THE EFFECTS OF AGE OF ACQUISITION IN PROCESSING FAMOUS FACES AND NAMES: EXPLORING THE LOCUS AND PROPOSING A MECHANISM

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Abstract

Words acquired early in life are recognised and produced faster than words acquired later in life. It has been proposed that the effect of age of acquisition (AoA) arises from the development of phonological representations during language acquisition. Moore and Valentine (1998) found an effect of AoA on the speed of naming celebrities' faces. This result is problematic for an account of AoA based on language development because knowledge of celebrities is acquired the after the early representations in the phonological output lexicon are formed.

Three experiments explore the locus and mechanism of AoA in face and their processing tasks. Participants read aloud early-acquired names faster than late-acquired names (Experiment 1). Familiarity decisions are faster to early-acquired celebrities' names and faces than to late-acquired names and faces (Experiments 2 & 3). These finding present a challenge for connectionist models to provide an adequate model of both AoA and cumulative frequency. It is argued that temportal order of acquisition rather than age of acquisition may be the chief determinant of processing speed.

Introduction

A number of studies report faster naming for pictures with high frequency names like 'chair' than with low frequency names like 'metronome' (e.g. Oldfield & Wingfield, 1964; 1965; Humphreys, Riddoch & Quinlan, 1988; Jescheniak & Levelt, 1994). High frequency words are judged to be English words faster than low frequency words (e.g. Scarborough, Cortese & Scarborough, 1977) and are also read aloud faster (e.g. Monsell, Doyle & Haggard 1989; Seidenberg, Waters & Barnes, 1984). These effects influence the design of current models of lexical processing, with the mechanism postulated as greater connection strengths between levels of representations for frequently encountered items than for less frequently encountered items. This is especially pertinent to connectionist models, for example backward error propagation can simulate word frequency (WF) effects on word naming and lexical decision (e.g. Seidenberg & McClelland, 1989) and interactive activation and competition architectures can simulate WF effects on picture naming (e.g. Humphreys, Lamote & Lloyd-Jones, 1995).

However, it has been demonstrated that the age at which a word was first learned is a powerful determinant of processing speed. A controversy over whether WF or age of acquisition (AoA) is *the* important processing determinant arose because high inter-correlations exist between WF and AoA, and because most WF studies did not control for AoA.

Carroll and White (1973a, 1973b) reanalysed Oldfield and Wingfield's data (1964) and included AoA as a variable. They found that the age at which object names were acquired was the chief determinant of naming speed, and argued that measures of WF only predicted naming latency to the extent that they reflect AoA. Furthermore, when the correlation between WF and AoA was taken into account, WF played no independent role. These findings have been replicated many times (e.g. Lachman, 1973; Lachman, Shaffer & Hennrikus, 1974; Butterfield & Butterfield, 1977, Morrison, Ellis & Quinlan, 1992; Ellis & Morrison, 1998).

An effect of AoA, but not of written WF were apparent for word naming speed, but both spoken WF and AoA exerted independent effects in a lexical decision task (e.g. Morrison & Ellis, 1995; Gerhand & Barry, in press). However, AoA alone affects auditory lexical decisions (Turner, Valentine & Ellis, 1998). These effects were interpreted using a logogen-type model of word and object recognition (e.g. Morton, 1979; 1980). The effects of AoA in object and word processing tasks have been located at the stage of lexical retrieval (e.g. Ellis & Morrison, 1998). Consistent with these findings, Moore and Valentine (1998) report that early-acquired celebrities' faces are named faster than late-acquired faces. These effects were interpreted in terms of a functional model of face recognition (e.g. Bruce & Young, 1986; Valentine, Brennen & Brédart, 1996) which evolved as analogous to the logogen model of object recognition.

The phonological completeness hypothesis (Brown & Watson, 1987) assumes that AoA effects arise from phonological representations established during language development. The hypothesis is that early learned words are stored in a 'more complete form' during the early stages of language acquisition. A functionally different storage mechanism is used for late-acquired words, which are stored in a less complete form and require re-assembly for production. This account of AoA is entirely consistent with the primary locus of AoA effects at the level of phonological representations.

