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17 Maturational Constraints in SLA

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1 Introduction

Adult second language acquisition sometimes results in the extraordinary achievement of ultimate levels of proficiency comparable to those of native speakers. When this happens, it is the object of much admiration and even astonishment. For child learners, however, everything short of nativelike levels is seen as failure. This difference in judgments is of course due to different implicit standards for adults and children: both the entirely successful adult learner and the slightly unsuccessful child deviate from the unspoken norm.

That children are more efficient second language learners than adults was given its first scientific formulation by Penfield and Roberts (1959) in an account where the biological and neurological basis for children's advantages in language learning was specified. These neuroscientists contended that "the child's brain has a specialized capacity for learning language" (p. 240) and that "[t]here is a biological clock of the brain" (p. 237). They further suggested an age limit of approximately 9 years on cerebral flexibility allowing "direct learning" from the input, and explained the poorer attainment levels resulting from later ages of onset (AOs) with reference to the fact that children become "more analytical" and learn "indirectly" via their first language after that age. Working from studies of recovery from aphasia, Lenneberg (1967) suggested that the loss of this biological predisposition for language acquisition could be explained by the completion of hemispheric lateralization, which in his view coincided with puberty, and labeled the time span between age 2 and puberty a *critical period* for language acquisition (cf. p. 175f).

Since the late 1960s, the existence of a critical period for language acquisition has been one of the most widely debated issues in second language acquisition research. While few researchers today would deny long-term advantages for child starters – especially after reviews have found no counter-evidence to this contention (Krashen, Long, and Scarcella, 1979; Long, 1990; cf. also Singleton,

1989, 2001) – views differ as to whether these observations should be explained by biological scheduling, that is, by constraints imposed on the learner along with maturation, or by social/psychological factors. Thus, the controversy about the existence of a critical period remains as intense as ever (see contributions in Birdsong, 1999a; Hyltenstam and Abrahamsson, 2001; Marinova-Todd, Marshall, and Snow, 2000; Scovel, 2000; Singleton, 2001); indeed, few empirical results in the field remain uncontroversial.

It would seem that many of the disagreements are related to, or can be seen in the light of, Lenneberg's original formulation of the *Critical Period Hypothesis* (CPH). Lenneberg claimed that:

> automatic acquisition from mere exposure to a given language seems to disappear [after puberty], and foreign languages have to be taught and learned through a conscious and labored effort. Foreign accents cannot be overcome easily after puberty. However, a person *can* learn to communicate at the age of forty. This does not trouble our basic hypothesis. (1967, p. 176)

Thus, what was central to the original formulation of the CPH was the "possibility to acquire a language, be it L1 or L2, to normal nativelike levels" (Birdsong, 1999b, p. 1). More recently, several authors have underscored just that: the CPH, or maturational constraints in general, concern the ability to reach nativelike attainment (e.g., Birdsong, 1999b; Eubank and Gregg, 1999; Long, 1993). As with other types of maturationally constrained behavior, what is of interest is not just the development of *any* behavior in the area studied, but rather the exact species-specific behavior. A parallel example often mentioned is the familiar case of song-birds, where the young bird must experience singing from adult birds in order for its species-specific singing to develop. Claiming for an individual bird that "it sings" is clearly not relevant – it must sing *exactly* in the way that other birds of that specific species sing. If it does not, it would be considered not to have received the appropriate triggering from the environment at the right time in development.

As we will see in the literature review below, research on maturational constraints, or on the CPH specifically, has developed research questions based either on factors that were actually mentioned by Lenneberg, or on factors that could be derived from his formulation; other questions have – intentionally or unintentionally – disregarded one or more of the central aspects of his hypothesis. At least three different conceptualizations on which research questions have been based can be discerned.

The first conceptualization is fully congruent with Lenneberg's formulation and focuses on the attainability of *nativelike* ultimate proficiency *from mere exposure* to a given language. Here, the CPH would be falsified if nativelike proficiency were found in learners who started acquiring a language outside a certain age limit (i.e., puberty in Lenneberg's specific formulation) *and* who have acquired the language naturalistically without tutoring. However, most studies of nativelike second language proficiency have not addressed the

restrictions that follow from the hypothesis's qualification, "from mere exposure." That is, the CPH is frequently considered falsified if nativelike proficiency is found in learners who start acquiring a language outside a certain age limit regardless of how they have acquired it.

Being somewhat less restricted, the second conceptualization concerns the relationship between age and *ultimate attainment*, and suggests that younger learners outperform older learners with respect to eventual outcome. However, as with the younger-is-better version below, it disregards the constraint of *nativelike* outcomes, and is falsified, therefore, if older learners reach comparatively higher ultimate attainment levels than younger learners, given equal learning conditions.

The third conceptualization is that the *younger* learner *is better* at language learning than the older learner. This version is unrestricted, and so in research based on it, younger and older learners have been compared in one respect or another. The hypothesis is falsified if older learners are "better" than younger learners on a certain measure of success given the same learning conditions (e.g., Snow and Hoefnagel-Höhle, 1978). Research based on this conceptualization, amazingly enough, completely disregards both the condition of ultimate attainment and the condition of nativelike proficiency.

The fact that different researchers have implicitly based their research on conceptually different interpretations of the CPH is, of course, one source of confusion in the field. Additional sources for disagreement about maturational constraints comprise the many ways in which the notion of "language" has been defined and operationalized. This question will be dealt with below. Suffice it to say at this point that, in our view, the domain for maturational constraints in general is the human capacity for language both at the level of knowledge and at the level of processing. On such an assumption, the critical period relates to a comprehensively defined notion of language proficiency, including but not restricted to "grammatical competence."

It is obvious that several of the questions that have been investigated over the years remain unanswered. One of the most basic ones is: if it is at all possible to attain full nativelike proficiency in a second language, is there an AO limit for such attainment? Or is it possible to reach nativelike proficiency starting at any age? Several related issues, not dealing specifically with the attainability of nativelike proficiency, are also central within this area. For example, as certain age-related factors are obviously involved in determining ultimate proficiency levels even during later phases of the life span (Bialystok and Hakuta, 1999; Birdsong, 1999b), language proficiencies resulting from AOs beyond a possible critical period also need to be dealt with in order to fully understand the implications of maturational constraints and their interaction with other determining factors. It is also reasonable to ask what levels of *near-native* and *non-native* proficiency are attained at which age ranges. Another question is what effects an increasingly constrained language learning mechanism would have across sub-components of language and across different phenomena within sub-components.[1]

This chapter does not intend to suggest final answers to these questions, but will rather be specifically concerned with discussing how such questions have been approached. We will propose that the empirical data discussed in this research area are not sufficiently rich to constitute a basis for the falsification of hypotheses, primarily because the notion of "nativelike proficiency" is highly elusive. In our view, however, the most reasonable interpretation of the limited data that exist does support a maturational constraints hypothesis, although this hypothesis is not necessarily identical to the original or any other prevalent formulation of the CPH. We will conclude by attempting to provide an integrated perspective, where maturational constraints in interaction with other factors play a definite role for second language acquisition. Some methodological requirements for future research will also be discussed.

2 Maturational Constraints as the Default Hypothesis

The theoretically unmarked position is to postulate one comprehensive account for different manifestations of human language learning rather than having to deal with each type on its own terms. Therefore, if language acquisition is maturationally constrained, the theoretical constructs employed to define the workings of such constraints should have identifiable implications for language acquisition under all conditions, that is, in first, second, atypical, etc., language acquisition (cf. Harley and Wang, 1997; Long, 1990). Long (1990) argues that "positing maturational constraints . . . is the *un*marked hypothesis" (p. 253); we should expect there to be such constraints "because they are so well attested in the development of other animal species, in other types of human learning, and in other human neurological abilities" (ibid.).

In Gleitman and Newport (1995), a wealth of facts from first language acquisition, language deprivation, and delayed first language acquisition are discussed under such assumptions. The observations discussed can be given a consistent explanation if maturational constraints exist, but these observations would require different and at times arbitrary explanations if one assumes the *non*-existence of such constraints. We will briefly review these facts in order to position data from second language acquisition within this wider context.

Gleitman and Newport (1995, p. 21) argue that "biologically given dispositions" are reflected in all types of language acquisition. Given normal environmental exposure to any language, the child acquires it relatively rapidly in a universally uniform development. The development is marked by a strict set of milestones (cf. Singleton, 1989, pp. 8ff), including early phonological distinctions and a one-word stage at about 1 year, a sudden growth of vocabulary and a two-word stage during the second year, then, by the age of 3, an increase of syntactic complexity and development of function morphemes until, finally, a principally complete system has developed by the age of 5. Such

regular sequencing is typically seen in other areas where an inborn biological timetable for development must be postulated, such as in motor and cognitive development. Indeed, "[t]he learning of the mother tongue is normally an *inevitable* process" (Penfield and Roberts, 1959, p. 240; our italics), except in cases of deprivation from input caused by either severe abuse or inherent physiological or mental disabilities. This uniform development occurs irrespective of a wide range of individual, social, and cultural variation in input qualities and quantities that children receive under normal conditions. An obvious interpretation is that the range of input that is sufficient for language acquisition to take place is a wide one: "virtually any exposure conditions short of total isolation and vicious mistreatment will suffice to bring [language] forth in every child" (Gleitman and Newport, 1995, p. 21).

There are data, admittedly sparse and difficult to interpret, suggesting that AOs delayed beyond 6 or 7 – due to deprivation or isolation – result in a less than complete ultimate attainment in first language acquisition. Gleitman and Newport's (1995, pp. 10ff) comparison of the well-known case of "Genie" (Curtiss, e.g., 1977, 1988) with the cases of "Chelsea" (Curtiss, 1988, 1989) and "Isabelle" (Davis, 1947) illustrates the effects of being severely deprived of linguistic input. Genie was isolated and deprived of linguistic input from the time she was 1½ years old until she was discovered at the age of 13. Chelsea was born with a hearing deficit, but was erroneously diagnosed as mentally retarded or emotionally disturbed. It was not until she had reached the age of 31 that a neurologist rightly diagnosed her as hard of hearing, and when tested with hearing aids she reached near-normal hearing levels. Isabelle had been hidden away in an attic and given only minimal attention until she was discovered at the age of 6. While Isabelle reached "native-level fluency" (p. 11) after only one year of exposure, Genie stopped at a level similar to that of 2-year-olds, and Chelsea did not develop "even the rudimentary aspects of grammatical structure" (p. 12) that were characteristic of Genie's speech. To the extent that cases of abuse, as with Genie, can be taken as evidence, the differences between the two cases of Isabelle and Genie support the view that a pronounced decrease in potential to acquire nativelike proficiency in a first language occurs between the age of 7 (Isabelle) and puberty (Genie).

