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Determinants of famous name processing speed:

Age of acquisition versus semantic connectedness

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Abstract

The age of acquisition (AoA) and the amount of biographical information known about celebrities have been independently shown to influence the processing of famous people. In this experiment, we investigated the facilitative contribution of both factors to famous name processing. Twenty-four mature adults participated in a familiarity judgement task, in which the names of famous people were grouped orthogonally by AoA and by the number of bits of biographical information known about them (number of facts known; NoFK). Age of acquisition was found to have a significant effect on both reaction time (RT) and accuracy of response, but NoFK did not. The RT data also revealed a significant AoA x NoFK interaction. The amount of information known about a celebrity played a facilitative role in the processing of late-acquired, but not early-acquired, celebrities. Once AoA is controlled, it would appear that the semantic system ceases to have a significant overall influence on the processing of famous people. The pre-eminence of AoA over semantic connectedness is considered in the light of current theories of AoA and how their influence might interact.

Keywords: Age of acquisition; name processing

Classification codes: 2340, 2343

1. Introduction

People are faster and more accurate to respond to items that they have learnt earlier in life than those that they have acquired later. This processing advantage is known as the age of acquisition (AoA) effect and continues to influence processing after other influential variables, such as cumulative frequency of encounter (e.g., Cortese & Khanna, 2007; Peréz, 2007), have been controlled. Age of acquisition effects have been well documented across a range of different processing tasks, such as word naming (e.g., Brown & Watson, 1987), lexical decision (e.g., Morrison & Ellis, 1995), face naming (e.g., Moore & Valentine, 1998), familiarity decisions to names and faces (Moore & Valentine, 1999), and object processing (e.g., Moore, Smith-Spark, & Valentine, 2004). Amongst a number of different theoretical accounts of the phenomenon, a role for the semantic system in producing AoA effects has been proposed (e.g., Brysbaert, van Wijnendaele, & De Deyne, 2000). In the present paper, a famous name familiarity decision task was employed to investigate how AoA and the semantic system, operationalised in terms of the number of facts known about a celebrity, would contribute to famous name processing. Both AoA and the amount of biographical information known about a celebrity have been independently demonstrated to yield effects on cognitive processing (Brédart, Valentine, Calder, & Gassi, 1995; Moore, 1998). Our orthogonal manipulation allowed us to determine whether these two effects are independent and to see how well current theories of AoA (e.g., Brysbaert et al., 2000; Ellis & Lambon Ralph, 2000) are able to integrate the relative influences on processing of the two factors.

It has been argued that AoA effects are actually cumulative frequency effects. It is, therefore, important to address this potential explanation before considering AoA theories themselves. According to the cumulative frequency hypothesis (e.g., Lewis, Gerhand, & Ellis, 2001; Zevin & Seidenberg, 2002), the greater number of experiences with early-acquired stimuli results in AoA effects. Early-acquired items, by virtue of their being learnt earlier in life, are encountered more often over a person's lifetime than late-acquired items. This greater frequency of encounter is argued to lead to the processing advantage enjoyed by early-acquired items.

The cumulative frequency hypothesis may seem intuitively attractive, but it has not stood up to empirical scrutiny. Cumulative frequency is argued to be residence time in memory multiplied by the number of times the word is experienced or employed in each year of life. This means that AoA effects should become less pronounced with age, since differences in residence time will be proportionally smaller for elderly adults than for young adults. According to the cumulative frequency hypothesis, smaller AoA effects should be manifested in older individuals than in younger people when word frequency is matched. Morrison, Hirsh, Chappell, and Ellis (2002) put this prediction to the test, using word and object naming tasks. They found no interaction between the age of participants and AoA. Contrary to the prediction derived from the cumulative frequency hypothesis, AoA effects of a similar size were found in the RTs of younger adults (aged from 18 to early-30s) and older adults (aged in their 60s to 90s).

Whilst AoA and frequency effects are highly correlated, an explanation of AoA simply couched in terms of frequency effects cannot explain the full range of empirically documented effects of AoA (e.g., Belke, Brysbaert, Meyer, & Ghyselinck, 2005; Cortese & Khanna, 2007; Ghyselinck, Lewis, & Brysbaert, 2004; Moore & Valentine, 1998; Peréz, 2007; Turner, Valentine, & Ellis, 1998) or the computational modeling of AoA effects in which frequency of encounter has been equated over training (e.g., Ellis & Lambon Ralph, 2000; Monaghan & Ellis, 2010). Indeed, Brysbaert and Ghyselinck (2006) have argued for two AoA effects. The first is a frequency-related AoA effect, found in response to words requiring simple responses, and in which AoA is yoked to frequency. The second is a frequency-independent AoA effect and is found on tasks that require some form of semantic analysis, such as naming or the generation of word associates.

An initial account of AoA, the phonological completeness hypothesis (Brown & Watson, 1987), placed the locus of the effect at speech output. However, the weight of empirical evidence argues against this explanation (e.g., Izura & Ellis, 2002; Moore & Valentine, 1998, 1999). More recent theories have argued that AoA constitutes a general property of learning and, rather than having a single locus, can be found at a number of different loci (e.g., Belke et al., 2005; Brysbaert et al., 2000; Catling & Johnston, 2009; Ellis & Lambon Ralph, 2000; Hernandez & Li, 2007; Moore, 2003; Moore & Valentine, 1999; Reilly, Chrysikou, & Ramey, 2007). Henceforth, we will focus predominantly on the two most influential of these theories, the neural plasticity account (Ellis & Lambon Ralph) and the semantic hypothesis (Brysbaert et al.).