The majority of studies support a single locus for AoA effects at the level of speech output. According to Levelt's (1989) model of lexicalization, two pre-articulatory processing stages for lexical access exist. The first stage of activation is retrieval of an abstract representation of semantic and syntactic information (or lemma selection). The second stage involves activation of the word's phonological representation (or lexeme activation), which will initiate articulatory encoding. If indeed AoA effects are located at speech output, this model allows for three possible loci: lemma selection, links between lemma and lexemes or lexeme selection. Based on an interaction between the effects of WF and AoA, established in a repetition priming paradigm, Barry, et al. (in press) propose the locus of AoA to be at the lexeme. This locus was also proposed for the effects of WF (Jescheniak & Levelt, 1994). However, as Jescheniak & Levelt did not include AoA in their study, the possibility that WF and AoA were confounded must be considered and their conclusion is possibly consistent with Barry et al. (see Levelt, Roleofs & Meyer, in press)

However, a single locus for AoA effects is not universally supported, Yamazaki, Ellis, Morrison and Lambon Ralph (1997) report that reading speed of Japanese Kanji characters was affected by the age at which words entered the *spoken* vocabulary and the age that children learn the *written* characters. Yamazaki *et al.* argue that AoA affects the quality of lexical representations in the speech output *and* visual input lexicons, requiring at least two loci of AoA.

Moore and Valentine (1998) explored AoA effects on naming famous faces. They report consistently faster naming for early-acquired celebrities (acquired between 6 & 12 years) than late-acquired celebrities (acquired after 18 years). Their multiple regression study showed that familiarity with celebrities was the major predictor of speed naming. The instructions for rated familiarity explicitly required ratings to reflect the number of times a celebrity had been encountered (in the media, etc.) and should be interpreted as an explicit measure of accumulated (lifetime's) frequency of encounter. However, AoA significantly influenced naming speed in their factorial designs (with matched familiarity ratings). The AoA effects in face naming were consistent with a locus at the phonological output level. It is implausible that these effects can be explained by language development, because early-acquired celebrities were rated as acquired between 6 and 12 years of age. In contrast, the majority of early-acquired object names are acquired between 2 and 6 years of age.

A developmental view of language specificity currently proposes that infants are innately equipped to process the tone, stress, vowel length, etc. of any of the world's languages. Infants become attuned to the phonemic contrasts in their linguistic environment during the first year of life (Werker, 1994). Once established, these representations are used to discover regularities in speech, for example by nine months of age infants show a 'preference' for listening to words rather than non-words (Juscyk, Cutler & Redanz, 1993). Infants also show a 'preference' for listening to phoneme structures conforming to their own language (Juscyk & Aslin, 1995), implying that infants, just like adults, use language regularities to hypothesise word boundaries in continuous speech streams. Thirteen-month old infants can learn novel words from as few as nine presentations, suggesting that a powerful learning mechanism for forming object-label association already exists (Woodward, Markman & Fitzsimmons, 1994). By around eighteen months of age a 'spurt' of language comprehension and often production (Goldfield & Reznick, 1992) suggests the triggering of a new principle of organisation into the child's understanding of the object-to-label relationship. These features are consistent with AoA effects resulting from a 'critical' period of language development, and a locus for AoA effects to be at the phonological level. Also it might be expected that representation of phonological *input* as well as phonological representations for speech production might be a locus of AoA. Turner *et al's* (1998) finding that AoA affects auditory lexical decisions supports this proposal. Furthermore, insights from language acquisition may explain why AoA effects are absent in semantic classification tasks (e.g. man-made or natural decision to pictures, Morrison *et al.,* 1992). When acquiring language, a stress occurs for associations between the appearance of the object and it's name. The acquisition of super ordinate categories of natural and manufactured objects would occur after the formation of object-to-label associations.