However, there are empirical results that suggest even lower age limits for nativelike ultimate attainment. Data from deaf children who started to acquire their first language, American Sign Language (ASL), between the ages of 4 and 6 showed slight differences from native proficiency levels even after 30 years or more of using the language; in addition, and as expected, a group of learners who started their first language acquisition from puberty onwards, as expected, showed clear signs of non-native proficiency (Newport, 1990). Similar results were obtained in studies by Mayberry and her colleagues (see summary in Morford and Mayberry, 2000, and below). Likewise, in studies reported by Ruben (1997),[2] hearing children who, due to otitis media, suffered from continuing hearing impairment during their first 12 months of life, and then recovered, scored significantly lower than controls for verbal memory and

phonetic perception when tested at age 9. On the basis of these results, Ruben suggests that a critical period for phonology might already terminate by age 1, and he further speculates that "[i]nsufficient early phonological input results in flawed semantic and syntactic capacities" (p. 117).

Therefore, although the general belief until now has been that full nativelike proficiency in a first language is attainable given AOs up to the age of approximately 6 or 7, data showing effects of deprivation during very early phases actually call this contention into question. As a matter of fact, the only empirical evidence that directly supports the age limit of 6–7 is the case of Isabelle. However, the statement that she achieved full nativelike fluency after one year may not be totally reliable as it is not substantiated by detailed linguistic analysis. Neither is the absolute absence of input during her first six years wholly clear.

Gleitman and Newport (1995) contend that the atypical cases mentioned above aptly illustrate what takes place in *all* individual children: "Every learner is an isolate"; that is, individual learners have to identify for themselves the regularities of the target language. According to the position that Newport and Gleitman represent, these regularities or generalizations cannot be arrived at from experience alone, that is, from the examples of the target language; learners have to rely on an innate mechanism that allows them to acquire any language they encounter in their environment, "just because in some sense they know, from their biological predispositions, the essence of language" (p. 17). What facts like these underscore is the child's ability to reach perfection even on the basis of reduced input. The uniformity of the child's creativity and inventiveness across the various conditions can be understood only if we assume that "significant aspects of language development are dictated by our biology" (p. 10).

If it is the case that the human brain is particularly adapted for language acquisition during an early period of life, but less so later in life, there should be manifestations of this adaptation in a second language context that are parallel to the manifestations in first language contexts. Even if this does seem to be the case at some level of comparison, in second language acquisition the effects of exposure later than the early childhood years are not nearly as dramatic as in the L1 cases just mentioned. What we see, rather, when we compare L2 starters at the age ranges of Genie or Chelsea, is "neither nativelike mastery of the L2 . . . nor the near-total incompetence in the L2 that Genie and Chelsea manifested in their first" (Eubank and Gregg, 1999, p. 79). As we will see from the review of studies in the following section, much of the research appears to support the view that nativelike proficiency can also be reached in a second language given early AOs (Hyltenstam, 1992; Johnson and Newport, 1989; Oyama, 1978; Patkowski, 1990). Furthermore, it is also almost certainly the case that most learners who start acquisition after early childhood can reach nativelike attainment in certain sub-components of language, as demonstrated in studies on nativelike behavior on, for example, intuitive judgment tasks (Birdsong, 1992; White and Genesee, 1996) and pronunciation (Bongaerts, 1999;

Bongaerts, Mennen, and van der Slik, 2000; Moyer, 1999) among adult second language starters. An important apparent difference from the first language context is that nativelike proficiency in a second language is not *inevitable*, even with AOs in early childhood. Several studies note enduring non-native features in the ultimate attainment even of some very young starters (Bialystok and Miller, 1999; Butler, 2000; DeKeyser, 2000; Ekberg, 1998; Flege, 1999; Hene, 1993; Hyltenstam, 1992; McDonald, 2000; see also summary in Harley and Wang, 1997, p. 38). One factor that these studies single out is the effect a bilingual speaker's languages may have on each other at any age. It also seems that the nature of input (amount, quality, etc.) is much more decisive in the second language context – or in the case of bilingualism generally – than in first language contexts. It has been suggested that early childhood bilingualism is typically unbalanced, with one of the languages weaker than the other (Pulvermüller and Schumann, 1994; Schlyter, 1993; Wong Fillmore, 1991). This weaker language, be it L1 or L2, or one of two simultaneously acquired L1s, characteristically exhibits non-native features; in fact, as Harley and Wang (1997) conclude, "[m]onolingual-like attainment in each of a bilingual's two languages is probably a myth (at any age)" (p. 44). The long-term effects of "weak" language development have not been studied, however, and they therefore remain unclear.

3 The Empirical Evidence

Literature reviews on age-related differences in L2 acquisition usually either start or conclude by iterating the now well-known generalizations by Krashen et al. (1979) that "(1) adults proceed through early stages of morphological and syntactic development faster than children (where time and exposure are held constant): (2) older children acquire faster than younger children (again in early stages of morphology and syntax, where time and exposure are held constant: and (3) child starters outperform adult starters in the long run" (Krashen, Scarcella, and Long, 1979, p. 573). What motivated the pioneering review by Krashen et al. (1979) was that the then existing empirical results concerning age-related differences in L2 acquisition seemed to be inconsistent and conflicting, insofar as some studies demonstrated an advantage for younger learners, while others seemed to show that older children and adults are "better" language learners than young children. These apparent inconsistencies dominated the theoretical debate during the 1970s, and raised questions about whether children have a greater L2 learning ability than adults, and, consequently, whether there are biologically determined constraints on language acquisition. Krashen et al. (1979) resolved this problem by dividing the empirical studies into two types, "initial rate" and "eventual attainment." The generalizations given above simply state that older learners acquire (certain aspects of) a second language at a faster rate than younger learners in the beginning of the acquisition process, but that younger learners, especially small children, catch up and eventually

surpass older children and adults. Even though the last generalization is neutral about the final state of L2 proficiency (Long, 1990, p. 260), research has demonstrated that young starters seem to end up as nativelike speakers of the L2, which is rarely, if ever, the case for adult or adolescent starters.

3.1 Age effects on initial learning efficiency: who is faster in the short run?

Studies addressing the issue of acquisition rate have been both naturalistic and experimental in nature. In naturalistic rate studies, the subjects have been exposed to the target language in an L2 environment, while in experimental laboratory studies, there has been no such natural exposure, but rather the subjects have first been taught limited aspects of a language previously unknown to them, and shortly thereafter tested for their acquired L2 "proficiency." The vast majority of rate studies have been short-term studies with "acquisition" periods ranging from a few minutes to a number of weeks or months.

Despite Krashen et al.'s (1979) efforts in bringing some order to age studies, some conflicting results still remain for the rate studies. While some have indeed pointed to greater success for older learners (e.g., Asher and Price, 1967; Loewenthal and Bull, 1984; Olson and Samuels, 1973; Snow and Hoefnagel-Höhle, 1977, 1978), others have indicated that younger learners have advantages over older learners (e.g., Cochrane, 1980; Cochrane and Sachs, 1979; Tahta, Wood, and Loewenthal, 1981a, 1981b; Yamada, Takatsuka, Kotake, and Kurusu, 1980), and still others have indicated no significant rate differences between younger and older learners (e.g., Slavoff and Johnson, 1995).

The crucial question is, however, what studies of initial rate of L2 acquisition, in fact, are able to tell us about the existence of a critical period/maturational constraints. First of all, do laboratory studies, in which "[c]hildren and adults [are] brought into the lab, taught some property of a second language, and then immediately tested on what they [have] learned" (Slavoff and Johnson, 1995, p. 3), represent a reasonable procedure for investigating the ability to acquire a second language? Do such studies measure L2 proficiency at all, or are the frequently reported advantages for older learners just an artifact of the experimental nature of the studies? Long (1990) believes the latter to be the case, and argues that such studies "probably favor older learners because of their "teach and test" or laboratory interview formats and their occasional use of tasks where superior cognitive skills and/or test-wiseness can obviously play a role" (p. 260). Similarly, Loewenthal and Bull (1984) speculate whether older–faster results could be due to the social psychology of the testing situation, rather than to older learners being "better" at L2 acquisition.

Moreover, even though many naturalistic rate studies (e.g., Snow and Hoefnagel-Höhle, 1978) probably reflect language acquisition more accurately than laboratory studies do, there are still reasons to doubt their relevance to the issue of maturational constraints. Learning *rate*, in contrast to *attainment*,

is, as indicated above, of little relevance to the existence or non-existence of a critical period, as is *initial*, in contrast to *ultimate*, proficiency. Long (1990) argues that initial rate advantages for older over younger learners in early morphosyntax "should be interpreted as just that – a short-lived rate advantage" (p. 274). For him, older–faster results constitute no evidence that older children and adults are better learners. Patkowski (1990) basically holds the same position when stating that "the issue of initial learning rates is a separate one, and one which does not bear directly upon the validity of the CPH" (p. 75). According to Patkowski, the only evidence with any validity for the CPH is that of eventual proficiency of differently aged learners.[3]

3.2 *Age effects on eventual learning outcomes: who is better in the long run?*

As a consequence of the doubts concerning their applicability to the question of a critical period or maturational constraints in L2 acquisition, rate studies more or less fell out of fashion in the 1980s, and the focus moved instead to long-term AO effects. The consistent pattern observed in a number of ultimate attainment studies – for example, Asher and García (1969), Oyama (1976, 1978), and Patkowski (1980) – is a significant correlation between AO and ultimate L2 outcomes, while other factors, such as length of residence (LOR) and degree of motivation, cannot account for the variation in ultimate attainment.

The most frequently cited study of this type is that of Johnson and Newport (1989),[4] who showed that when factors other than starting age are controlled for, such as LOR, motivation, or amount of formal instruction, AO turns out to be the only relevant predictor for eventual proficiency in a second language. Using a 276-item grammaticality judgment test, Johnson and Newport (1989) investigated the grammatical intuitions of 46 adult Chinese and Korean L2 learners of English who had arrived in the United States between the ages of 3 and 39. Results showed that the youngest AO group (3–7) performed within the range of native controls; for subjects with AOs above 7, there was a linear decline in performance up through puberty; from the age of 17 and upwards, the linear decline in performance with increasing age vanished. Except for the overall poorer performance than that of the younger arrivals, the adult learners thus demonstrated a high degree of inter-learner variability, something that was absent among younger arrivals. Johnson and Newport (1989) concluded that their results support a maturational account, since "the age effect is present during a time of ongoing biological and cognitive maturation and absent after maturation is complete (i.e., after puberty)" (p. 90).