Ellis and Lambon Ralph (2000) argued that AoA effects will be found wherever learning occurs cumulatively over time. Ellis and Lambon Ralph trained a connectionist model to learn input-output patterns, with half of these patterns being introduced at the beginning of training and the remaining half being introduced after 250 training epochs had elapsed. The network was then trained on the full set of patterns for a further 250 epochs, equating the frequency with which the early- and late-acquired patterns were encountered over training. Early-acquired items were found to hold a processing advantage (in terms of reduced output error; the equivalent of reaction time in human participants) and similar effects were found with much longer training periods. Ellis and Lambon Ralph argued that this was due to the early patterns configuring the network's input to output connections whilst it was more plastic. Early training had a greater effect on the structure of the network than later training. As more patterns were acquired the plasticity of the network reduced, rendering the network less able to change its patterns of connectedness to accommodate new patterns. As it learned the correct mappings for the early set of patterns, there was an increasing commitment to representing these early patterns. As the network moved towards a more stable and rigid representational structure, it became increasingly less able to assimilate new patterns introduced later in training. The learning of later patterns generated greater processing error, with later-acquired patterns being less well differentiated and represented in the network. The neural plasticity account argues that AoA effects are not to be found at a single locus or representational level but, rather, are to be found distributed in the links between levels of representation.

Whilst the necessity of hard-wired entrenching and the resultant loss of network plasticity can be convincingly argued for language learning by Ellis and Lambon Ralph's (2000) model, it is less clear how it extends to explain AoA in other processing domains. The Set-up of a Specialised Processing System (SSPS) hypothesis (Moore, 2003; Moore & Valentine, 1999; see also Smith-Spark et al., 2012) proposes a role for affect when encountering novel stimuli and setting up a semantic processing system with which to deal with further instances of that type. Multiple loci of AoA effects are predicted by this account and the semantic system is proposed to play a key role in setting up a new SSPS module. The absence of semantic information about a stimulus category leads to the instantiation of a new specialised processing system to process further exemplars of that category, allowing more automatic processing of later learnt material in that stimulus domain. This instantiation process results in a 'gateway' into the semantic system for that type of information, with early-acquired exemplars in a particular domain generating a discrete state-space for the representation of that type of information. Unlike the neural plasticity account, the SSPS hypothesis argues that later learning is facilitated, rather than restricted by early learning.

The semantic hypothesis (e.g., Brysbaert et al., 2000) proposes that AoA effects will emerge on tasks that require access to semantic representations. It states that there is a semantic processing advantage for early-acquired words due to their being the first to enter the representational system. Early-acquired words then influence the way in which late-acquired words are represented. Accordingly, AoA effects are, at least partly, explicable by differences in semantic processing;

larger AoA effects should be generated when a task requires greater involvement of semantic representations. The semantic locus hypothesis is supported by computational modelling. Steyvers and Tenenbaum (2005) have implemented AoA effects within a semantic ‘hub’ network model. In this model, nodes established early on in the network’s development form ‘central hubs’. The early nodes set out a basic semantic structure which permits accelerated learning of later-acquired items. The centrality of early-acquired nodes leads to the development of richer patterns of semantic connections than those developed by later-acquired nodes. The larger number of connections for early-acquired concepts should therefore result in faster responses on semantic processing tasks. However, within the Steyvers and Tenenbaum model, it should be noted that the AoA effect is secondary to the number and quality of semantic connections possessed by early-acquired items compared to the relative paucity of connections for later-acquired items.

Whilst the neural plasticity hypothesis (Ellis & Lambon Ralph, 2000) and the semantic hypothesis (Brysbaert et al., 2000) are the two the most influential theoretical accounts of AoA, criticisms have been levelled at both. Brysbaert and Ghyselinck (2006) highlighted problems with the neural plasticity account, arguing that its adoption of distributed, rather than localist, representations makes the model difficult to integrate within larger models of lexical processing. Izura and Ellis (2004), on the other hand, presented evidence from second language (L2) learning that argues against the semantic hypothesis. Their findings indicated that L2 AoA is influenced by the age at which words were learnt in L2 and not the age at which the corresponding L1 word was acquired. This is problematic for the semantic locus hypothesis as semantic representations would be shared between L1 and L2 (although see Palmer & Havelka, 2010).

Menenti and Burani (2007) investigated the predictions of the neural plasticity model (Ellis & Lambon Ralph, 2000), the cumulative frequency hypothesis (Lewis et al., 2001), and the semantic hypothesis (Brysbaert et al., 2000). By comparing the regression coefficients of the same participants over two tasks (lexical decision and semantic categorisation), they found support for the neural plasticity model but not for the cumulative frequency or semantic hypotheses. For both their tasks, the coefficients for AoA were found to be of greater magnitude than those for frequency, contrary to the predictions of the cumulative frequency hypothesis. Of more relevance to our study, there was no significant difference in coefficient size between the lexical decision and semantic categorisation tasks. These results run counter to the semantic hypothesis which would predict greater effects of AoA on tasks requiring greater levels of semantic processing. However, Menenti and Burani's two findings do support the Ellis and Lambon Ralph model, which posits that, for arbitrary mappings of input to output, AoA effects of equivalent size will be found across different tasks.

2. The current experiment

Brédart et al. (1995) have proposed a semantic locus for the facilitation of people processing. The existence of such a locus may help to indicate the relative contributions of AoA and the semantic system to efficient processing when task demands do not require lexical output. It might also demonstrate how the two variables may interact to facilitate response time and accuracy. Brédart et al. asked participants to name the faces of famous people about whom much was known (on average, seven or more bits of information, such as a celebrity's nationality, family details, the titles of films or television programmes in which they had appeared, and anecdotes) and the faces about whom little was known (on average, less than seven bits of information). Familiarity was controlled across the two groups of stimuli. Their participants were 180ms faster to name the faces of celebrities about whom many pieces of semantic information were known than faces about whom little was known. Brédart et al. concluded that knowing more about a familiar person led to faster retrieval of that person's name.

