**Low**
	Phoneme	0.17	.62	7.00	6.00
“	Image agreement	0.28	.11	4.65	4.62
“	Frequency Measure	88.29	.0001	93.00	4.33
“	Objective AoA	1.35	.80	40.19	41.54
“	Visual Complexity	0.45	.10	2.56	3.00
“	A priori Familiarity Ratings	0.76	.01	3.58	2.82
“	A priori AoA Ratings	0.12	.26	2.40	2.28
“	Post hoc Familiarity Ratings	0.31	.01	6.45	6.13
“	Post hoc AoA Ratings	0.13	.37	2.96	2.83

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