The Johnson and Newport (1989) study has a central position within the field, and it has been given a great deal of attention in the literature – by both proponents and opponents of maturationally based explanations for age-difference effects. Proponents have described it as the best-designed and most important ultimate attainment study, providing the CPH debate with "[the]

least ambiguous evidence to date of maturational constraints operating in the morpho-syntactic domain" (Long, 1990, p. 271); Birdsong (1999b) states that in SLA research on ultimate attainment, "no single study has contributed more to the case for critical period effects" (p. 10); DeKeyser (2000, p. 517) refers to it as a "landmark study." The critics, on the other hand, have expressed reservations about the methods and materials used (for example, that a minimum of five years was probably not enough for some learners to have reached their ultimate proficiency levels, and that the length of the test may have resulted in concentration difficulties; see, e.g., Bialystok and Hakuta, 1994; Juffs and Harrington, 1995; Kellerman, 1995), as well as about various aspects of the statistical analyses adopted (see, e.g., Bialystok, 1997; Bialystok and Hakuta, 1994).

In a recent replication of the Johnson and Newport (1989) study, DeKeyser (2000) managed to avoid most of these methodological weaknesses. A modified version of the grammaticality judgment test used by Johnson and Newport was distributed to 57 Hungarian L2 learners of English with 10 years of residence or more in the United States and with AOs between 1 and 40 years. Instead of 276 test items, DeKeyser's test included only 200 sentences; a few of the original sentences were also deleted or changed, and some structures were included that were predicted to be particularly difficult for Hungarian learners. In addition to the grammaticality test, a language learning aptitude test was distributed to the subjects.[5] The main purpose of the study was to test the *fundamental difference hypothesis* (Bley-Vroman, 1989; see further below), which states that while children learn language through implicit, domain-specific mechanisms, adults have lost most of their ability to learn languages implicitly, and must instead use their explicit, problem-solving capacities in L2 acquisition.

As with the Johnson and Newport (1989) data, DeKeyser's results exhibited no significant correlations between test scores and variables such as LOR, years of schooling, or age at time of the test; only the predicted negative overall correlation between AO and grammaticality judgment scores was found. All child arrivals (AO < 16) scored above 180 out of 200 (except for one who reached 170), while most adult arrivals (AO > 16) scored below this 180 limit. However, a certain overlap between the two groups was found: six of the late starters produced relatively high test scores (over 175), and three of these scored within the range of child arrivals (i.e., above 180). DeKeyser explains this result with the significant correlation between grammaticality judgment scores and aptitude scores among these successful adult starters; in the AO < 16 group, there was no correlation between grammatical competence and aptitude. In other words, and as was predicted, those late starters who performed near or within the range of early starters also had high verbal aptitude, which would have allowed them to learn the L2 through explicit reflection on grammatical rules (cf. also Harley and Hart, 1997, for similar results from the immersion setting). Moreover, DeKeyser's study showed that some structures are less sensitive to age effects than others (see further below), something that is explained by their differing perceptual saliency.

Even though DeKeyser's (2000) study must in many ways be viewed as an improvement and development of Johnson and Newport (1989), it still suffers from some weaknesses. First, one might question the accuracy of the aptitude scores obtained by most of the learners. DeKeyser concludes, on the basis of data in Ottó (1996), that the average score for monolingual Hungarian speakers is 10 rather than 4.72, as was obtained by the bilingual subjects in this study. The fact that verbal aptitude was assessed with a test in Hungarian, even though 20 of the 57 learners reported that they felt more comfortable in English, may have blurred the results in unpredictable ways. Second, the argument that only those adult starters who have high verbal analytical abilities will score within the range of child starters is weakened by the fact that one of the three most successful adult starters did not, in fact, have a high score on the aptitude test. The criterion for high aptitude was set at "6 or higher on the aptitude test" (p. 24), but this individual (the second best adult, with a grammaticality judgment score of 186/200) had an aptitude score of only 3.[6] Third, since no native English controls were included in the study, it is difficult to relate the scores to nativelike proficiency.

As White and Genesee (1996) note, studies that have used randomly selected learners with different AOs only indicate that children typically achieve higher ultimate levels than adults – by now a fully established fact – but "leave unanswered the question of whether late L2 learners can ever attain linguistic competence that is indistinguishable from monolingual native speakers" (p. 235). In other words, although the youngest arrivals in both Johnson and Newport (1989) and DeKeyser (2000) scored very high (in the range of native controls in the Johnson and Newport study), a fact that significantly separated them from the rest of the subjects, the question remains whether there actually are nativelike adult L2 learners who, because of their infrequency, were not captured by these studies or by any of the other ultimate attainment studies mentioned above. White and Genesee (1996) argue that, in order to investigate the absolute potentials of late learners, only subjects who seem to have reached nativelike L2 proficiency levels should be selected, because "[if] such subjects give the appearance of having attained nativelike use of the L2, one can then ask whether they have in fact attained nativelike competence" (p. 234). If so, such individuals would constitute evidence against the claim that late starters cannot obtain nativelike proficiency – and, thus, against the existence of maturational constraints.

3.3 Age effects on ultimate learning potentials: who can become nativelike in a second language?

Bearing most directly on the issue of maturational effects is the research that has consciously attempted to locate second or foreign language learners who – after initial screening for nativelikeness/near-nativeness – have undergone careful testing or assessment of their *actual* L2 proficiency. Ever since rate studies disappeared in the 1980s, leaving the opponents of the CPH with no

empirical data to support their critique of maturational effects in L2 acquisition, the crucial empirical task for researchers has been to demonstrate that adult L2 starters – under advantageous learning circumstances – are in fact able to perform within the range of native speakers, that is, to reach native levels of L2 proficiency. If such individuals are to be found, then there is some justification for the belief that factors other than maturation are responsible for late starters' typical failure in achieving nativelike proficiency (Patkowski, 1990). In this section, we will discuss those ultimate attainment studies that have challenged the CPH and/or maturational constraints by claiming to have found late L2 starters who have reached native levels of proficiency.

The first study to adopt this approach was that of Coppieters (1987). He distributed a syntactic/semantic judgment task to 21 highly successful and highly educated adult foreign language learners of French, and also engaged them in follow-up interviews. These learners were selected because of the absence of any salient foreign accent in several of the subjects. However, even though the learners were initially judged as nativelike and even though they managed to respond to judgment items correctly, their overall performance was still distinctly below that of native controls; the recorded interviews revealed errors in structures that were mastered in the judgment task. However, in a replication of Coppieters (1987), although using stricter criteria for subject screening, Birdsong (1992) found that 15 of his 20 late foreign language learners of French performed within the same range as native speakers on a difficult grammaticality judgment task.

In the area of phonology, Bongaerts (1999; see also Bongaerts, Planken, and Schils, 1995; Bongaerts, van Summeren, Planken, and Schils, 1997) reports on the nativelike pronunciation of some highly proficient post-puberty Dutch foreign language students of English and French in the Netherlands. These subjects were chosen for the study because EFL and FFL[7] experts had designated them as exceptionally successful and advanced learners. A read-aloud task was used, where subjects were to read sentences and phrases which contained sounds that were predicted to be particularly difficult for Dutch learners. Results showed that significant proportions of these subjects passed as native speakers according to panels of native judges; in fact, they performed in the *upper* range of native controls. In a similar fashion, Bongaerts et al. (2000) investigated the pronunciation of very successful, immersed/naturalistic learners of Dutch as L2. By asking experts of Dutch as a second language, and through a personal networking procedure, they managed to select 30 highly educated L2 speakers, with a variety of L1 backgrounds, who had settled in the Netherlands between the ages of 11 and 34. Ten native controls also participated in the study. The subjects read aloud 10 sentences three times, and the second attempt was used for the rating procedure (except when this attempt included reading errors or slips). Pronunciation was then rated on a five-point scale (from "very strong accent; definitely non-native" to "no foreign accent at all; definitely native") by 21 Dutch judges, some with linguistic training, some without. Details aside, the results showed that two participants

in particular (with AOs 21 and 14; Bongaerts, p.c.) stood out from the general pattern, and received ratings in the lower range of native controls; in other words, they passed as native speakers.

In another recent ultimate attainment study of phonology, Moyer (1999) investigated the pronunciation of 24 late, though very advanced and highly motivated, American learners of German as a foreign language. They were all graduate students and employed as teachers in a German program at an American university. In addition, their exposure included up to several years of immersion in Germany. Four native German controls also participated. Three read-aloud tasks were used (word list, sentences, and paragraph) in addition to one free oral production task. The speech samples were then rated independently by four native German judges, using a six-point scale (from "definitely native" to "definitely non-native"). Results clearly showed that the native judges were able to differentiate the L2 subjects from the native subjects; in other words, the L2 speakers performed distinctly below native pronunciation. However, there was one subject who performed within the range of native controls across all four pronunciation tasks. Moyer describes this individual as an exceptional learner, who was largely self-taught and who had "a strong desire to sound German (a goal very few of the other subjects had)" (p. 98).[8]

One interesting aspect of Moyer's (1999) results is that there was a trend toward more native accent ratings for more isolated task items: word list reading resulted in the lowest accent ratings, followed by the reading aloud of sentences, and, next, the reading of paragraphs; free production resulted in the highest foreign accent ratings. In light of these findings, one might argue that, despite the fact that some learners reported in Bongaerts (1999) and Bongaerts et al. (2000) appear to have reached nativelike L2 pronunciation, there is a risk that these studies highlight skills other than "real" pronunciation skills. It is not surprising that some very advanced learners perform very well, even within the same range as native speakers, when they read relatively few, short sentences. But in the absence of evidence to the contrary, we find it reasonable, at this point, to question whether Bongaerts's learners would perform as well on tasks involving longer units of spontaneous speech (say, five minutes) such as story-retelling or free conversation, or on reading tasks involving paragraphs or longer texts. Although their pronunciation most certainly would get exceptionally high ratings on such tasks, there are reasons to doubt that they would still be able to pass as native speakers for any native judge.[9] However, as Moyer (1999) points out, "the inclusion of tasks beyond word recitation naturally involves suprasegmental features as well as lexical, syntactic, and pragmatic fluency" (p. 86); therefore, "a clean measure of phonological fluency alone is not possible for extended, naturalistic speech," since raters are "indeed influenced by structures beyond L2 phonological production in their assessments of performance" (ibid.).

Ioup, Boustagui, El Tigi, and Moselle (1994; see also Ioup, 1995), in a case study, report on Julie, a talented L2 speaker of Egyptian Arabic who had

immigrated to Cairo from Britain at the age of 21. Her acquisition of Arabic was naturalistic, in that she had received no formal L2 instruction, and she was not literate in Arabic. Her LOR in Egypt was 26 years at the time of the study. She was married to an Egyptian man, had two children, and worked as an EFL teacher at an Egyptian school. In addition to Julie, this study reported on a second subject: Laura, also an exceptionally talented, yet tutored, L2 speaker of several varieties of Arabic. Her L1 was American English, she had taken Arabic at different universities and in different countries (France, Morocco, etc.), and was at the time of the study living in Cairo with her Egyptian husband. Her LOR was 10 years, and she worked as a university professor of Standard Arabic.