Whilst familiarity was controlled in Brédart et al.'s (1995) study, AoA was not. Since the publication of their paper, AoA has been demonstrated to have an effect on the confrontation naming of famous faces, with faster naming of early-acquired celebrities (e.g., Moore & Valentine, 1998, 1999; Smith-Spark & Moore, 2009). Therefore, to explore the relative contributions of AoA and the semantic system to people processing, we adopted a similar experimental approach to Brédart et al. but manipulated AoA as well as the amount of information known about each famous person. We chose to use names as stimuli, rather than faces, as they (generally) remain constant over time whilst faces are considerably more mutable; in the short-term between different photographs of the same celebrity and in the long-term with the ageing of that celebrity. Ensuring that a photograph of a celebrity matches a participant's internal representation of that celebrity can prove problematic and may lead to confounds in the data. In order to obtain the most robust possible findings, we therefore employed names as stimuli in our experiment. The administration of a name familiarity decision task also extended the literature from the naming of faces in Brédart et al.'s study to the processing of famous names. Robust AoA effects have been elicited on naming and perceptual familiarity decision tasks involving the processing of famous names and faces (e.g., Moore & Valentine, 1998, 1999; Richards & Ellis, 2008, 2009; Smith-Spark & Moore, 2009; Smith-Spark, Moore, & Valentine, 2012). We, therefore, considered that this domain might provide fertile ground for further exploration of AoA effects. Furthermore, using a task in the people processing domain allowed us to see how well the two theoretical accounts of AoA generalised from the processing of words and pictures of objects. Given that both Ellis and Lambon Ralph (2000) and Brysbaert et al. (2000) argue that AoA effects are a general property of learning, empirical data across a range of processing domains need to be collected and explained within their theoretical frameworks.

To this end, we administered a famous name familiarity decision judgement task to our participants in which the AoA and the number of facts known (NoFK) about celebrities were manipulated orthogonally. We chose to administer the task to mature adults in order to allow a clearer and more distinct separation between early- and late-acquired stimuli than can be obtained with typically young university students acting as participants. That is, we ensured a gap between early- and late-acquired stimuli in the range of decades rather than simply years. We used a priori and post hoc measures of familiarity and facial distinctiveness to control for the influence of these two variables on processing time. Familiarity was matched, since it is an estimate of the relative frequency of encountering each celebrity (or, in other words, a subjective measure of cumulative frequency; see Smith-Spark et al., 2012). The instructions for the familiarity ratings explicitly asked that they should reflect how many times a celebrity had been encountered in the media (or in real life). Rated facial distinctiveness has been demonstrated to influence decision speeds even to name, rather than face, stimuli (Moore, 1998; Moore & Valentine, 1999; Valentine & Bruce, 1986). We therefore also controlled for this potentially confounding variable.

Since AoA effects are considered to be domain-general in nature by the neural plasticity model (Ellis & Lambon Ralph, 2000) and the semantic hypothesis (e.g., Brysbaert et al., 2000), a main effect of AoA would be predicted by both accounts. However, differences between the two theories would emerge with respect to the influence of the semantic system on processing. The neural plasticity model would predict AoA effects based on stronger connections to and from early-acquired items. As stated previously, semantic AoA accounts (e.g., Ghyselinck, Custers, & Brysbaert, 2004) commonly call upon the Steyvers and Tenenbaum (2005) model, so we used this model as the basis of our predictions for semantic accounts. Such explanations argue that AoA effects are subsumed by semantics. Earlier acquired items would elicit more efficient processing due to their more central location in the network structure and their greater interconnectedness to other nodes in the network. Therefore, according to the semantic hypothesis, the semantic system (in the form of NoFK) should have a greater effect on performance than AoA. The neural plasticity account would predict a standard effect of AoA, with no expectation of significant semantic effects. A second prediction derived from the semantic hypothesis is that there would be a significant AoA x NoFK interaction, manifested in an advantage for stimuli that were early-acquired and had many NoFK. Such a finding may lend support to the argument that early-acquired items (nodes) are represented with richer patterns of semantic connectedness than those of later-acquired items.

3. Method

3.1 Participants

Twenty-four mature adults (15 females, 9 males, mean age = 69 years, *SD* = 10) participated in the experiment. All the participants stated that they had been resident in the UK for their entire lives.

3.2 Materials

In order to generate our experimental stimuli, people aged over 40 years old (N = 105, mean age = 60 years, *SD* = 12) were requested to write down all the bits of information that they knew about highly familiar celebrities drawn from the Smith-Spark, Moore, Valentine, and Sherman (2006) database of famous names. To maintain goodwill, each participant was asked to do this for around 30 celebrities taken from a set of 157 famous names. The participants were given a general indication of the kind of information they should write down, such as nationality, family details, the titles of films or television programmes in which they had appeared, and anything else they knew about each famous person (see Brédart et al., 1995).

Forty of these celebrity names were then chosen as critical stimuli, on the basis of having few or many facts known about them and as being either early- or late-acquired (using Smith-Spark et al.'s, 2006, ratings). The stimulus selection procedure allowed AoA and NoFK to be manipulated orthogonally, creating four 10-item stimulus groupings (early-AoA, few-NoFK; early-AoA, many-NoFK; late-AoA, few-NoFK; and late-AoA, many-NoFK). One-way ANOVAs (see Table 1) indicated that the stimulus groupings varied significantly on AoA and NoFK (with differences reflecting the orthogonal manipulation of the two variables), but were well matched for other influential variables. The ratings from Smith-Spark et al. (2006) were also used to match stimuli for familiarity and facial distinctiveness. Further details on the critical items are given in the Appendix.