The completeness hypothesis argues that AoA effects arise from the development of phonological representations. Alternatively, Moore (1998) argues that these effects arise from the *order* in which information is acquired. Furthermore, she argues that a critical period of language development cannot account for the effects of AoA established in face naming. However, the possibility of separable mechanisms for word, picture and face naming cannot be excluded. We propose that an explanation of *temporal order* of acquisition is supported by data from the neuropsychological literature. For example, SS, a 65 year-old man suffering from organic amnesia, evinced an effect of order of acquisition (Verfaellie, Croce & Milberg, 1995). Items were words or concepts, for which entry into the English language were dated into hemi-decades. Pre-morbid items entered the language between 1920 to 1970, post morbid items between 1971 and 1990. The sets were matched on attributes including WF, the presence of compound words, etc. SS could recall and recognise the meaning of novel acquired in the 1970s significantly better than words acquired in the 1980s, although both had entered the general vocabulary after the onset of his amnesia. SS did recognise a few of the 1980's items, but these were new combinations of old words (e.g. sun-block). Control subjects also showed a non-significant effect of *order* on recall of words acquired between 1920 and 1970.

Patient WK, (56 year old) a man with a person-naming deficit (Shallice & Kartsounis, 1993) could name highly familiar personalities famous 20 years ago or more, e.g. Harold Wilson (British prime minister twice between 1964 to 1976) but not Margaret Thatcher (contemporary British prime minister). He could name historical personalities but not one contemporary media personality. However, the effect of temporal order was not specific to peoples' names, but generalised to naming from definitions of words that entered the vocabulary over the past 20 years (e.g. "A device used to record TV programmes so that one can see them at a later date" - *video*).

We propose that the face naming, developmental and neurological literature may offer converging support for an effect of *temporal order of acquisition*. To understand the mechanism(s) giving rise to age or order effects it is necessary to explore these effects in a domain where items are acquired after the period of language development. Therefore, processing famous faces and names provides an ideal domain to determine whether these effects are specific to language acquisition. Recognition of famous faces and names is particularly suitable because current theories of face and name processing were developed by analogy to theories of object and visual word recognition. The same hierarchy of representations are assumed for naming both faces and objects. Initially visual representation of the stimulus are activated (object or face recognition units) before access to semantic or identity-specific semantic information; finally representations of the name are activated (e.g. Bruce & Young, 1986). The major difference between object recognition and face recognition is the assumption that access to semantic information about people and their names is achieved via a Person Identity Node or PIN (Hay & Young, 1982). PINs play the role of token markers in memory (denoting an individual), and are assumed to be the critical difference between processing proper name stimuli (e.g. celebrities, landmark names) and common name stimuli (e.g. words & objects).

Having established a robust effect of AoA in face naming paradigms (Moore & Valentine, 1998) the same items (matched on all variables other than measures of AoA) are used in the experiments reported below. In Experiment 1 printed names were read aloud (analogous to word reading). Experiments 2 and 3 report face and name familiarity decision tasks that do not require a spoken response. A locus at speech output would predict an advantage for reading early-acquired names. Automatic activation of the phonological output lexicon may predict and effect of AoA for familiarity decisions to printed names, but not for familiarity decisions to faces.

Methodology. These details pertain to all of the reported experiments. The same critical items were used in each experiment because AoA effects were established from these items and the selection validated by *post hoc* ratings (Moore & Valentine, 1998). The two groups of celebrities did not differ significantly on: rated familiarity (all celebrities were rated as highly familiar); facial distinctiveness; surname frequency; initial phonemic power, name-letter and phoneme length. The groups differed in ratings of AoA (early vs. late) in a one tailed t-test ($t(1,24) = 10.20$, $p<.0001$). *Post hoc* ratings were collected after each experiment to check the validity of those ratings.

Images of celebrities were created by scanning up-to-date, quality photographs or by capturing video stills. Images were monochromatic (256 x 256 pixels in size) and displayed at a resolution of 640 x 480 on a 14 inch screen using 16 grey levels. Images were edited to obscure as much background and clothing as possible. Images were displayed individually against a black background in the centre of a blank PC screen. Filler items were created in the same way. Written names were displayed individually in uppercase Geneva font (20 point) in the centre of the PC screen.