What makes the Ioup et al. study methodologically interesting for the assessment of nativelikeness is the employment of a large set of elicitation instruments that included some particularly demanding tasks. Julie and Laura were assessed for production, dialect differentiation abilities (two tests), and grammatical competence (translation, grammaticality judgment, and interpretation of anaphora). Results showed that both Julie and Laura performed as well as (and even better than) some native controls on the dialect differentiation test, and Julie performed somewhat better than Laura. Where production was concerned, a majority of 13 judges (all native speakers of Egyptian Arabic and teachers of Arabic as a foreign language) rated both Julie and Laura as native speakers; judges who gave non-native ratings commented on some element of pronunciation. Finally, both subjects also scored high on tests of grammatical intuition, although slightly below native controls. In other words, there were small differences between the two subjects and native controls and small differences between Julie and Laura.[10] Ioup et al. (1994) conclude that, if there are exceptions to the critical period, the assumed neurocognitive change does not happen in the usual way, although it remains uncertain whether the ordinary acquisition system continues to function or whether an alternative learning system takes over.

White and Genesee (1996) point out that individuals who *appear* to have achieved nativelike proficiency nevertheless frequently differ from native speakers "in subtle ways" (p. 234). Therefore, prior to investigating the accessibility of the Universal Grammar (UG) features *Subjacency* and the *Empty Category Principle* (*ECP*) in adult L2 acquisition, they adopted a strict and extensive criteria-based screening procedure in order to separate "truly" near-native L2 speakers from non-native ones.[11] Randomly selected portions of tape-recorded language samples from 89 differently aged advanced learners of L2 English (AOs: 0–7 [n = 28], 8–11 [n = 12], 12–15 [n = 18], 16+ [n = 31]) were independently evaluated by two native English judges for pronunciation, morphology, syntax, vocabulary, fluency, and overall impression of nativeness. Samples from native English control subjects were also included. The screening resulted in one group of 45 near-native subjects (i.e., L2 learners who passed as native speakers) and one group of 44 non-native subjects (i.e., those learners who, despite being highly advanced L2 learners, did *not* pass as

native speakers). As frequently observed, there was a biased distribution in terms of learners' AOs in these two groups: the majority of the near-native learners (29 out of 45) had started their acquisition of English before age 12, while the majority of the non-native learners (33 out of 44) had started after that age. After this initial screening process, the "real" testing procedure took place. A grammaticality judgment test (a computerized task that, besides recording yes-no answers, also measured reaction times) and a question formation test (an untimed pen-and-paper task) – both of which included sentences relevant to Subjacency and the ECP – were administered to the subjects individually. The results exhibited significant differences between the non-native group and the native group, although no significant differences were found between the near-native group and the native control group on either of the measures, even for reaction times. In addition, there were no effects for age within groups, that is, late starters performed as well as young starters. These findings led White and Genesee (1996) to conclude that access to UG is unaffected by starting age, and thus that nativelike proficiency levels in a second language are indeed attainable even by adult L2 starters, at least in the domain they chose to investigate (p. 261).

Despite the careful screening procedure, ironically, perhaps the most serious objection that one might have to the White and Genesee study concerns another aspect of subject selection. Most of the L2 learners were L1 speakers of French, a language in which Subjacency and ECP work largely as they do in English. From this one might expect these learners to experience little or no difficulty with sentences involving these aspects of UG. Eubank and Gregg (1999) speculate that the White and Genesee data perhaps reflect continued access to L1 principles – in combination with high metalinguistic awareness – rather than continued access to UG principles.

In order to put the above results on late learners' potentials into perspective it is crucial to consider as well the few studies that have paid attention to the ultimate attainment of very young starters. Hyltenstam (1992; see also Hyltenstam, 1988) investigated the grammatical and lexical performance of 24 near-native 17–18-year-old Spanish and Finnish L2 learners of Swedish. Among these, 16 subjects had AOs at 6 years or earlier, and 8 had AOs at 7 years or later. These highly proficient learners were selected by their teachers because they were "not . . . immediately identifiable as non-native speakers in their manifestation of phonology, grammar and/or lexicon" (p. 355).[12] The subjects were active bilinguals, in that they used both their L1 and L2 on a regular basis. A group of 12 native Swedish speakers served as controls. Free speech was elicited through oral retellings of four prepared texts (two presented on tape, two in written format) and one untimed written composition about a section of Charlie Chaplin's silent film *Modern Times*. Each group produced approximately 12,000 words. Although an error analysis revealed an extremely low error frequency in all groups, the native controls made 1–10 errors, the AO < 6 subjects 1–23 errors, and the AO > 7 group 13–26 errors; in other words, the older learner group did not overlap with the native group,

whereas the younger learner group overlapped with both the other groups. Hyltenstam concluded that "[the] age 6 or 7 does seem to be an important period in distinguishing between near-native and nativelike ultimate attainment" (p. 364). However, as not all of the early learners performed within the range of native controls, it was further suggested that "an early AO may be a necessary although not sufficient requirement for nativelike ultimate attainment" (ibid.).

Other studies of very early L2 starters suggest that frequency differences may exist between native and near-native speakers of a language, for example, in the use of specific structures, or in the size and quality of vocabulary. These characteristics of near-native language proficiency are not directly detectable, as errors are, but observable only in the results of linguistic analyses. Ekberg (1998) investigated the use of certain discourse and grammatical structures among 13 bilingual adolescents who had grown up in Sweden, spoke Swedish at school and in out-of-home contexts, but spoke a language other than Swedish at home. The study included a control group comprising 14 Swedish monolingual children. Ekberg found significant differences between the two groups in frequencies of the following: sentence connectors, presentation, pseudo-coordinations expressing progressive aspect, and complex predicates. Hene (1993) studied several aspects of the vocabulary of 24 10–12-year-old children who had been adopted from other countries by Swedish families when the children were between the ages of 3 months and 6 years. The children were compared to 24 native speakers of Swedish of the same ages. The results showed differences between the two groups in several respects. The largest differences were found in the comprehension of some quite frequent words and phrases that appear in school materials for their age groups (e.g., *anse* 'be of the opinion'; *avskaffa* 'abolish'; *början av* 'the beginning of') in tasks that involved prepositions of place, and in giving lexical explanations using synonyms or paraphrases (p. 204). Unfortunately, however, the results are not presented in a way that makes it possible to distinguish L2 children with different AOs.

In a further investigation along the same lines but with a more elaborate design, Hyltenstam and Abrahamsson (forthcoming) studied 20 highly educated adult L2 speakers of Swedish who had been carefully screened for nativelikeness in an informal conversational setting. The subjects were distributed evenly across four AO groups (4–5, 8–10, 12–15, and 19–23), had a LOR of 10 years or more, and used both their L1 and L2 on a regular basis. They were compared to two control groups matched for age and educational background, one of which comprised first language speakers of Swedish (n = 5) and the other advanced but clearly non-nativelike speakers (n = 5, AOs between 4 and 25). Three different instruments were used: a test of perception in white noise, a cloze test, and a grammaticality judgment test.[13] Results consistently revealed significant differences between first language speakers on the one hand and second language speakers of *all* AO groups on the other – that is, even the very early starters differed significantly from native controls. However,

differences between the different AO groups were small and in most cases non-significant. Furthermore, within-group variation among the second language speakers was salient, but minimal among first language speakers.[14]

Similar results were demonstrated by Butler (2000) for adult Chinese L2 speakers of English. Three AO groups and one native control group ($n = 8$ per group) were compared with regard to their performance on three different grammaticality judgment tests. Early arrivals (AO 3–5 years) performed significantly below native controls, but above mid arrivals (AO 5–10 years), who, in turn, scored better than late arrivals (AO 10–15 years). Thus, as in the Hyltenstam and Abrahamsson (forthcoming) study, not even the very young starters exhibited completely nativelike proficiency. Similarly, Bialystok and Miller (1999) and McDonald (2000) report on some very early starters with less than nativelike ultimate attainment.

Thus, results such as those obtained by Butler (2000), Ekberg (1998), Hene (1993), Hyltenstam (1992), and Hyltenstam and Abrahamsson (forthcoming) for second language learners with very low AO are consistent with those reported by Ruben (1997) and Morford and Mayberry (2000) in the first language acquisition context: they all seem to indicate that even a very short delay in onset has effects on the ultimate level of language proficiency.

Likewise, studies that have examined late, advanced L2 learners have failed to localize completely nativelike individuals. While some studies were simply not able to demonstrate full proficiency in the L2 for their advanced learners (Coppieters, 1987; Hyltenstam and Abrahamsson, forthcoming; Ioup et al., 1994; Moyer, 1999),[15] others indicated that their subjects were non-nativelike in areas of the L2 *outside* the areas investigated. For example, referring to his 1992 replication of Coppieters (1987), Birdsong (1999b) claims that several of the 15 participants who had passed as native speakers "deviated very little from native norms" (p. 9), thereby indicating that these learners had *not* attained full nativelike L2 proficiency. Similarly, Bongaerts (p.c.) observed from pilot studies that non-native features beyond pronunciation (e.g., deviant frequency distributions or avoidance of certain lexical/grammatical items) occurred in some of his advanced learners during free oral production. Similarly, although maintaining that late L2 starters can indeed achieve nativelike proficiency, at least in the domain of (certain) UG principles, White and Genesee (1996) see it as a challenging further question "whether this is true of all domains and, if not, in which areas nativelike success is not attainable and why not" (p. 262).

However, research has convincingly demonstrated that, although not entirely nativelike in every aspect of the L2, there is a small population of late L2 learners who, under exceptionally advantageous circumstances, have a potential of reaching high overall levels, perhaps even nativelike proficiency in one or several areas of the L2. In fact, in normal verbal interaction, it may be difficult, even impossible, for native listeners to distinguish such individuals from native speakers. Furthermore, these learners have frequently been characterized as either being highly motivated (Moyer, 1999), or having a high

degree of aptitude for language learning (DeKeyser, 2000; Harley and Hart, 1997; Ioup et al., 1994), or having received intensive and focused L2 instruction (Bongaerts, 1999; Moyer, 1999).

Having presented portions of the relevant empirical research, we will now review some of the theoretical discourse which has framed studies in this area.

4 Theoretical Foundations

4.1 Formulations of maturational constraints

In the most general sense, the notion of maturational constraints suggests that there is a causal relationship between biologically scheduled changes in the developing human brain, on the one hand, and language acquisition potential, on the other. The formulation of maturational constraints most often referred to is Lenneberg's original *Critical Period Hypothesis* (CPH). A second, fairly common formulation has been labeled the *Sensitive Period Hypothesis* (SPH). While the SPH formulation shares with the CPH the view of a heightened sensitivity for natural language input in an early phase of life, the two versions entail different interpretations of the workings of maturational constraints.