TABLE 1 ABOUT HERE

Forty unfamiliar, distractor names were also presented. The unfamiliar names were constructed by recombining the first and family names of other famous people appearing in the Smith-Spark et al. (2006) database of famous people. In order to avoid priming of target stimuli, there was no overlap in names between the distractors and targets.

Testing was conducted using an IBM-compatible computer running the E-Prime experiment generator package (Psychology Software Tools, Inc.). The stimuli were presented in reverse video 12-point Courier New font. A push-button response box connected to the PC was used to record reaction time (RT) and accuracy of response.

3.3 Design

Multilevel modelling analysis allows the generalisation of findings across both participants and items (e.g., Brysbaert, 2007). Separate multilevel modelling analyses were conducted on RT and accuracy of response (%). Age of acquisition (early- vs. late-acquired) and NoFK (few vs. many facts known) were entered into the analyses as fixed factors, along with the AoA x NoFK interaction. Participant number and stimulus number were entered as random factors.

3.4 Procedure

The participants gave their informed consent to take part in the experiment. A 12-item practice session preceded the experiment proper. The participants were instructed to press one of two push-buttons to indicate whether or not each name presented on the screen was familiar to them, pressing the 'YES' button if the name was familiar to them and the 'NO' button if it was not. The participants were requested to respond as quickly and as accurately as they could. On each trial, a central fixation point appeared on the VDU for 700 ms, followed by a 2000Hz warning tone of 250ms duration, and then the stimulus name was displayed in the centre of the screen until it was extinguished by a response. The next trial was then initiated.

Once the name familiarity decision task was completed, the participants were asked to rate each of the 40 celebrities for their familiarity, facial distinctiveness, and AoA.

Familiarity: The participants rated each celebrity for how often they had been encountered across different media or in real life. The instructions stressed that the ratings should reflect how many times, prior to the experiment, the celebrity had been encountered by the participant in films, newspapers, magazines, posters, on the television, etcetera. A 7-point scale was used, from 1 being completely unknown to 7 being very familiar.

Distinctiveness: The participants estimated how easy each celebrity would be to spot based on facial features alone, on a crowded railway platform (Valentine & Bruce, 1986). A 7-point scale was employed, with 1 representing a ‘typical’ face, hard to distinguish in a crowd, and 7 being a highly distinctive face, easy to pick out in a crowd.

AoA: Ratings of when the participant first became aware of each celebrity were made on a 10-point scale. A score of 1 represented a famous person that the participant first became aware of before the age of 5 years, a score of 2 indicating that the celebrity had been acquired before 10 years of age, a score of 3 reflected a famous person first encountered before the participant was 15 years old. Points on the scale then went up in 10 year increments to 10 being a celebrity acquired before 85 years of age.

The participants were then asked to report verbally all the facts that they knew about each famous person (following the same instructions as Brédart et al., 1995). These were recorded by the experimenter.

A verbal debriefing concluded the experiment.

4. Results

Three stimuli were removed entirely from the data set. The names of Josef Stalin and Charles de Gaulle were placed in the early-acquired, few-NoFK grouping based on a priori scores, but post hoc ratings indicated that the participants actually knew many facts about them, whilst the participants knew fewer facts about Sean Connery than expected from the a priori data. Of the remaining 887 responses, 29 (3.27%) were removed prior to the analyses due to their being 2.5 SDs from a participant's mean RT.

3.1 Post hoc ratings

Analysis of the post hoc ratings taken from the participants yielded a similar pattern of results to the a priori matching of stimulus groups, indicating that the stimulus groupings were well matched. There were no significant differences in either post hoc familiarity, $F(3, 33) < 1$, $MSE = .256$, $p = .685$, partial $\eta^2 = .043$, or facial distinctiveness, $F(3, 33) < 1$, $MSE = .341$, $p = .925$, partial $\eta^2 = .014$.

The post hoc data supported the orthogonal grouping of stimuli by AoA and NoFK. Post hoc AoA ratings differed significantly, $F(3, 33) = 51.89$, $MSE = .488$, $p < .001$, partial $\eta^2 = .825$. Bonferroni post hoc comparisons indicated that the significant differences lay between early-acquired (both few and many NoFK) and late-acquired stimuli (both few and many NoFK), all at $p < .001$. Celebrities allocated to the early-acquired groupings were rated as being acquired earlier than those allocated to the late-acquired groupings. There was also a significant difference in post hoc NoFK reporting, $F(3, 33) = 47.46$, $MSE = .328$, $p < .001$, partial $\eta^2 = .812$. Bonferroni post hoc comparisons showed that few fact stimuli (both early- and late-AoA) differed significantly in the number of facts generated about them from the post hoc ratings of many fact (both early- and late-AoA) stimuli, all at $p < .001$. Participants indicated that they knew less biographical information about the celebrities in the two few fact groupings than they did about those in the many fact groupings. The mean scores for the post hoc ratings are shown in Table 2.

TABLE 2 ABOUT HERE

3.2 RT

The mean overall RT to target items was 1139 ms (*SD* = 303).

The participants responded more rapidly to early-acquired stimuli (mean = 1090 ms, *SD* = 292) than to late-acquired stimuli (mean = 1183 ms, *SD* = 306). The multilevel modelling analysis indicated that the effect of AoA on RT was highly significant, $F(1, 827) = 21.03$, $p < .001$.