Each Experiment employed 24 UK university students between the ages of 18 and 25, who had spent the first 18 years of life in the UK. They participated in one experiment only and were paid for their time.

There was one independent variable AoA with two levels (early vs. late). Analyses were performed by related (t_1 participants) and independent (t_2 items) t tests. The dependant variable is latency of response.

Apparatus and Procedure: Micro Experimental Laboratory software (Schneider, 1988) controlled the rating tasks and experiments, randomised stimuli for presentation and recorded response latencies (with millisecond accuracy). Ten practice stimuli (not experimental items or analysed) preceded the experiments. Participants focused on a centralised fixation point for 250 msecs. the screen cleared, a tone sounded followed by a 250 msecs. interval before the stimuli appeared (name or face). Participants' response (via a hand-held response box or by voice-key connected to a computer port) ended the display and decision latencies were logged.

***Post Hoc* Stimulus Ratings:** After completing an experiment, participants provided three ratings of the critical items. The instructions emphasised that *personal opinion was the important factor*. Participants were given as much time as required. Rating tasks were presented in the fixed order: familiarity, distinctiveness and AoA. Ratings were entered into the computer by pressing the space-bar to see the appropriate response scale, this remained on the screen until the score was confirmed. The ratings took approximately 25 minutes.

Familiarity: The instructions stressed that *ratings should reflect how many times, prior to the experiment, each celebrity had been encountered*, *on TV, in films, newspapers, magazines, posters, etc.*, and could be regarded as a measure of cumulative frequency of lifetime encounters Ratings were made on a 7 point scale (1 = unknown to 7 = very familiar).

Distinctiveness: Participants were instructed to imagine that they had not seen the faces before and ignore previous *knowledge of characteristics other than those apparent in the images* (e.g. height, hair colour, etc.). They were to imagine how easy identification would be if they were sent to meet each celebrity in a crowded railway station (e.g. Valentine & Bruce 1986a; 1986b). A score of 1 should be given for faces that would be hard to spot (typical faces), a score of 6 for easy to spot faces (distinctive). Ratings were made on a 6 point scale as 'unknown' would be inappropriate.

Age of Acquisition: Participants estimated when they *first became aware of each celebrity*. Ratings were made on a 7 point scale where 1 = unknown. Two for celebrities first acquired under 3 years; three, for a celebrity acquired under 6 years; four, a celebrity acquired under 9 years; five, a celebrity acquired under 12 years; six, acquired under 18 years and seven, acquired over 18 years.

EXPERIMENT 1: READING CELEBRITIES NAMES.

Participants (9 males & 13 females; mean age = 19.96 years, s.d. = 1.23) were asked to *read printed names as quickly and accurately as possible.* Spoken responses triggered a voice key and the latency was recorded. The task took 15 minutes. Faces were presented for ratings.

Results and Discussion

Incorrect responses were removed (92) and mean scores derived (RT = 563 msec., s.d. = 117; accuracy = 23.08; s.d. = 1.98). Significantly faster reading times occurred for early-acquired (mean = 551 msecs., s.d. = 111) than late-acquired celebrities' names (mean = 575 msecs., s.d. = 123) by participants ($t_1(23)=35.30$, $p<.0001$) and approached significance by items ($t_2(48)=1.44$, $p<.08$).

The *post hoc* ratings confirmed the validity of selected stimuli. The differences between rated familiarity (early = 5.14 (s.d. = .69) vs. late = 5.32 (s.d. = .63)) and distinctiveness (early = 3.95 (s.d. = .97) vs. late = 3.57 (s.d. = .84)) were not significant. The difference between rated AoA (early 4.03 (s.d. = .75) vs. late = 6.20 (s.d. = 45) was significant ($t(24)=9.88$, p<.001).

