Age-related changes in L2 performance could result from either:

1) maturational changes in brain structures used to learn and/or process language

2) interaction between a bilingual’s two language systems:

   under this scenario, age is an index of the state of development of L1

   Assumption: the more fully developed the L1, the greater its influence on L2

Three problems:

- neural development and L1 acquisition inextricably confounded in childhood or age of arrival (AOA)
- confounded with other variables or age-related changes in L2
- not tested with much specificity

Three different measures used to test the critical period hypothesis:

1) discontinuity - those who start learning L2 before the critical period should outperform (by a lot) those who start after

   "The effect of a critical period could, therefore, be demonstrated by showing a significant departure from linearity in functions relating measures of L2 performance to AOA [ = age of arrival, i.e. in the US] at an appropriate AOA." (p. 79)

   Two problems with the discontinuity test:

   a) no one can agree on when the critical period ends
   b) not everyone would agree that the absence of a discontinuity constitutes evidence that the CPH is false

       specifically, while lack of discontinuity in performance between early and late arrivers would falsify the CPH, it would not falsify a more general, gradual notion of "sensitive period"

2) pre/post-correlation

   "This test involves computing the correlation between AOA and L2 performance for groups of participants thought to have begun learning their L2 before versus after the end of a critical period. According to Johnson and Newport (1989), a significant AOA-performance correlation will be observed for individuals who began learning their L2 before the end of the critical period, because their performance declines increasingly as one nears the end of the critical period. However, a significant AOA-performance correlation would not be expected for a group of individuals who had all begun learning their L2 at varying times after the end of the critical period. This is because 'postmaturational' learners are all thought to suffer to the same degree from the same deficit, viz. having passed a critical period." (p. 80)
A problem with the pre/post-correlational test:

A significant AOA-L2 performance correlation might be obtained for postmaturational learners due to factors OTHER THAN the critical period:
- chronological age,
- use of L2,
- use of L1,
- years or US residence,
- years of education.

3) matched subgroup

In this measure, subgroups of subjects are put together based on factors OTHER THAN AOA (i.e., they might have the same number of years of formal education, or they might use English to the same degree, despite the fact that their AOAs differ widely), to see if these other factors could account for the difference.

Finally, a subgoal was to see if the critical period affects all aspects of language development equally.

- e.g. does it affect phonology but not morphosyntax?
- does it affect rule-governed processes
  - (e.g. regular plural and past tense formation; see Appendix 1, p. 101)
  - AND
  - idiosyncratic, lexically-based processes
    - (e.g. the kinds of prepositional complements different verbs take, ‘hope for’, ‘insist on’, ‘believe in’, etc.; see Appendix 2, p. 101)
    - differentially?

METHODS

Subjects

Controls: 24 native speakers of English

- Age at time of testing: 20 to 45 years, mean 27

Test group: 240 [!] native Koreans who arrived in the US between the ages of 1 and 23

- Age at time of testing: 17 to 47 years, mean 26

Assigned to 10 subgroups based on average AOAs:

- 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, and 21 years

Half the participants in all subgroups were female.
Average highest grade completed in Korea 5.6 years
Those with AOA greater than 12 first exposed to English in school
in Korea
Average of 10.1 years of education in the US
All but one subject had completed high school in the US; 156 had BAs

General Procedure and Analysis

Subjects tested individually by Korean/English bilinguals

1) filled out questionnaire to assess use of L1 and L2,
   plus motivation to learn L2 and retain L1

2) produced sentences rated for degree of foreign accent

   repeated 21 sentences, each presented twice, following a taped model
   same sentences on written list given to each subject
   first repetition after 700 ms; second after 3600 ms

   only five sentences used in analysis (???)

   later presented three times each in separate, counterbalanced blocks
   to ten native speakers (three male), mean age of 31,
   born and raised in D.C./Baltimore area, but living in Birmingham, Alabama

   sentences from both natives and non-natives scored on a nine-point scale,
   1 very strong foreign accent
   9 no accent

   average of 150 judgements calculated for each subject

3) responded to a grammaticality judgement test

   144 items, 128 of which were drawn from Johnson and Newport’s (1989)
   battery of test items (minus present progressive, word order, and
   auxiliary tests, which produced fewer errors in the previous study)

   two new sets created from existing sets in the original design:

   a) rule-based (regular inflectional morphology)

      regular past tense formation (walk vs. walked)
      regular plural formation (student vs. students)
      third-person -s on present tense verbs (go vs. goes)
      case marking on personal pronouns (he vs. him)

   b) lexically based (i.e. specific properties of individual lexical items,
      cf. Appendix 2, p. 90)

   half grammatical, half ungrammatical
   all 144 sentences printed on an answer sheet
   subjects listened to a recorded version of each sentence, then
   checked ‘yes’ or ‘no’ on the answer sheet
   no time pressure
RESULTS

Effects of AOA:

Phonology

- The later the AOA, the stronger the accent. Native speakers had higher ratings than all but a few of the early arrivals. All ten subgroups rated lower on average than the native speaker control group. As AOA increased, scores decreased; variance within subgroups also increased with AOA (cf. Johnson and Newport (1989)).