The participants were also somewhat faster to classify famous people about whom many facts were known (mean = 1120 ms, *SD* = 296) than those about whom little was known (mean = 1160 ms, *SD* = 310). However, the effect of NoFK on RT was not statistically significant, $F(1, 827) = 2.97$, $p = .085$.

There was a significant interaction between AoA and NoFK, $F(1, 827) = 5.24$, $p = .022$. The interaction diagram is displayed in Figure 1. Means and post hoc *t*-tests are presented in Table 3. Post hoc *t*-tests indicated that was no significant difference in responses to the two early-acquired groups of celebrities ($p = .684$). Greater semantic richness (or interconnectedness) did not confer a processing speed advantage on celebrities about whom more was known. In contrast to the pattern of data for the early-acquired stimuli, the amount of information known about the celebrities was found to influence RT in the case of late-acquired items; knowing more about a celebrity led to significantly faster responses (*p* = .004). The early AoA-few NoFK vs late AoA- few NOFK comparison indicated that, if there is little semantic information available, AoA results in faster processing of early-acquired than late-acquired celebrities ($p < .001$). A significant advantage (*p* = .037) of AoA over NoFK was also shown in faster RTs to early AoA- few NoFK than late AoA-many NoFK celebrities. Early AoA- many NoFK celebrities were responded to significantly more rapidly than late AoA- few NoFK stimuli ($p < .001$). The mean difference in RT (131ms) is of a similar magnitude to the early AoA-few NoFK vs late AoA- few NOFK comparison, suggesting that the processing advantage had its roots in AoA rather than the semantic system. Finally, whilst there was no significant difference between early AoA- many NoFK and late AoA- many NoFK (*p* = .093), the means indicated that there was a 48ms advantage in RTs to the early-acquired celebrities. Whilst non-significant, the pattern of the data suggests AoA plays a role in influencing RTs when there is much semantic information available.

FIGURE 1 ABOUT HERE

TABLE 3 ABOUT HERE

3.3 Accuracy

The overall mean proportion of correct responses was .94 (*SD* = .24).

The participants were more accurate in response to early-acquired stimuli (mean = .96, *SD* = .20) than late-acquired stimuli (mean = .92, *SD* = .27). This difference was found to be statistically significant, $F(1, 882) = 5.29$, $p = .022$, indicating an effect of AoA on accuracy.

The participants were also rather more accurate when responding to the names of famous people about whom much was known (mean = .95 *SD* = .21) than to those about whom little was known (mean = .92, *SD* = .27). However, NoFK did not have a statistically significant effect on accuracy, $F(1, 882) = 3.48$, $p = .062$.

There was no significant interaction between AoA and NoFK, $F(1, 882) = 1.55$, $p = .214$. The mean accuracy scores for each condition are shown in Table 4.

TABLE 4 ABOUT HERE

5. Discussion

This experiment adds to a growing corpus of research showing AoA effects in the people processing domain (e.g., Moore & Valentine, 1998, 1999; Richards & Ellis, 2008, 2009; Smith-Spark & Moore, 2009; Smith-Spark et al., 2012). The participants were faster and more accurate to respond to early-acquired than late-acquired famous names. Whilst AoA had a significant effect on performance, the effect of NoFK fell short of significance for both RT and accuracy. Our findings differed from those of Brédart et al. (1995) where the amount of biographical information known about celebrities was found to have a significant influence on processing. Once AoA was introduced at the point of stimulus selection and stimuli were matched on other variables, no main effect of semantics was found. However, the significant AoA x NoFK interaction found on the RT data indicated that the semantic system did play a facilitative role in the processing of late-acquired celebrities. Whilst NoFK did not speed up responses to early-acquired items, knowing more about late-acquired celebrities led to faster RTs than knowing little about them.

Our data indicate that AoA has a much greater effect on processing efficiency than NoFK; a result that casts a new light on Brédart et al.'s (1995) findings. However, it is important to note that our experiment differed from theirs in two crucial aspects. Firstly, we used names rather than faces as stimuli. But, given that robust AoA effects are well reported in the literature on face naming, face familiarity, name reading, and name familiarity tasks (e.g., Moore & Valentine, 1998, 1999), it seems likely that the lack of control of AoA may have contributed to Brédart et al.'s results. Secondly, we used a familiarity decision task rather than a naming task. It might be suggested that the change in task demands may have resulted in there being less time for the semantic system to become involved in the processing of the stimuli, since participants were not required to read the famous names out loud but, instead, to indicate whether the famous name matched the preceding area of fame. Data from Moore and Valentine (1999), in which participants were enthusiastically encouraged to make judgements as quickly as possible and without error, would argue against this. In their experiments, the mean RT for reading names aloud (563 ms) was just 83 ms shorter than their familiarity decision task (646 ms). The similarity of these mean RTs suggests that the participants did indeed demonstrate the on-line processing that the experimenters were attempting to capture. Conversely, our participants were asked to respond as quickly and accurately as possible, but without the added emphasis on speed, resulting in a mean overall RT of 1139ms, nearly double that reported by Moore and Valentine (1998, 1999). Our mean RTs are thus reflective of the times taken to perform semantic processing (typically with RTs of around 900 ms) rather than perceptual tasks (Moore, 2003). Given that processing speed slows with age (e.g., Salthouse, 1991), it is to be expected that our mature adult participants' RTs were slower than those produced by Moore's university students, who were typically young. The RT evidence supports the argument that the RTs fall in the range associated with the *semantic* processing of celebrity stimuli. Therefore, we feel confident that these RTs are indeed reflective of the time required to access semantic information before making these familiarity decisions.