These AoA effects of reading aloud printed names are analogous to the AoA effects for reading words aloud (e.g. Gerhand & Barry, 1998). However, the items analysis 'borders significance' yet all items analyses were highly significant for the speed of naming celebrities' faces (Moore, 1998).

Deciding whether a person is familiar or not is assumed to be based on activation of the PINs. An effect of AoA for familiarity decisions to printed names is predicted, if it is assumed that phonology is automatically activated from a printed name.

EXPERIMENT 2: FAMILIARITY DECISION TASK TO PRINTED NAMES

Effects of AoA in lexical decision tasks are assumed to occur because visual word recognition automatically activates the phonology of the word (Ellis & Morrison, 1998; Gerhand & Barry, in press; Morrison & Ellis, 1995). Experiment 2 investigates AoA effects in a name familiarity decision task.

Participants (12 males & 12 females; mean age = 19.38 years, s.d. = 1.44) were asked to *decide as quickly and accurately as possible* whether each of 100 printed were famous or not (50 celebrities & 50 unknown). "YES" (famous) or "NO" (not famous) buttons were pressed on a hand held response box. This task took approximately 10 minutes. Familiarity and AoA ratings were made to printed names, (distinctiveness ratings were inappropriate).

Results and Discussion

Incorrect responses were removed (91) and mean scores derived (RT = 646 msec., s.d. = 100; accuracy = 23.10; s.d. = 1.80). Significantly faster familiarity decisions were made to early-acquired (mean = 630 msecs., s.d. = 100) than to late-acquired celebrities' names (mean = 662 msecs., s.d. = 100), by participants ($t_1(23)=3.09$, $p<.01$) and approached significance by items ($t_2(48)=1.39$, $p<.08$). Participants were faster to make a familiarity decision to famous names rated as early-acquired than to late-acquired names.

Post hoc ratings made to printed names confirmed the experimental groups validity. They significantly differed on measures of AoA (early = 4.23 (s.d. = .58) vs. late = 6.01, (s.d. = .35)), $t(48)=12.09$, p<.01 but familiarity was not significantly different (early = 5.68 (s.d. = .50) vs. late = 5.81, (s.d. = .59)).

It is possible that automatic activation of phonology (Morrison & Ellis, 1995; Gerhand & Barry, 1998) can explain these AoA effects. It is also possible that dual loci at input and output could explain the AoA effects (Yamazaki, *et al.,* 1997). However, these automatic activation cannot account for the non significant results of the items analysis.

EXPERIMENT 3: FACE FAMILIARITY DECISION TASK.

Bruce (1983) developed the face familiarity task as an analogue of the lexical decision task. By extension we argue that an effect of AoA in face familiarity would be analogous to that established for lexical decision tasks (LDT) because activation of a stored representation is required. Face familiarity decisions are assumed to be based on activation of the PINs (Burton, Bruce & Johnston, 1990) and do not require phonology. Automatic activation of the phonology of a person's name from seeing their face in most unlikely, naming difficulties are well documented (e.g. Brédart, 1993: 1996; Burke, MacKay, Worthley, & Wade, 1991). Valentine, Hollis & Moore (1998) showed that face naming significantly primed a subsequent name familiarity decision, but a face familiarity decision did not prime a name familiarity decision. This result demonstrates that names are not automatically activated in a face familiarity decision. Therefore, effect of AoA is not predicted for familiarity decisions to faces by all of the theoretical accounts.

Participants (7 males & 17 females; mean age = 22.46 years, s.d. = 1.80) were asked to *decide as quickly and accurately as possible* whether each of 100 faces were famous or not (50 celebrities & 50 unknown faces). "YES" (famous) or "NO" (not famous) buttons were pressed on a hand held response box. This task lasted 10 minutes.

Results and Discussion

Incorrect responses were removed (125) and mean scores derived (RT = 662 msec., s.d. = 81; accuracy = 22.40 msec; s.d. = 2.31). Significantly faster familiarity decisions were made for early-acquired celebrities' faces (mean = 642 msecs., s.d. = 86) than late-acquired celebrities' faces (mean = 682 msecs., s.d. = 76) $t_1(23)=6.29$, $p<.0001$; $t_2(48)=1.72$, $p<.05$.