The concept of *critical period* is typically associated with those types of behavioral developments that have sudden onsets and offsets, result in all-or-nothing events, depend on instinct, are unlearned and irreversible, and for which environmental influences such as motivation do not play any role (see summaries in Harley and Wang, 1997; Long, 1990). Most importantly, in the *critical period* formulation, maturation is thought to take place and come to an end within an early phase of the life span, abruptly set off from the rest at a specific age (puberty or earlier). However, it is not always the case that periods of special adaptability in any area of temporally scheduled development are sharply set off from what comes before or follows them. This type of pattern has often been referred to as a *sensitive period* (Harley and Wang, 1997, p. 20; Long, 1990, p. 252; Oyama, 1978). As in the critical period formulation, the special adaptation is thought to occur during an early phase, but in this weaker formulation, the sensitivity does not disappear at a fixed point; instead it is thought to fade away over a longer period of time, perhaps covering later childhood, puberty and adolescence. The concept of a critical period, in other words, would represent "a comparatively well-defined *window of opportunity*" (Eubank and Gregg, 1999, p. 68), while a sensitive period would represent "a progressive inefficiency of the organism, or a gradually declining effectiveness of the peripheral input" after a certain time (ibid.). In spite of the fact that this distinction between sensitive and critical periods has been generally acknowledged, and although some people, therefore, prefer the notion of sensitive to critical and see the SPH as a revised form of the CPH (see Obler and Hannigan, 1996, p. 510), in practice, the two terms are often used interchangeably. This may be due in part to the extreme difficulty of drawing a clear distinction

between the two phenomena, which led researchers such as Eubank and Gregg (1999, p. 72) "to use [critical period] in its more widely accepted sense, while ignoring the term *sensitive period* as unhelpful."[16]

4.2 *Exercise and maturational state versions of the CPH*

Another dimension of maturational constraints and how they are formulated concerns the relevance of maturation in L2 acquisition as compared to L1 acquisition. Johnson and Newport (1989) suggested two possible versions of the CPH, "one which does not include second language acquisition in its effects and one that does" (p. 64). They call these the *exercise* version and the *maturational state* version, respectively. The exercise hypothesis predicts that if the language learning capacity is not exercised in early childhood, through the learning of an L1 (cf. Genie and Chelsea), it will disappear with maturation. If this capacity is exercised during this time, however, it will remain intact. The exercise version of the CPH thus predicts that late first language learners will inevitably arrive at levels lower than native proficiency, while late second language learners will not necessarily do so, but may well reach fully native-like levels of the L2. On the other hand, the maturational state hypothesis, which is the most common version of the CPH, states that maturation has an effect on the acquisition of *any* language; that is, if nativelike levels are to be achieved, the acquisition of a first or second (or third, etc.) language must begin early in life, since the human capacity for learning languages declines with maturation, whether exercised in early life or not. This version of the CPH thus predicts non-native proficiency levels for anyone first exposed to the L2 after a critical period.

However, even though a maturational state version of the CPH emphasizes the negative effects of maturation, it does not necessarily ignore the positive effects of exercise. As was pointed out above, adult L2 acquisition results neither in the rudimentary levels reached by Genie or Chelsea, nor the proficiency levels of native speakers, but in outcomes somewhere between those extremes. A study by Mayberry (1993) confirmed just this. In a comparison of late first and second language learners of ASL (AOs 9–15) who had all used ASL for an average of 50 years, the second language users clearly outperformed the first language users. For facts such as these, Eubank and Gregg (1999) offer the explanation that in adult L2 acquisition, "the neural architecture is already developed" (p. 78) as a result of normal and successful acquisition of an L1 during the critical period, whereas in the case of Chelsea's late acquisition of her mother tongue, "the relevant neural architecture is presumably unorganized and unspecific" (p. 77) because "a [critical period] has been missed outright" (ibid.). Thus, as Harley and Wang (1997) point out, "the exercise and maturational state versions of the critical period hypothesis are not mutually exclusive" (p. 27).

4.3 Characteristics of a critical period

Being the formulation of maturational constraints referred to most frequently, the CPH has been characterized in greater detail than other formulations. In a recent summary of earlier discussions of what constitutes a critical period in any area of behavioral development, Harley and Wang (1997) mention the following six characteristics: (i) an onset, (ii) a terminus, (iii) an intrinsic component, (iv) an extrinsic component, (v) an affected system, and (vi) ultimate causes. It is the offset, or terminus, characteristics that actually distinguish the formulations of maturational constraints discussed above; the other characteristics are neutral with regard to these differences and can be said to be valid for maturational constraints in general. We will briefly comment on the characteristics in (i)–(v) here; (vi) will be discussed in a separate section.

There are definitely few elaborated suggestions as to the age at which the *onset* of a critical period for language acquisition occurs. Lenneberg's (1967) proposal of an onset at the age of 2, among other things coinciding with the development of increased syntactic complexity, contrasts with suggestions that such a period begins at 6 months, when the child is clearly sensitive to phonetic categories, or even at birth, when sensitivity to segmental and prosodic distinctions, as well as turn-taking, has been reported (see discussion in Singleton, 1989, p. 78). The question of a critical period's onset is obscured by the fact that some authors equate the onset of the period with the onset of primary language acquisition in general, while others seem to refer to an onset where there is a characteristic acceleration in linguistic development. In his review, Singleton (1989) presents a detailed discussion of onsets in the domains of phonology, grammar, lexicon, and discourse, paying attention to documented "milestones" of language development. Indeed, such milestones are reflections of the fact that different aspects of language have their different onsets. According to what Schachter (1996) refers to as the Windows of Opportunity hypothesis, "principles or properties of [competence] mature, like other biological properties, and become available to the learner at particular points in their linguistic development" (p. 183). The notion of *multiple critical periods* (cf. Seliger, 1978) captures this observation that there are different onsets (and offsets) for different sub-components of language, for example phonology and morphosyntax, or for different (sets of) features within or cutting across these sub-components. In short, with few exceptions (notably Bialystok, 1997, pp. 120, 134), authors prefer to talk about "different [critical periods] with different time courses" (Eubank and Gregg, 1999; see also Long, 1990, among many others).

A critical period should have an identifiable *offset* (or *terminus* in the terminology that Harley and Wang use). The offset issue, in fact, is the most debated question in the field. As we saw above, Penfield and Roberts (1959) suggested that the critical period ends at the age of 9, on the basis of their observation that at this age the child no longer learns language directly but via the units of the first language, due to a reduced cerebral flexibility. Lenneberg (1967) pointed to puberty as the end of the critical period, and suggested that it coincides with the completion of lateralization. His view on the lateralization

process has later been challenged; the process is believed to be completed well before puberty, possibly at the age of 5 or earlier (Krashen, 1973). However, Lenneberg's suggestion of puberty is congruent with observations often made by lay people and with the interpretations in some empirical studies (e.g., Patkowski, 1980; cf. also Scovel, 1988). Since the appearance of empirical work in the late 1970s and in the 1980s, where different AOs are correlated with ultimate level of attainment, an upper limit has been suggested for the acquisition of phonology at age 6 "in many individuals" and at the age of 12 for the rest (Long, 1990, p. 280). For morphology and syntax, Long (1990) concludes on the basis of his review that the age of 15 seems to be the upper limit for nativelike abilities. However, there are indications that the age of 6 or 7 may also be relevant for morphosyntax (Johnson and Newport, 1989) or morphosyntax and lexicon (Hyltenstam, 1992). On the basis of such research, Long (1993, p. 204) suggests that the placement of the upper limit at puberty may be "due to studies having used insufficiently sensitive measures and/or inadequate corpora to detect L2 [phenomena]."

According to the third general characteristic of maturational constraints, there should be some genetically determined mechanism that accounts for the route that language acquisition takes. This *intrinsic component* covers the idea of such an inborn predisposition for language acquisition, that is, some form of linguistic nativism. There have been few expansions on how an intrinsic component specifically would constrain second language acquisition, except within the UG framework. Although, as Wolfe-Quintero (1996, p. 340) notes, "the theory of UG has been the most widely researched variant of linguistic nativism in the field of language acquisition," all current theories of language development are nativist (p. 336) and could therefore be researched specifically for their claims on maturational constraints.

The *extrinsic component* deals with the issue of how environmental factors influence language development. Harley and Wang (1997, p. 24) point out that the effect of environmental factors is "underplayed in critical period studies." From studies of young starters, for example, it is obvious, as we have pointed out above, that a low AO does not necessarily lead to a nativelike ultimate attainment. Among other factors, frequency and quality of input as well as identity issues seem to play an important role and interact with maturational constraints for the outcome even at a low age (Hyltenstam, 1992, p. 364).

The *affected system* – in our context, language proper – is often described as simply as that, especially in early discussions of the CPH. Obviously, more detailed specification is needed in order to support empirical statements, and caution should be exercised in generalizing from empirical results in a specific domain to "language." However, although one must agree with Eubank and Gregg's (1999, p. 66f) contention that "discussions of the [critical period] conducted at the level of Language [i.e., a folk-psychological notion of language] are inherently unfruitful" and that it is necessary to define which components or elements are discussed, it seems premature to exclude factors other than "linguistic competence" from the agenda of maturational constraints, as they do. Instead, one should recognize the relevance and validity of "the human

capacity to utter sounds, to learn words, to construct narratives, to participate in conversations, to produce and understand metaphor, to accommodate to another's speech, to persuade . . . , and, in general, to engage in social discourse" (Schumann, 1995, p. 60). In short, a framework for the understanding of the notion of "language" would be the "human cognitive capacity for language learning (language knowledge, learning, and processing)" (Wolfe-Quintero, 1996, p. 335).

Because, as we have tried to underscore in this chapter, maturational constraints make predictions about the ability to become nativelike in a second language, an important goal for second language acquisition theory is to specify what aspects of language are maturationally affected. As the human capacity for second language acquisition allows learners at any age to acquire large portions of the target language, specifications should concern features that not everyone seems to be able to acquire. Therefore, it is just those features which distinguish near-native and native speakers of a language that are of particular interest. Schachter's (1996, p. 160) discussion of differences between "the child L1 and the adult L2 cases" captures some of this. Schachter points to four differences, two of which distinguish the ultimate attainment even of very successful L2 learners from that of L1 learners: (i) incompleteness with regard to the grammar of the L2; and (ii) fossilized variation, that is, "errors and non-errors in the same linguistic environments." (The other two differences concern transfer and lack of equipotentiality for all languages due to L1 characteristics.) The issue of completeness concerns linguistic competence, while fossilized variation most likely should be considered primarily a processing phenomenon at this level (p. 161). With regard to completeness of competence, there is at present little clear evidence for specific phenomena being maturationally constrained. Among those researchers arguing for the existence of maturational constraints from a UG perspective, Schachter (1996, p. 188) notes that "evidence . . . is just beginning to emerge," and suggests on the basis of various investigations that there is support for the view that the Subjacency Principle is maturationally constrained. Likewise, empirical results by Lee (1992; cited in Schachter, 1996) are taken as support for the Governing Category Principle being sensitive to maturational constraints. Eubank and Gregg (1999, p. 89) draw a different conclusion with reference to a study by Beck (1997), where a theoretical framework relying on the idea of lexical parameters is used, when they suggest that "adult L2 learners, however proficient they may be in other areas of language, share an inability to represent parametric values drawn from the lexicon."