Morphosyntax

- Effect of AOA on grammaticality judgement scores agreed with Johnson and Newport (1989). Scores arcsine transformed to control for variance:
  - those with AOAs of 2 to 6 years did not differ from native speakers
  - those with AOAs of 7 to 23 years did

Phonology and Morphosyntax Compared (number of Koreans within two SDs of natives)

- Number of Koreans who met the criterion differed in phonology (18 individuals) and morphosyntax (76 individuals). So AOA may constrain phonology more than morphosyntax??

The Relation between AOA and L2 Performance:

Was there a discontinuity? (i.e. would a linear or a non-linear function account for more of the variance?)

Phonology and AOA

- Non-linear (3rd order) function accounted for more of the variance

  - all participants (1.9%) and between 7 and 23 AOA (2.5%), but NOT between 7 and 18 AOA (1%) 

  - The non-linearity did not occur at the traditional breaking point (12-15 years). Pronunciation ratings of Koreans with AOAs of 1-5 years were similar to but slightly lower than those of native English speakers. Roughly linear decrease in performance in AOA groups of 5-15 years, "followed by a slowing in the rate at which the strength of foreign accents increased" (p. 87). A mean split of subjects with AOAs greater or less than 12 years (the pre/post-correlation test) showed correlations of AOA with foreign accent ratings in both groups

  - i.e. no break in performance around puberty
  - i.e. there is something wrong with the CPH

Morphosyntax and AOA

- Non-linear function again accounted for more of the variance

  - all participants (1.2%) and between 7 and 18 AOA (5%), but NOT between 7 and 23 (1.1%)
Thus the traditional breakpoint of 12 years emerged in these data.

"A visual inspection of the fit function indicates that the scores declined in a roughly linear fashion between AOAs of about 6 to 15 years. There is no evidence of a nonlinearity at AOAs of 12 or 15 years. However, as can be seen in Fig. 3, there was an increase in the number of participants beyond an AOA of 12 years who gave a large number of incorrect responses to grammatical sentences." (p. 87)

i.e. this is in agreement with Johnson and Newport (1989)

A mean split of subjects with AOAs greater or less than 12/15 years (the pre/post-correlation test)

showed correlations of AOA with morphosyntax scores in both groups, though 2 (vs. 12+ AOA) to 3 (vs. 15+ AOA) times greater in the group BELOW the split (i.e. with younger AOAs)

i.e. this is NOT in agreement with Johnson and Newport (1989)

In general, the discontinuity test was consistent with the CPH in the area of morphosyntax: non-linearity in AOA 12-15 years (but see Fig. 3)

However, the pre/post-correlation test for morphosyntax did not support the CPH

Sentence Types:

While native English speakers and early-arriving Koreans (NK3 and NK5) did not differ on this parameter, later-arriving Koreans (NK7-21) got higher scores on grammatical than on ungrammatical sentences

8 AOA groups differed from English-speaking natives on ungrammatical sentences vs. 6 AOA groups differing from natives on grammatical sentences

This could mean that

- they were more likely to accept sentences of all types, or
- their grammars were more fluid and less determinate
- they were worse at detecting errors of morphosyntax

Effects of AOA on sentence judgement accuracy were significant for all nine sentence subtypes tested; however,

- nine (AOA 5-21) subgroups differed from native controls on plural formation
- eight (AOA 7-21) on determiners and subcategorization
- seven (AOA 11-21) on subject/object raising the third person singular
- six (AOA 13-31) on past tense, question, and particle movement
- four (AOA 15-21) on pronouns

lots of variability within sentence subtypes, however

Sentences within rule types were heterogeneous, so correlations of AOA with various rule types should be taken with caution
Rule Based versus Lexically Based Sentences:

- On rule-based sentences, subjects with AOAs of 5 did best, and there was then a gradual decline with increased AOA

- On lexically based sentences, subjects with AOAs of 8 and under did best, and there was then a steep decline to chance levels at an AOA of 16 and above

  - Those with AOAs greater than 13 years (NK13-21) got lower scores on lexically based sentences than they did on rule-based sentences

- Overall, performance on grammatical sentences was much better (95%)

  - Those with AOAs greater than 13 years (NK13-21) scored lower than English-speaking native controls on grammatical sentences