Analyses of *post hoc* ratings confirmed the selection of items. The differences between rated familiarity (early = 5.85 (s.d. = .63) vs. late = 5.65 (s.d. = .41)) and distinctiveness (early = 3.81 (s.d. = 1) vs. late = 3.35 (s.d. = .86)) were not significant. The difference between rated AoA (early 4.51 (s.d. = .61) vs. late = 6.05 (s.d. = 34)) was significant $t(24)=10.20$, p<.0001.

REPLICATION OF EXPERIMENT 3

As the results OF Experiment 3 are difficult to reconcile with existing accounts of AoA a replicate study was conducted. There were 24 participants (11 males & 13 females; mean age = 20.63 years, s.d. = 1.45) who evinced the same result. The incorrect responses were removed (224) and mean scores derived (RT = 766 msec., s.d. = 191; accuracy = 20.13; s.d. = 3.58). Significantly faster familiarity decisions were made to early-acquired celebrities' faces (mean = 753 msecs., s.d. = 162) than late-acquired (mean = 825 msecs., s.d. = 135) celebrities' faces ($t_1(22)=3.01$, $p<.01$; $t_2(48)=1.71$, $p<.04$).

The significant items analysis suggests that printed names may be mediated by a somewhat different manner than faces. Automatic activation of phonology from a face to a name is untenable because faces are notoriously difficult to name. This result is inconsistent with a single locus of AoA effects in face processing at the stage of name retrieval because naming responses were not made. Taken together these data suggest a locus for AoA effects in processing faces at or before the PINs.

General Discussion.

These Experiments use the same celebrities from who an effect of AoA occurred in face naming (Moore & Valentine, 1998). The effect of AoA was found in reading aloud printed names and in face and name familiarity decisions. Celebrities rated as early-acquired were processed significantly faster than late-acquired celebrities.

Early-acquired celebrities' names were read faster than late-acquired names (analogous to reading printed words aloud, Morrison & Ellis, 1995; Gerhand & Barry, 1998). It has been argued that AoA effects have a single locus at the phonological output lexicon. An effect of AoA for lexical decision was attributed to automatic activation of phonology from visual word recognition (Ellis & Morrison, 1998; Morrison & Ellis, 1995; Gerhand & Barry, in press). A single locus at this level may account for AoA effects on celebrities' printed names, but it is untennable for the effects of AoA established for face familiarity decisions.

Experiment 3 (and replication) shows that a single locus at a phonological level for all AoA effects can no longer be maintained. The effect on face familiarity decisions require a locus at, or before the PINs, because familiarity decisions are assumed to be caused by activation of the PINs (Burton *et al.,* 1990). Valentine, *et al.* (1998) demonstrated a face familiarity decision does not automatically activate a phonological representation of the name. Therefore, automatic activation of phonology from face familiarity decisions is implausible. It is possible that representations of all familiar words, faces or objects are organised in a way that produces an effect of AoA, including the representation of lexical items in the semantic lexicon.

As yet there is insufficient converging evidence to enable specific loci of AoA to be identified. This task may be prove to be as difficult as identifying the loci of WF effects. However, three conclusions can be drawn. First, a single locus is no longer adequate to account for AoA effects. Second, AoA effects are widespread. Third, AoA may reflect a general property of the mental representation of perceptual and lexical information.

The challenge for any cognitive model is to account for the effects of AoA as well as WF. Age of acquisition may be a feature of the representation of information while WF may reflect the strength of connections. One challenge is to account for an effect of AoA in the absence of an effect of WF on *auditory* lexical decision (Turner *et al.,* 1998).

It is obvious that, even when familiarity is controlled, age or order of acquisition significantly affects processing of celebrities' faces and names, and to varying degrees, lexical and object processing tasks too. Equally clear is that frequency of encounter (and especially spoken frequency) affects very similar processing tasks. However, connectionist models fail to account for both of these influences.