DeKeyser's (2000) data, covering both UG and non-UG features, suggest a distinction between morphosyntactic aspects that are sensitive to maturational effects (the use of articles, the use and position of auxiliaries, the position of adverbs, certain elements of verb sub-categorization, and some uses of the plural morpheme) and aspects that, due to their saliency, are not (basic word order and pronoun gender).

Evidence from studies outside the UG framework seem to be more reliable for the simple reason that they have more frequently investigated the type of subjects which are crucial for the issue of maturational constraints, namely

seemingly nativelike (or near-native) second language learners. As we have seen above, studies that have identified second language learners who perform within the range of native speakers have in most cases concluded that there are still some minor differences between the two groups (e.g., Coppieters, 1987; Ekberg, 1998; Hene, 1993; Hyltenstam, 1992; Hyltenstam and Abrahamsson, forthcoming; Ioup et al., 1994; Moyer, 1999; cf. also Sorace's, 1993, distinction between "divergent" and "incomplete" L2 competence).

4.4 Ultimate causes: proposed explanations for age effects

4.4.1 Biological explanations

Ever since the early suggestions by Penfield and Roberts (1959) and Lenneberg (1967), biological explanations have addressed the brain's steady loss of flexibility or plasticity. Even though little is known about the exact cerebral mechanisms that are responsible for differential outcomes of language learning at different phases of life, there is enough independent knowledge of changes in the brain taking place during the time when language acquisition outcomes differ systematically to be suggestive of hypothesized relations between the two.

A broad characterization of the notion of *cerebral plasticity* is "the ability of neurons to make new connections, and varied connections depending on the stimulus" (Eubank and Gregg, 1999, p. 69). Furthermore, the "[s]trengthening of connections between neurons probably represents the neurobiological basis for learning," including language acquisition (Pulvermüller and Schumann, 1994, p. 691). The question, then, is what physiological cerebral correlates might have implications for the ability of neurons to make new connections.

This issue has often been discussed with reference to the process of *myelination*. The myelination of cortical neurons is a physical-chemical process in the brain in which glial cells wrap the axons of the neurons with myelin. (Myelin is a substance contained in the glial cells that consists of lipids and proteins.) The function of this wrapping of the axons with myelin is to provide the neurons with nutrition and to increase their ability to conduct electrical signals more rapidly. This promotes the ability for the transfer of information at larger cerebral distances. At the same time, it increasingly makes connections between neighboring neurons more difficult. The process of myelination starts at the fetus stage and continues for at least several decades; there is, however, evidence that a high number of neurons in the adult brain remain unmyelinated. Since the beginning of the twentieth century, it has been known that different cortical areas myelinate at different times (see references in Pulvermüller and Schumann, 1994, p. 711). By the age of 12 months, the primary sensory and motor areas along the Rolandic fissure are myelinated. Higher-order association areas of the cortex, such as the angular gyrus, are myelinated much later, and it is in these regions that some neurons remain unmyelinated in adults. The language areas around the Sylvian fissure myelinate after the primary sensory and motor areas, but before the higher-order

association areas: "Around puberty, all cortical areas, except perhaps the higher-order association cortices, have reached their full level of myelination" (Pulvermüller and Schumann, 1994, p. 713). The "maturation of the brain" is indeed often equated with the process of myelination.

These aspects of myelination are coupled with another well-established fact about cortical network organization in an interpretation that Pulvermüller and Schumann (1994) present of the relationship between brain correlates on the one hand and language acquisition potential on the other. They refer to the existence of two systems of cortical connections between neurons, one using what are called apical dendrites and axons that reach far from the cell body and connect different cortical areas, and another system using basal dendrites which are close to the cell body and local branches of the axons, which are called axon collaterals (these two systems are labeled the A-system and the B-system, respectively, by Braitenberg, 1978). Before myelination of a certain area has severed connections between neighboring neurons, a strengthening of connections naturally takes place locally through the B-system. This provides an explanation for why the learning of "how to sequence phonemes, syllables, and words" (Pulvermüller and Schumann, 1994, p. 713) – in other words, the acquisition of the phonological and syntactic system – is easy early in life but becomes increasingly difficult with age. Thus, it is assumed that the acquisition of these aspects of language relies on connections within a limited cortical area. Pulvermüller and Schumann account for the fact that maturation (i.e., myelination) has less of an effect on semantics, pragmatics, and vocabulary with the explanation that these aspects of language rely on connections handled by the A-system, which typically has the ability to connect different cortical areas, not least to involve the higher association areas. With myelination, the electrical signals can be conducted more efficiently between the language areas and other relevant cortex areas through the apical axons, while, at the same time, local connections are enhanced within these areas because myelination is absent.

Of course, a number of facts remain unexplained or ignored in Pulvermüller and Schumann's proposal. It would, for example, be interesting to speculate on how the coupling of prosodic and segmental features should be accounted for in such a framework, or what explains the sudden growth of vocabulary in the 2–3-year-old child. However, it is not unreasonable also to see explanations for such phenomena in terms of myelination.

Interestingly, the model can to some extent be said to find corroboration in recent ERP (Event-Related Brain Potentials) work by Weber-Fox and Neville (see 1999, pp. 27ff, for a summary of studies). For example, in a study of ERP responses for content and function (or grammatical) words, it was demonstrated that in native speakers and early second language learners (AO < 7 years), these two word classes led to different responses, while in groups of second language learners with AOs above that age, there was no obvious difference. Weber-Fox and Neville conclude that "grammatical and syntactic aspects of language processing appear to be more vulnerable to alterations in the timing of language experience compared to more semantic or lexical processing" (1999, p. 34).

Other proposals of cerebral correlates for differences in second language acquisition outcomes include metabolic differences in pre-puberty and post-puberty brains (see references in Pulvermüller and Schumann, 1994, p. 710), thickening of the corpus callosum (Seliger, 1978), and, of course, lateralization (Lenneberg, 1967; see discussion in Long, 1990, p. 278).

4.4.2 Social/psychological explanations

As has already been made clear, there is certainly no consensus on a biological interpretation of differences in outcome of child and adult second language learning. Alternative explanations, with no basis in biology, refer to *social/psychological factors* that are thought to co-vary with age, including motivational, affective/attitudinal, and input factors. That is, it is sometimes claimed that children are inherently more motivated than adults to acquire nativelike levels of the L2, that younger learners develop positive attitudes toward the L2, its culture, and its speakers more easily than older learners do, or that children receive more and simpler input than adults (e.g., Bialystok and Hakuta, 1999). As Long (1990) points out, however, there are some major problems with accounts that use these factors as explanations for child–adult differences. For example, there is no direct evidence that children would be inherently more motivated to learn the L2, or that they receive more input than adults; on the contrary, children may vary in their desire to acquire the L2 and in the input they receive, but invariantly end up with much higher ultimate attainment than most adults. In addition, several empirical studies (e.g., Johnson and Newport, 1989; Oyama, 1978) have shown that motivational factors cannot account for the decrease in ultimate attainment with increasing AOs. Moreover, as was mentioned initially, even though children may generally receive simpler L2 input than adults, research on caretaker talk (or motherese) indicates that course, speed, and success in *first* language acquisition are relatively insensitive to qualitative and quantitative variation in input and interaction. This is true both within and across cultures, and there is no obvious reason to doubt that children can reach very high, if not nativelike, L2 standards from quite poor and sparse input/interaction (see, further, Gleitman and Newport, 1995; see also Ellis, 1994, pp. 267–9).[17]

As there is no convincing counter-evidence to the default assumption that biology constrains L2 acquisition, we must maintain that maturation does have a significant impact on decreasing learning potentials with higher AOs. As maturation clearly plays a major role in L1 acquisition, it would be surprising if L2 acquisition were not strongly influenced by learners' maturational states as well. However, it would be equally surprising if social/psychological factors were shown to have no effect at all on L2 outcomes. There is most certainly an interplay between maturational and non-maturational factors, where the latter sometimes combine into advantageous learning circumstances that may "compensate for the biological disadvantages of a late start" (Bongaerts et al., 1995, p. 45).

In cases of late L2 learning, the advantageous learning circumstances embrace not only motivational, affective/attitudinal, and input factors, but also

social/psychological factors relating to amount and type of instruction, verbal analytical ability, metalinguistic awareness, and a general talent for acquiring languages. While maturation would seem to be responsible for the inevitable overall age-related decline in learning potential (for delayed L1 learners and "normal" L2 learners, as well as for exceptionally successful late L2 learners), the variability between exceptionally successful and other L2 learners *of the same starting age* may be seen as a result of (a certain combination of) these non-maturational factors. The study by Moyer (1999) mentioned earlier showed that, in addition to degree of motivation, the amount and type of instruction that post-puberty L2 learners receive strongly correlate with success, whereas varying starting ages after the completion of maturation do not correlate with levels of proficiency (i.e., ultimate outcomes become statistically unpredictable from AOs after puberty; cf. Johnson and Newport, 1989). Similarly, Bongaerts and his colleagues have suggested that the intensive training in the perception and production of L2 sounds that their foreign language students had received, in combination with high motivation and continued access to ample L2 input, may have been decisive for their attainment of a nativelike pronunciation (Bongaerts, 1999, pp. 154–5). Furthermore, all but one of the late L2 starters in DeKeyser's (2000) study who had achieved scores within the range of child starters on a grammaticality judgment test also scored high on a test of verbal analytical ability. This result led DeKeyser to conclude that only adults with such special abilities can reach near-native L2 competence. Similarly, Ioup et al. (1994; see also Ioup, 1995) stressed the importance for adult learners of focusing on form. Julie reported that from the very beginning of her acquisition of spoken Egyptian Arabic she "consciously manipulated the grammatical structure of the language" (p. 92), that she noticed redundant morphological structure, and that her "attitude toward grammar was that it needed to be mastered correctly" (ibid.). However, another factor is given even more prominence by Ioup et al. (1994), namely an innate talent for learning languages. This trait has been hypothesized (and to some extent observed) to correlate with characteristics "such as left-handedness, twinning, and allergies, among others"[18] (p. 92), and it is also manifest in the speed of L1 acquisition, all of which seemed to fit Julie's profile well.[19] Talent for language learning is also hypothesized by Ioup et al. to originate in "unusual brain organization where a greater proportion of cortex is devoted to language" (ibid.), which leads them to suggest that "any apparent exceptions to the CPH will manifest some aspects of the neuropsychological profile that characterize language learning talent" (p. 93), although just "how the talented brain acquires language in comparison with the normal brain" (ibid.) remains unclear.

