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Age/order of acquisition effects and the cumulative learning of foreign words: A word training study

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ABSTRACT

Early acquired words are processed faster than later acquired words in lexical and semantic tasks. Demonstrating such age of acquisition (AoA) effects beyond reasonable doubt, and then investigating those effects empirically, is complicated by the natural correlation between AoA and other word properties such as frequency and imageability. In an effort to find a laboratory analog of AoA effects which would allow such issues to be addressed more easily, we conducted three experiments in which participants learned foreign words, with some ('early') words trained from the outset while other ('late') words were introduced some time later then interleaved with the early words. Order of acquisition effects were observed in picture naming, lexical decision and semantic categorization, persisting for several weeks after the end of training. The results demonstrate an important role for order of acquisition in the formation of lexical representations that is independent of other factors such as cumulative frequency, frequency trajectory and imageability. Analyses of cumulative learning effects offer the potential to investigate the differential impact of early and later experiences on the formation of lexical and other mental representations. The discovery of order of acquisition effects in word learning also has implications for classroom teaching of second language vocabulary.

Introduction

A large body of cognitive and psycholinguistic research has shown that adults can identify, produce and read aloud words learned early in life faster, and with fewer errors, than words learned some time later (Alario et al., 2004; Johnston & Barry, 2006; Juhasz, 2005). *Age of acquisition* (AoA) effects of this sort were first demonstrated for object naming speed (Carroll & White, 1973) and have now been replicated many times across many different languages (e.g., Barry, Morrison, & Ellis, 1997; Belke, Brysbaert, Meyer, & Ghyselinck, 2005; Cuetos, Ellis, & Álvarez, 1999; Dell'Acqua, Lotto, & Job, 2000; Ellis & Morrison, 1998; Kauschke & von Frankenberg, 2008; Pind & Tryggvadóttir, 2002; Pérez, 2007; Weekes, Shu, Hao, Liu, & Tan, 2007). Faster and more accurate recognition of early than late acquired spoken words was reported by Turner, Valentine, and Ellis (1998) and Fiebach, Friederici, Müller, von Cramon, and Hernandez (2003), while an advantage for early learned words in visual word recognition has been observed using a variety of tasks, languages, scripts and measures, including lexical decision, word naming, semantic categorization, and eye fixation durations, (e.g., Alija & Cuetos, 2006; Bonin, Barry, Méot, & Chalard, 2004; Brysbaert, Van Wijnendaele, & De Deyne, 2000; Chen, Zhou,

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Dunlap, & Perfetti, 2007; Cortese & Khanna, 2007; Havelka & Tomita, 2006; Izura & Ellis, 2002; Liu, Hao, Shu, Tan, & Weekes, 2008; Menenti & Burani, 2007; J. Monaghan & Ellis, 2002a, 2002b; Morrison & Ellis, 2000).

The first demonstrations of AoA effects all involved the recognition or production of words. Subsequent studies looked for effects of AoA effects in tasks which attempt to minimize the involvement of lexical representations to see if such effects apply only to words or are a more general feature of the processing of representations acquired cumulatively over time. Faster identification of early learned objects has been observed in a familiarity decision task where participants are simply required to indicate on each trial whether a pictured object is real or imaginary (Holmes & Ellis, 2006; Moore, Smith-Spark, & Valentine, 2004). Effects of AoA on object recognition have since been observed using other nonverbal tasks such as object classification, picture verification or semantic classification tasks (Catling & Johnston, 2006, 2009; Johnston & Barry, 2005), while Moore and Valentine (1999) and Richards and Ellis (2008), Richards and Ellis (2009) found effects of AoA on the speed of distinguishing famous faces from unfamiliar faces in familiarity decision tasks. The discovery that AoA effects extend beyond words to other classes of familiar stimuli raise the possibility of a general principle that when large numbers of exemplars of a class are learned cumulatively over time, with early items continuing to be experienced and trained as later ones are introduced, the representations formed for the early items may be superior to those created for the later items. A number of theories have been put forward to explain why this effect of age or order of acquisition might exist. Those theories will be reviewed after a brief discussion of some of the practical issues concerned with isolating and studying AoA effects using naturally-occurring stimuli.