- Performance on ungrammatical sentences showed declines with increased AOA, with ungrammatical lexically based sentences showing a steeper decline than ungrammatical rule-based sentences

  - Those with AOAs greater than 11 years (NK11-21) scored lower than English-speaking native controls on ungrammatical sentences

- This suggests that AOA influences the acquisition of lexical idiosyncrasies more than it does the acquisition of rule-governed L2 processes

Factor Analyses:

- Four factors from language background questionnaires accounted for variance in the pronunciation ratings and grammaticality scores:

  1) age of learning (AOA plus age at which English first spoken "comfortably")
  2) English media input
  3) sound processing ability
  4) length of residence

- More variance accounted for by age of learning in the foreign accent ratings (68%) than in the morphosyntax scores (49%)

  - expected because AOA correlated better with the former than with the latter

- Age of learning accounted for more variance than any other variable in both degree of foreign accent and grammaticality judgement scores

- This might suggest, as in other studies, that AOA is the most important variable in both phonological and morphosyntactic L2 performance

- However, AOA also correlated with lots of other factors pertaining to USE of English and chronological age:

  - years of education in the U.S.
  - use of Korean with a spouse
  - use of Korean with close friends
- use of Korean at social gatherings
- use of English at social gatherings
- age

Matched Subgroup Analyses:

- In addition, AOA correlated with chronological age, self-estimated use of English and Korean, and years of residence and education in the U.S.

- All of these variables also significantly correlated with each other

- Purpose of these analyses:
  - re-examine the effect of AOA when other variables are controlled
  - assess the influence of language use and education on outcome measures

- The ratio of English use to use of Korean is plotted in Figure 6 on p. 95; it shows the same AOA-related decline as L2 performance measures, and partial analyses suggested that use of Korean and English correlated with L2 performance measures independently of AOA

- note the age at which usage drops to 50/50 in Fig. 6 on p. 95

- The other variable looked at was years of formal education in the U.S.

- Hypothesis 1: When AOA is controlled for, those who use English more and Korean less should outperform those who do the opposite on both pronunciation and morphosyntax measures

  Two groups who differed in their relative use of English (3.3 vs. 4.5) and Korean (4.1 vs. 2.1) were matched for AOA (mean = 11.4 years) and compared
  
  the groups did not differ in years of US education or residence
  
  those who used English more and Korean less had better pronunciation scores and better lexically based morphosyntax scores;
  
  the groups did not differ on rule-based morphosyntax or on overall morphosyntax scores

  Then two groups who had different AOAs (16.2 vs. 7.0 years) but equivalent amounts of Korean use as the matched subgroups (4.1 vs. 2.1) were chosen as controls
  
  those with early AOAs outperformed those with late AOAs on ALL pronunciation and morphosyntax measures

BOTTOM LINE: those who use English more do better on do better on lexically based L2 morphosyntax, independently of age of arrival

>> HYPOTHESIS 1 CONFIRMED
Hypothesis 2: When AOA is controlled for, those with more educational experience in the U.S. should outperform those with less, especially on measures of morphosyntactic performance, and more for rule-based than lexically based measures.

Two groups with a mean AOA of 12.3 but with differing amounts of formal education in the US (15.1 vs. 8.9 years) were compared.

Those with more U.S. education indeed had higher rule-based morphosyntax scores.

The two groups did not differ on pronunciation measures, on lexically based morphosyntax, or on overall morphosyntax scores.

Then two groups who had different AOAs (7.2 vs. 16.2 years) but equivalent amounts of formal US education as the matched subgroups (15.1 vs. 8.9 years) were chosen as controls.

Those with more formal education (and earlier AOAs) did better than those with less on ALL measures.

BOTTOM LINE: Those with more formal education in the US do better on rule-based L2 morphosyntax, independently of age of arrival.

>> HYPOTHESIS 2 CONFIRMED

Hypothesis 3: When other variables confounded with AOA are controlled for, AOA should still affect pronunciation.

Two groups with different AOAs (9.7 vs. 16.6 years) were matched for years of US education (mean = 10.5); the groups did not differ on:

- years of residence in the US
- use of Korean
- English use

Those with early AOAs had better English pronunciation than those with later AOAs.

However, the groups did not differ at all on morphosyntax.

Then two groups who had equivalent AOAs (7.2 vs. 16.2 years) as the matched subgroups but were not matched for amount of formal US education (14.4 vs. 8.0 years) were chosen as controls.

Those with earlier AOAs (and more formal education) outperformed those with later AOAs on ALL pronunciation and morphosyntax measures.
BOTTOM LINE: AOA has an independent effect only on pronunciation (phonology), not on morphosyntax (which is influenced by amount of formal education)

>> HYPOTHESIS 3 CONFIRMED