4.4.3 Cognitive explanations

Finally, a general consensus exists around the position that "cognitive factors must be implicated in sensitive period effects at some level" (Long, 1990, p. 277), although this consensus does not extend to views on exactly how cognition comes into play; in fact, these views are not at all consentient. Cognitive

explanations for children's superiority at second language acquisition are often based on different versions of the idea that general problem-solving mechanisms are involved in the older learner's processing of second language data. Penfield and Robert's (1959) view of the development of analytical thinking in children by the age of 9 is an early predecessor of explanations built upon Piagetian theorizing about the development of the formal operations stage. Conscious reflections on the structure of the target language are supposed to counteract the normal "direct" processing of target language input. Similar reasoning lies behind later cognitive explanations linked to UG assumptions on language competence. According to the *fundamental difference hypothesis* (Bley-Vroman, 1989), adult learners differ from child learners in that they no longer have access to the inborn language acquisition device specified in UG and instead have to rely on general problem-solving procedures. In contrast, the *competition hypothesis* (Felix, 1985) assumes continued access to UG and suggests that the language acquisition device competes with general problem-solving mechanisms, which eventually win out over the language acquisition device. According to the *less is more hypothesis* (Newport, 1990), limitations on cognitive capacity allow the child to focus on and store component pieces of the input, while adults unsuccessfully try to analyze complex chunks of input simultaneously.[20]

A different perspective on the role of cognition in explaining age-related differences is that of Bialystok and Hakuta (1999). On the basis of categorical, self-reported census data from 63,690 Spanish- and Chinese-speaking immigrants to the United States, with AOs between zero and 70+ and with 10 years of exposure or more, these researchers claim to demonstrate a perfectly linear relationship between AO and ultimate proficiency in L2 English. According to Bialystok and Hakuta, "there appears to be nothing special about the age range before puberty," and rather "[the] decline in proficiency remains constant across ages" (p. 175).[21] They interpret this linear pattern as evidence against a critical period, and propose an explanation based on certain cognitive mechanisms.[22] More specifically, "studies of lifespan cognition" provide evidence that in learning experiments, older subjects are more sensitive to timing factors in the presentation of materials and need longer recall time. There is also a general decline in the recall of details and a tendency for older learners to remember "only the gist." Moreover, the cognitive decline is gradual and constant, just as the levels of language proficiency become gradually poorer with increasing AOs. As all of these deteriorating cognitive abilities are involved in the learning and use of a new language, "age-related changes in ultimate language proficiency are to be attributable to these cognitive changes and not to a specific language module that is constrained by a maturational schedule" (ibid., p. 172). Similarly, although expressing a preference for a maturational interpretation, Johnson and Newport (1989) admit that their results are also congruent with this kind of cognitive account, adding that "future research will [hopefully] provide more detailed results which may differentiate these views from one another" (p. 97). However, Long (1990, p. 277) discusses problems associated with particular cognitive explanations

and with cognitive explanations in general. The strongest argument against general problem-solving and metalinguistic abilities as explanations for age-related differences in outcome is the fact that there is no co-variation between language proficiency and these specific types of cognitive ability. Furthermore, cognitive explanations would predict fundamentally different learning processes for children and adults (in terms of order and sequence of acquisition etc.), which does not seem to be the case.

5 Toward an Understanding of the Role of Maturation

The preceding sections have demonstrated some of the complexities that characterize research on maturational constraints. As mentioned, few empirical results remain uncontroversial, and authors and researchers have taken a wide range of theoretical stances on the basis of quite different – and, at times, similar – empirical data. The aim of this section is to arrive at an understanding of the reasons for these conflicting positions and to suggest a unitary interpretation of existing data.

5.1 Age of onset and ultimate attainment: a unitary interpretation of conflicting observations

From the review of empirical results and theoretical arguments above, we find that different authors claim to have made one of two main kinds of empirical observations of the relationship between AO and nativelike ultimate attainment in a second language:

i Nativelike L2 proficiency is observed in early starters only.
ii Nativelike L2 proficiency is observed in early starters, and also in individual late starters.

That is, while some studies suggest that only child learners can reach nativelike levels, others indicate that nativelike proficiency can be reached regardless of starting age. However, our review has also shown that there are results, especially in more recent research, that give us reason to reinterpret these observations and suggest a third possibility:

iii Nativelike L2 proficiency is observed in neither early nor late starters.

In other words, some studies indicate less than nativelike ultimate attainment even in very early learners; in fact, some studies suggest that ultimate attainment already begins to correlate negatively with AO from birth.

The observations in points (i)–(iii) are displayed graphically in figures 17.1–17.3 respectively.

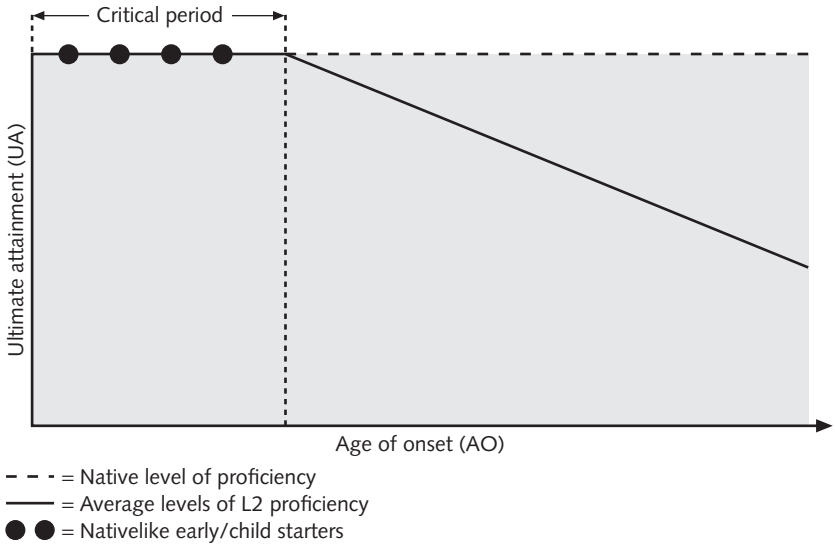

Figure 17.1 Observations of nativelike ultimate attainment in early starters only

Notes: This is based on studies showing that the average UA seems to be uniformly nativelike in early starters, and that UA begins to correlate negatively with higher AO after a certain age (e.g., Johnson and Newport, 1989; Patkowski, 1980, 1990). The typical interpretation attributes this to biological critical period effects (e.g., DeKeyser, 2000; Johnson and Newport, 1989; Patkowski, 1980, 1990). An alternative interpretation attributes it to other, non-biological changes at a certain age, such as identity, motivation, cognition, input, formal training, and other social conditions (e.g., Bialystok and Hakuta, 1999; Bialystok and Miller, 1999).

As can be seen in figure 17.1, which displays the observations formulated in point (i) above, all AOs below a certain age are associated with nativelike ultimate proficiency; AOs after a specific age limit are generally associated with successively lower ultimate attainment. In addition, although not indicated in the figure, inter-learner variability in achieved ultimate proficiency becomes increasingly greater, as has been mentioned earlier.

The pattern in figure 17.1 has typically been interpreted as support for the existence of a biologically defined critical or sensitive period, and thus the existence of maturational constraints, with the implication that the language learning mechanism is less effective after the completion of maturation. However, this has not been the only interpretation. Non-biologically based positions postulate systematically higher degrees of motivation or more supportive input for learners below a certain age than for learners beyond that age limit.

Figure 17.2 illustrates the situation in which we find nativelike L2 proficiency in early starters generally, but also in individual late starters, as stated in point (ii) above. The typical interpretation of this pattern is that there are no maturational constraints on L2 acquisition. It is not an inherent biological restriction on language acquisition that causes the uneven distribution of nativelike

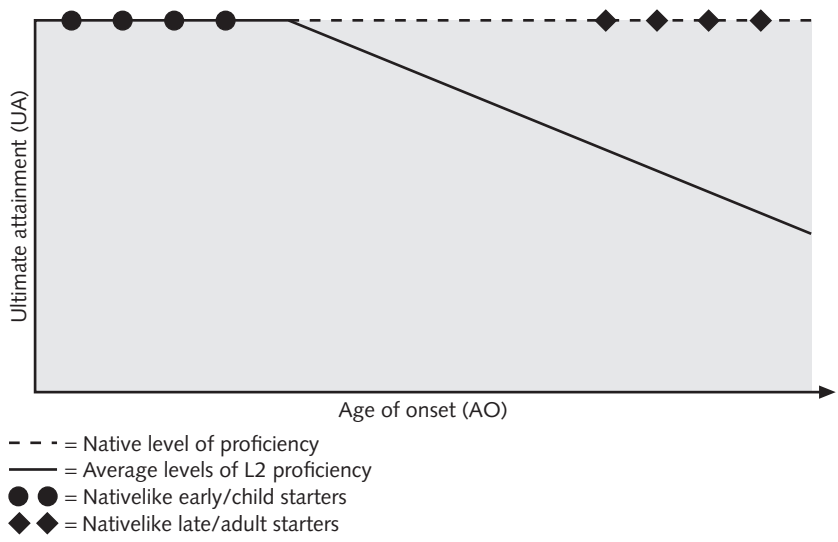

Figure 17.2 Observations of nativelike ultimate attainment in early starters and individual late starters

Notes: This is based on studies demonstrating that late L2 starters who have become highly successful do exist, some of whom even seem to have reached nativelike proficiency (e.g., Birdsong, 1992; Bongaerts, 1999; Bongaerts et al., 2000; Moyer, 1999; White and Genesee, 1996). The typical interpretation is that there is no biological critical period, and learners at any age can, in principle, reach nativelike UA (e.g., Birdsong, 1992; White and Genesee, 1996). An alternative interpretation is that even though a biological critical period exists (see figure 17.1), a few late starters are able to "beat the predictions of the CPH" through compensatory factors, such as high aptitute (e.g., DeKeyser, 2000; Ioup et al., 1994), high motivation (Bongaerts, 1999; Bongaerts et al., 2000; Moyer, 1999), formal training and input (Bongaerts, 1999), etc.

ultimate proficiency among learners with different AOs, but rather differences in their learning circumstances. Within this interpretive framework, a frequently made claim is that motivation and input factors are more favorable for children than for adults. Cognitive factors have also been mentioned as a source of the variability. In particular, it has been claimed that the deterioration of certain cognitive abilities across the life span correlates with the more limited achievement we see in the average learner (Bialystok and Hakuta, 1999).

A biologically based interpretation of the pattern observed in figure 17.2 is related directly to the uneven AO distribution of nativelike ultimate proficiencies. While most younger learners have a special predisposition for acquiring language from mere exposure, this ability is lost with maturation. However, we find exceptional adult learners who have either a different psychological setup in terms of verbal memory and ability to focus on form (Novoa, Fein, and Obler, 1988), or a willingness to adopt a new cultural identity (Schneiderman and Desmarais, 1988), or a high verbal analytical ability (DeKeyser, 2000), or some other more unspecified talent for language generally (Ioup et al., 1994).