In terms of AoA theory, our findings can be more readily explained by the Ellis and Lambon Ralph (2000) neural plasticity model, given that this account predicts AoA effects resulting from stronger connections from the input to the output units of early-acquired items. But how can the AoA x NoFK interaction be explained by their model? If NoFK were taken to be a part of the early items responsible for configuring the network in Ellis and Lambon Ralph's (2000) account, then it might be predicted that early-acquired, many facts known items would elicit faster RTs than the other groups of stimuli. We found no difference between our two early-acquired conditions so this prediction was not supported by our empirical data. An AoA effect was evident in our experiment, but the nature of the interaction suggested an effect of the semantic system only on late-acquired celebrities. It would appear that such familiarity decisions to late-acquired celebrities were significantly supported by knowing more semantic information, despite the proposed rigidity of the network by this point in learning.

Since the Ellis and Lambon Ralph model was developed to simulate AoA effects in the language processing domain and people processing plots a different developmental course (e.g., Moore & Valentine, 1998, 1999), it is understandably silent on how the network might be configured for people processing. However, if the model is to explain AoA effects across a range of different processing domains, the nature of the initial configuration needs to be considered with regard to these data. At present, the Ellis and Lambon Ralph model can only provide a partial explanation of our results and does not seem unable to explain the role of semantics in processing late-acquired stimuli.

More unequivocally, our data cannot be explained by Steyvers and Tenenbaum's (2005) proposal that AoA has less of an influence on processing than the richness of semantic connections within a representational network. According to the semantic hypothesis, NoFK should facilitate RTs to early-acquired items to a greater extent than late-acquired items. In fact, our results indicate quite the reverse pattern, at least for people processing. Whilst our data do not in any way rule out a semantic locus for AoA effects, they do demonstrate that AoA effects can be found when the influence of the semantic system is controlled. This runs contrary to the semantic 'hub' network model of Steyvers and Tenenbaum (2005) in which the effects of AoA are subordinate to those of the semantic system. As the semantic hypothesis (e.g., Brysbaert et al., 2000) states, it may well be the case that there is a greater influence on RT of the semantic system in other processing domains and/or on tasks that explicitly require semantic processing, but this is an issue for future research to explore (but see Menenti & Burani, 2007). In the meantime, our data suggest that there is not an overarching influence of the semantic system on processing speeds. Again, this would not be predicted from the results of Brédart et al. (1995), nor do our empirical data fit with the strongest claims of the Steyvers and Tenenbaum model.

So, what do our results mean for Brysbaert et al.'s (2000) semantic hypothesis? The answer to this may lie in an argument proposed by Brysbaert and Ghyselinck (2006). They argued that early-acquired words may be represented semantically in a more experience-based way than later-acquired words. In support of their argument, they highlighted the imaging work of Fiebach, Friederici, Muller, von Cramon, and Hernandez (2003) which showed specific activation by early-acquired words of areas of the brain related to semantic and episodic memory, suggesting that the acquisition of words at a younger age is phenomenologically stronger, with closer links to the subjective experiences involved in the learning of these items. Morrison and Conway (2010) have also argued for a link between AoA and episodic memory, with the AoA of a word preceding the earliest memory associated with that word by several months.

Brysbaert and Ghyselinck's (2006) proposition may shed some light on the pattern of our results, in particular the absence of a difference in RT between many- and few-NoFK stimulus groupings. Extending their argument to the processing of famous people, it may be the case that a different, more phenomenologically-based semantic representation of the early-acquired stimuli may explain why semantic information seems to have no influence on RTs to these items. Whilst Brysbaert and Ghyselinck's argument addressed words learnt before the age of six years, there may be parallels in the people processing domain. We have argued elsewhere (e.g., Moore & Valentine, 1998, 1999; Smith-Spark et al., 2012), that celebrities are learnt later in life than words, typically after the age of six years, so any such explanation would suggest a domain-general property of AoA. The SSPS hypothesis (e.g., Moore, 2003; Moore & Valentine, 1999) argues for a role of affect in AoA (and, more generally, in learning). The post hoc ratings that we gathered from our participants indicate that the early-acquired famous people were first encountered in their teens and early-20s. Perhaps the excitement of things, such as celebrities, experienced when first coming into contact with the adult world could explain the absence of a role for NoFK in influencing responses to early-acquired famous names? If this were the case, then it would also suggest that Ellis and Lambon Ralph's (2000) neural plasticity model, to which the SSPS bears some similarity, could be developed to take account of affect.

The idea of heightened valence affecting familiarity decisions for famous individuals has also been proposed by Breen, Caine, and Coltheart (2000). The Breen et al. model describes two parallel routes for face recognition: the semantic route, concerned with familiarity detection (as reported by Burton, Bruce, & Johnson, 1990), and the affective route, which mediates responses on the basis of the emotional significance of a face. Stone and Valentine (2004) tested this proposal by using a 17ms masked presentation of stimuli, so that participants were not aware that a face had actually been shown to them. In two experiments, their participants were shown two faces simultaneously, one famous, the other not, and they were asked to identify which was the famous face. After completing this task, Stone and Valentine's participants then rated each famous person as 'good/evil' (Experiment 1) or 'liked/disliked' (Experiment 2). Their results indicated that selection of evil or disliked celebrities was less accurate and significantly below chance. Stone and Valentine concluded that famous faces are recognised pre-consciously and that responses may be based on affective valence and not on familiarity. Such an argument may also explain why the data on the semantic processing of people are less clear-cut than those reported when processing words or pictures of objects (e.g., Lewis, 1999; Moore, 2003; Moore, Valentine, & Turner, 1999). In contrast to the latter two types of stimuli, there will be great individual differences in the extent to which the same celebrity is liked or loathed by the general public. Under our account, such differences in valence would have an impact on RT and accuracy data.