The effects of AoA present serious problems for current computer models of cognition. Connectionist models that use backward error propagation to learn distributed representations, can readily model the effects of frequency (or familiarity). However, these networks suffer from interference of early learned material by subsequently acquired material. Therefore, it is not clear how such an architecture could model an effect of AoA. Interactive activation models of face recognition and naming do not generally include a learning mechanism. However Burton (1994) has developed an algorithm that enables interactive activation models to learn localist representations of new stimuli. It can be appreciated how this algorithm can model the effects of frequency (or familiarity) by increasing the weight of connections between nodes. It is not clear how it could model the effect of AoA.

Kohonen (1984: 1990), proposed a model based on 'self-organising maps'. This type of network is capable of learning to distinguish between different patterns of input by unsupervised learning. Similar patterns cluster at units in the same area, whereas dissimilar patterns are topologically distant. Morrison (1993) attempted to simulate AoA effects by introducing a specific order of patterns, she reports early-acquired patterns remained distributed over a greater area, with later-acquired patterns 'sandwiched' between them. Therefore, early encountered patterns played a prominent role in the organisation of input representations.

Both interactive activation models and models based on backward-error propagation remain unable to simulate the empirical effects and AoA. Therefore, it remains a challenge to connectionist modelling to provide an adequate model of both AoA and cumulative frequency.

The early-acquired celebrities in these studies were rated as acquired much later (between 5 and 12 years of age) than for early-acquired word and object processing studies (between 2 to 6 years of age). This difference in the AoA is important. It has been proposed that AoA effects result from a developmental process where language-specific phonology is established, but this is an unlikely candidate for the effects established on processing famous faces and names because these were acquired after the period of language development. In addition, critical periods of language development cannot account for effects of temporal order from patient studies cited above. The evidence from the cognitive, developmental and neuropsychological literature support *temporal order of acquisition*, which provides a plausible explanation for the effects on face and name processing. It is possible that *all* new patterns of information are processed in a fundamentally different way to later-acquired related material. We suggest that initial encounters with exemplars of a new class of information, of any type and at any age, would trigger the setting up of a fundamental organisation of the relevant information. Later acquired related information would be added onto the previous material which may be represented in a different manner to earlier-acquired information in a similar way to that proposed by Brown and Watson (1987). Such a mechanism may also serve to clarify the specific roles of WF and AoA using two assumptions. First, that initial unique patterns of information are responsible for the set-up of a dedicated processing module. Second, that frequent exposure of appropriate stimuli is required to maintain activity or connection strength. What results is an economical method for dealing with early exemplars of new classes of information, because a unit would be created to meet the demands of processing unique patterns of information. When representations of the same ilk occur it is incorporated into the existing module. The set-up of a systematised processing module is intuitively credible considering the normal temporal patterns of information acquisition. It follows that earlier acquired information should also be more robust to neurological insult. A significant advantage for early-acquired information was reported for aphasic patients (Hirsh & Ellis, 1994; Hirsh & Funnell, 1995) and dysphasic patients (Rochford & Williams, 1962).

This approach suggests some future lines of research. First, it suggests that it should be possible to demonstrate an effect of order for any modular input system (Fodor, 1983). According to the principle of modularity a variety of cognitive skills are mediated by a number of independent cognitive processes (e.g. face recognition, word recognition). Each module performs a particular type of processing independent of the activity in other modules, although there is obviously communication between output of these systems. Interestingly, Fodor proposed that faces would be candidates for a modular processing system (cf. Experiment 3). Although Fodor proposed that modular systems are innate, processing of written language is a good example of a skill that is only learnt with considerable instruction and effort. Nevertheless, there is considerable evidence of modular organisation of reading skills. Following, this line of thought would suggest that effects of AoA may be found in any area of highly skilled recognition of a stimulus class. The changes in representation that underlie the effects of AoA may underlie expert - novice differences in a wide range of skills.

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