Disentangling the effects of AoA from those of other factors

A persistent debate centers on the question of whether reported effects are genuinely due to differences in the age of acquisition of the stimuli or are due to other factors which correlate naturally with AoA. Goodman, Dale, and Li (2008) showed that for common nouns, verbs and adjectives, words that are used more frequently by parents tend to be learned earlier by young children. In addition to being of higher frequency in adult language, early acquired words also tend to be more concrete, more imageable and shorter than late acquired words (Barca, Burani, & Arduino, 2002; Bird, Franklin, & Howard, 2001; Gilhooly & Logie, 1980; Reilly, Chrysikou, & Ramey, 2007). The natural correlations between these factors mean that great care must be taken when attempting to attribute a behavioral effect to one of these factors rather than another (e.g., to AoA rather than frequency, or imageability rather than AoA). Failure to adequately control any of the factors that correlate with a variable of interest may cause effects to be misattributed. The initial studies of frequency effects in tasks like object and word naming did not control for AoA, which had yet to be identified as a significant variable (e.g., Forster & Chambers, 1973; Oldfield & Wingfield, 1965). The first reports of AoA effects in word recognition and production often pitted the relative contributions of AoA and word frequency against one another, sometimes going as far as to argue that apparent effects of word frequency are abolished when AoA is taken into account (e.g., Carroll & White, 1973; Morrison & Ellis, 1995). Zevin and Seidenberg (2002, 2004) took the opposite approach, suggesting that many reported AoA effects were due to inadequate control of word frequency. They showed that word sets chosen for being early or late acquired, and matched on one measure of word frequency, sometimes differed on other measures of frequency. They also noted that early and late acquired words matched on frequency of occurrence in samples of adult language may still differ on *cumulative frequency*; that is, on how often the words have been encountered in the course of a participant's lifetime (see also Lewis, Gerhand, & Ellis, 2001).

To test the possibility that AoA effects may be due to differences between early and late acquired words in cumulative frequency, Ghyselinck, Lewis, and Brysbaert (2004) converted AoA into a measure of the number of years that an individual has known a word (time known = participant age – word AoA). Ghyselinck et al. (2004) argued that if effects of AoA and frequency can both be explained in terms of the single factor of cumulative frequency, then when frequency and time known are represented in log units, the impact of the two measures on performance should be the same. In fact, they were different: across eight different tasks involving visual word recognition, including lexical decision, word naming and semantic categorization, the effect of time known on reaction times (RTs) was consistently greater than the effect of frequency, a pattern of results that is incompatible with the cumulative frequency hypothesis. Similar findings were obtained by Menenti and Burani (2007) in analyses of lexical decision and semantic categorization in Italian and Dutch. When Bonin et al. (2004) derived an estimate of cumulative frequency from a combination of child and adult frequency norms, the inclusion of that factor in a regression analysis of word naming RTs accounted for a significant proportion of the variance but did not eliminate the effect of an objective measure of AoA based on child naming data. Stadthagen-Gonzalez, Bowers, and Damian (2004) also found convincing evidence against the cumulative frequency hypothesis by showing that performance on lexical decision and word naming for late-acquired/high-frequency words (e.g. "strata" for a geologist) was not better than for early-acquired/low-frequency words (e.g. "dragon"), even though the cumulative frequency of the late words was higher than that of the early words.

Zevin and Seidenberg (2002, 2004) introduced another variant of word frequency into the AoA debate. They observed that the frequency histories of early and late acquired words (so called *frequency trajectories*) may differ. Almost by definition, late acquired words have higher frequencies in adult than child language. Early acquired words may have high relative frequencies in both child and adult language, or may in a few cases (like *giant*, *fairy* and *dragon*) be more frequent in child than adult language, showing a negative frequency trajectory. Bonin et al. (2004) derived a measure of frequency trajectory by comparing the relative frequencies of words in child and