In conclusion, it would appear that the earliest encounter of a celebrity seems to act as a kind of 'magnet' to which further details or information can adhere. Moreover, the initial processing of the early-acquired details remains robust over time. However, when celebrities are acquired later in life, the process is somewhat attenuated, in that more information is required to maintain levels of activity to facilitate processing. Therefore, we suggest that the previous semantic effect reported by Brédart et al. (1995) was, in fact, a disguised effect of AoA. More research is needed to determine i) whether NoFK (or another marker of semantic representations) plays a greater role on tasks requiring greater demands on semantic processing, ii) whether such a role for semantics is influenced by the response valence of stimuli, and iii) whether the effects we have uncovered generalise to other processing domains. Until answers to these questions are forthcoming, our data suggest that the semantic system affects only the processing of late-acquired stimuli and that this may because the lack of semantic information in a particular stimulus domain gives rise to the AoA effect.

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Table 1
A priori group statistics.

Variable	Early-acquired mean (SD)		Late-acquired mean (SD)			
	Few NoFK	Many NoFK	Few NoFK	Many NoFK	*F*	*p*
Number of times generated	69.10	69.30	71.40	76.30	< 1	.941
	(31.08)	(19.83)	(20.76)	(40.41)		
Number of syllables in name	3.30	4.20	4.10	3.90	1.65	.196
	(.48)	(1.40)	(.99)	(.88)		
A priori familiarity	4.37	4.66	4.47	4.65	< 1	.421
	(.18)	(.62)	(.37)	(.50)		
A priori distinctiveness	4.51	4.46	4.27	4.58	< 1	.667
	(.31)	(.76)	(.51)	(.64)		
A priori AoA	3.31	3.59	6.03	6.31	68.22	< .001 [a]
	(.50)	(.71)	(.65)	(.52)		
A priori NoFK	3.14	5.45	2.97	6.15	35.57	< .001 [b]
	(.42)	(1.01)	(.53)	(1.20)		

[a] Bonferroni post hoc comparisons indicated that the significant differences in a priori AoA ratings lay between early-acquired (both few and many NoFK) and late-acquired stimuli (both few and many NoFK), all at $p < .001$.

[b] Bonferroni post hoc comparisons showed that few fact stimuli (both early- and late-AoA) differed significantly from many fact (both early- and late-AoA) stimuli, all at $p < .001$.

Table 2

Post hoc group statistics after the three stimuli were removed.

Variable	Early-acquired mean (SD)		Late-acquired mean (SD)			
	Few NoFK	Many NoFK	Few NoFK	Many NoFK	*F*	*p*
Post hoc familiarity	4.29	4.43	4.32	4.55	< 1	.685
	(.30)	(.71)	(.39)	(.52)		
Post hoc distinctiveness	4.21	4.22	4.15	4.32	< 1	.925
	(.36)	(.85)	(.54)	(.46)		
Post hoc AoA	3.73	3.78	6.57	6.69	51.89	< .001
	(.74)	(.95)	(.56)	(.49)		
Post hoc NoFK	3.61	5.83	3.19	5.36	47.46	< .001
	(.49)	(.47)	(.54)	(.73)		

Table 3

Summary of the post hoc t-test results comparing participants' RTs to the different stimulus groupings.

Comparison	*t*	*p*	Description of difference in RTs
Early-few vs. Early-many	< 1	.684	12 ms faster to Early-few stimuli
Early-few vs. Late-few	4.72	< .001	143 ms faster to Early-few stimuli
Early-few vs. Late-many	2.10	.037	60 ms faster to Early-few stimuli
Early-many vs. Late-few	4.36	< .001	131 ms faster to Early-many stimuli
Early-many vs. Late-many	1.68	.093	48 ms faster to Early-many stimuli
Late-few vs. Late-many	2.89	.004	83 ms faster to Late-many stimuli

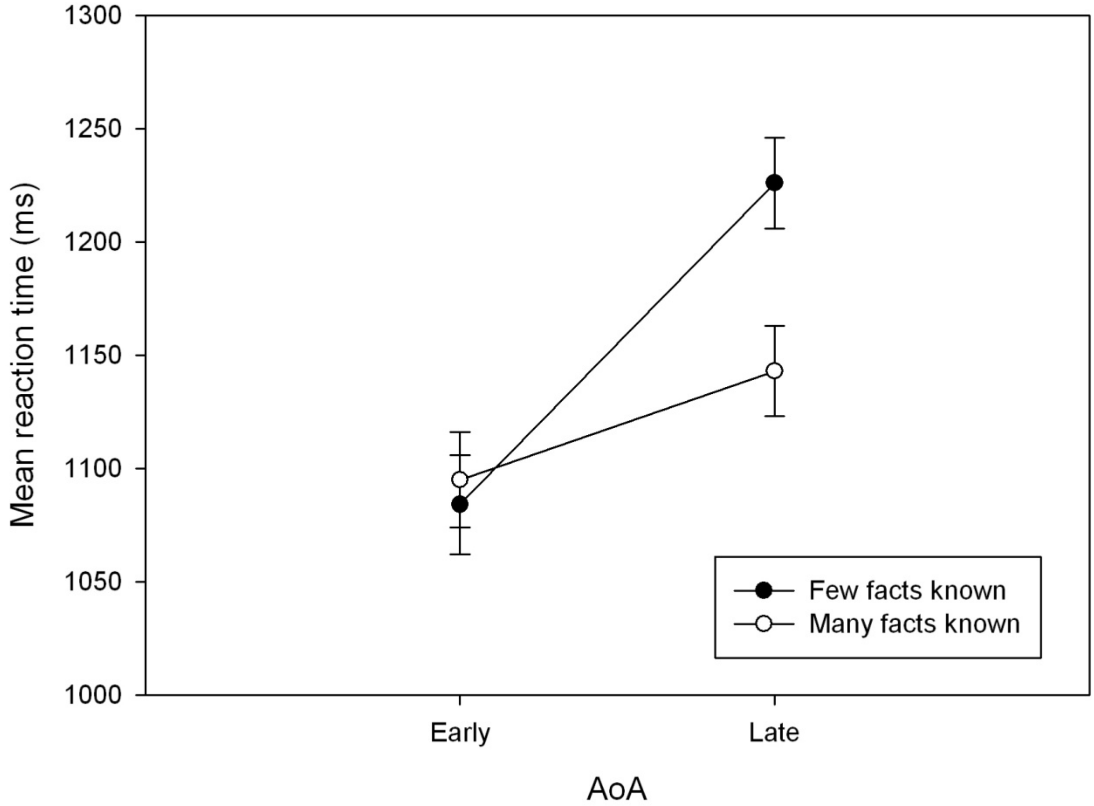
Table 4

Mean proportion correct (with SDs) in response to early- and late-acquired few- and many-NoFK stimuli.

NoFK	AoA		Mean
	Early-acquired	Late-acquired	
Few	.95 (.21)	.90 (.31)	.92 (.27)
Many	.96 (.19)	.95 (.23)	.95 (.21)
Mean	.96 (.20)	.92 (.27)	

Figure 1

Mean RTs for each stimulus grouping.



Appendix

Stimulus names, mean RTs, mean accuracy, and mean post hoc ratings for early-acquired stimuli.

		Mean score			Mean post hoc rating			Mean post hoc
	NoFK grouping	RT	*SD*	Acc (%)	Fam	Dist	AoA	NoFK
Albert Einstein	Few	1269	259	83	3.90	4.52	3.34	3.23
Bobby Moore	Few	1152	326	100	4.09	3.62	4.84	4.28
Cary Grant	Few	1085	322	96	4.58	4.54	3.38	3.09
Clark Gable	Few	946	229	96	4.17	4.34	3.15	3.55
Ernie Wise	Few	1123	281	100	4.71	4.02	4.98	3.64
Errol Flynn	Few	1012	284	96	3.98	3.80	3.19	3.49
Humphrey Bogart	Few	1052	228	96	4.52	4.60	3.40	4.40
James Stewart	Few	1046	238	96	4.40	4.21	3.58	3.17
Bing Crosby	Many	1005	322	100	5.04	4.50	2.60	5.23
Elizabeth Taylor	Many	1020	297	96	5.04	5.17	3.48	5.98
Elvis Presley	Many	1014	244	100	4.94	5.10	4.40	6.28
Frank Sinatra	Many	1036	353	100	4.96	4.72	3.51	5.91
Franklin Roosevelt	Many	1160	183	96	3.35	3.00	2.98	5.68
George Best	Many	1147	309	96	4.35	4.04	5.34	5.17
Judy Garland	Many	1063	327	100	4.31	4.13	3.10	6.26
Laurence Olivier	Many	1154	287	100	4.65	4.58	3.50	6.45
Ronald Biggs	Many	1303	271	79	3.21	2.77	5.09	5.47

Key: Acc = Accuracy; Fam = Familiarity (cumulative frequency)

Dist = Facial distinctiveness

Appendix (contd.)

Stimulus names, mean RTs, mean accuracy, and mean post hoc ratings for late-acquired stimuli.

		Mean score			Mean post hoc rating			Mean post hoc
	NoFK grouping	RT	*SD*	Acc (%)	Fam	Dist	AoA	NoFK
Andre Agassi	Few	1376	285	71	4.47	4.36	6.77	3.15
Angela Rippon	Few	1188	299	100	4.88	4.73	5.71	3.85
Anna Ford	Few	1151	331	100	4.44	4.02	6.13	2.79
Bjorn Borg	Few	1159	345	92	4.32	4.15	6.09	2.94
Colin Powell	Few	1387	331	79	4.20	4.26	7.38	3.59
Julia Roberts	Few	1233	327	83	3.98	3.96	7.34	2.30
Prince Harry	Few	1271	238	92	4.62	4.40	7.06	3.77
Sebastian Coe	Few	1175	255	100	3.76	3.11	6.20	3.81
Steve Davis	Few	1116	326	79	3.78	3.53	6.54	2.98
Trevor McDonald	Few	1244	358	96	4.75	4.96	6.48	2.72
Bill Clinton	Many	1065	257	100	5.29	5.10	7.08	6.26
David Beckham	Many	1110	331	100	5.13	4.79	7.68	6.23
Elton John	Many	997	288	96	4.44	4.31	6.31	5.30
Gary Lineker	Many	1201	280	96	4.48	4.39	6.87	5.23
John Major	Many	1076	294	100	5.15	4.29	6.67	5.60
Michael Heseltine	Many	1120	259	96	4.47	4.51	6.00	4.91
Paddy Ashdown	Many	1271	302	96	4.10	3.79	6.36	4.47
Paul Gascoigne	Many	1261	306	83	3.62	3.45	6.96	4.02
Robert Maxwell	Many	1184	257	92	4.23	4.44	6.26	5.83
Sarah Ferguson	Many	1171	243	88	4.58	4.17	6.69	5.70

Key: Acc = Accuracy Fam = Familiarity (cumulative frequency)

Dist = Facial distinctiveness