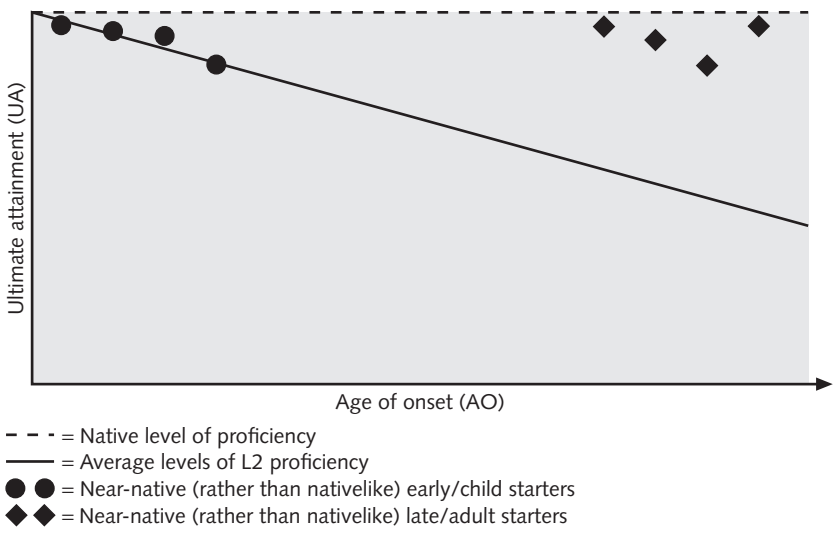

Figure 17.3 A reassessment of the nativelikeness of both early and late starters

Notes: This is based on:

i evidence suggesting that even very early L2 starters reach slightly non-nativelike UA (Ekberg, 1998; Hene, 1993; Hyltenstam, 1992; Hyltenstam and Abrahamsson, forthcoming; McDonald, 2000);

ii evidence or indications that the UA reported for the highly successful late starters in figure 17.2 is actually not completely nativelike, at least not in all relevant aspects of the L2 (e.g., Coppieters, 1987; Ioup et al., 1994; Moyer, 1999; White and Genesee, 1996);

iii suggestions that UA declines linearly with increasing AO, rather than abruptly at a certain AO (e.g., Bialystok and Hakuta, 1999; Birdsong, 1999; Butler, 2000; Flege, 1999; Guion et al., 2000).

Interpretation 1: Biological/maturational effects from birth with no abrupt cut-off point at a certain AO (e.g., Hyltenstam and Abrahamsson, forthcoming; cf. also Birdsong, 1999, pp. 11–12).

Interpretation 2: Lowered language learning ability as a function of a linear decline of cognitive abilities generally (e.g., Bialystok and Hakuta, 1999), or of different amounts of L1 and L2 use for learners with different AOs (e.g., Flege, 1999).

Both the "critical" and "sensitive" formulations suggest that there is a certain period during which the language acquisition ability is not maturationally constrained. This period has a more (in the CPH) or less (in the SPH) abrupt offset. Figure 17.3 shows observations according to which second language ultimate attainment decreases from birth. This pattern is based on studies of non-nativelike early starters as well as on recent research suggesting a linear relationship between AO and ultimate attainment instead of a non-linear one, as implied by the CPH. Here, the curve that describes language acquisition potentials at different AOs thus has no level phase before falling off, but rather describes a continuous decrease from birth over the life span.

However, this idea is not entirely new. Johnson and Newport (1989) speculated whether a critical period for L2 acquisition might terminate much earlier

than age 7, which was the age limit for nativelike attainment suggested by their L2 data. Referring to data on delayed L1 acquisition of ASL which show that children with AOs 4–6 score below native performance, they proposed that such an early decrease in learning abilities might be observed in L2 acquisition, as well, if tests included more complex structures that avoided ceiling effects for the younger starters (p. 96). However, since the proposed offset of a CP has been located at different ages (ranging between 6 and 15) over the years, and since some recent L1 data suggest that maturational effects can be detected much earlier, perhaps as early as 12 months (Ruben, 1997), it is not unreasonable to hypothesize that maturational effects are noticeable as early as from birth in both L1 and L2 acquisition. The few studies that have performed detailed analyses of early L2 starters' proficiency seem to indicate this.

Consequently, we would like to suggest that those studies that claim nativelike ultimate attainment in young learners generally do so on the basis of underanalyzed data. Similarly, it is clear from our review above that claims of nativelikeness for late L2 starters are also based on underanalyzed data. Therefore, the hypothesis that language learning must start "from the beginning" in order to result in full nativelike ultimate proficiency (see point (iii) above) seems to be in agreement with recent suggestions of a linear decline with increasing AOs rather than an abrupt cut-off point at a certain age (see Birdsong, 1999b, p. 11).

The maturational interpretation of observations of this type would be that biological factors play a prominent role in the ultimate attainment of young learners who do reach near-native levels, but that social/psychological and cross-linguistic factors also come into play even at an early age. With increasing AOs, maturational factors play a successively diminished role, whereas other factors become more influential, which is reflected in the greater inter-learner variability among learners with higher AOs (DeKeyser, 2000; cf. also Birdsong, 1999b, p. 12). A formulation along these lines might be considered a less spectacular view of maturational constraints, according to which it is true that biology constrains language acquisition, but not necessarily in terms of a critical period.

The maturational interpretation is not, however, a view that is unanimously embraced. Bialystok and Hakuta (1999), for example, seem to interpret a linear decline in ultimate attainment as evidence not only against a critical period, which it undoubtedly is – "discontinuity [i.e., a salient offset] is the minimal essential evidence needed to reject the null hypothesis of no critical period" (ibid., p. 173) – but against maturational constraints in general, that is, as an absence of biological causes for age-related differences. In such an interpretation, the observed distribution of ultimate attainment levels would again be accounted for by different learning conditions. According to Bialystok and Hakuta (1999), "social factors conspire to ease the effort for young children by providing a nurturing environment, simplified input, educational opportunities, cooperative peers, and other supporting aspects of a social context that facilitate the acquisition of any language" (p. 178). As mentioned earlier, they also suggest that the deterioration of general cognitive mechanisms over the

life span affects the ability to learn a new language. However, in our view, a perfectly linear, negative correlation between ultimate attainment and AO seriously weakens – perhaps even disqualifies – any kind of social/psychological explanation. A linear decline hypothesis predicts average differences in ultimate attainment even between learners with a minimal difference in AO, and at any point on the AO continuum. To our knowledge, no theory can specify the social/psychological (i.e., affective, motivational, educational, input-related, etc.) factors that enable the average 8-month-old starter to reach a slightly higher ultimate attainment than the average 12-month-old starter. Similarly difficult to specify is what cognitive changes during this early period of life would leave more negative traces in the ultimate attainment of the 12-month-old. Such differences in ultimate learning potential are better explained with reference to biological factors. In fact, we see these recent research findings of a linear decline in ultimate attainment as even stronger evidence for the role of maturation than the typical, non-linear pattern.

5.2 *The observations revisited: bringing the patterns together*

We would like to present figure 17.4 as a device for unifying and reinterpreting the quite diverse patterns presented in figures 17.1–17.3.

Earlier in this chapter, we mentioned the fact that it is inherently difficult, perhaps even impossible, to distinguish native from near-native speakers. The slight differences that exist between them may well be unnoticeable. Much of the data discussed in the literature on maturational constraints, and specifically on the CPH, has not been analyzed in sufficient detail to make possible any claims about whether the subjects are nativelike in all respects. On the contrary, it is only in exceptional cases that these very advanced L2 speakers have been the subject of in-depth studies over a range of phenomena that would reflect various aspects of their proficiency.

We can, therefore, readily imagine that many of the L2 learners identified in studies to be "within the range of native controls" should in actual fact be characterized as near-native rather than nativelike speakers. This would actually allow us to merge all types of observations presented in figures 17.1–17.3, and thereby envisage a situation where no L2 learners, irrespective of AO, can become nativelike. The observation in figure 17.1, that is, that only children eventually reach nativelike proficiency, is explained by the fact that most learners with AOs before a certain age limit (say puberty) and practically speaking all before an earlier age limit (say 6) reach proficiency levels above *the limit of perceivable non-nativeness*, thus making them *appear* to be nativelike. This, incidentally, gives an *apparent* cut-off point at a certain AO and consequently an "apparent" critical period prior to that AO. The same explanation may be used for the observation in figure 17.2 (i.e., that of nativelike late starters): because they have reached proficiency levels above this limit of perceivable

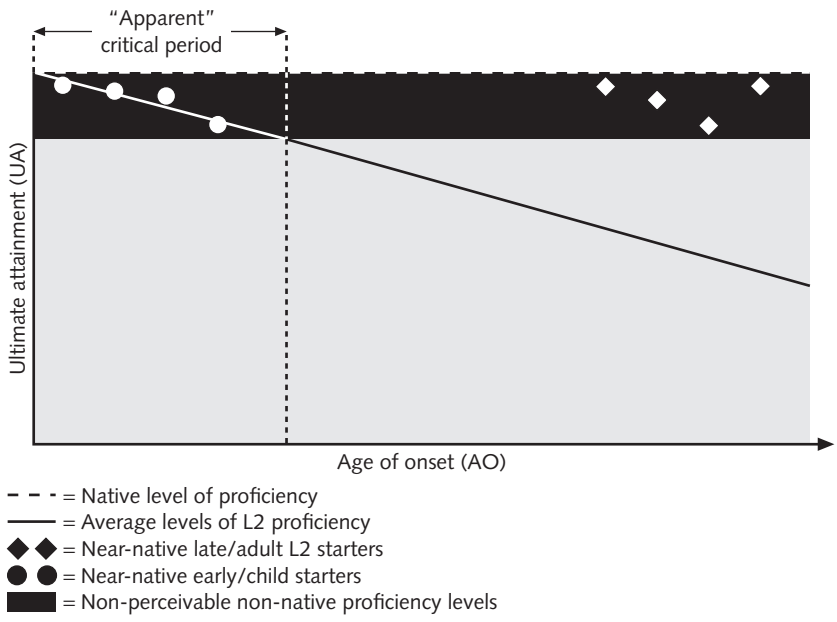

Figure 17.4 A reinterpretation of (i) nativelikeness as non-perceivable non-nativeness, and (ii) the critical period as an "illusion" based on data from underanalyzed early starters

Notes: This is based on all observations behind the patterns in figures 17.1–17.3. Our conclusions are that:

i underanalyzed subjects (both very early and late starters) have near-native (rather than nativelike) L2 proficiency levels that are extremely difficult to distinguish from native levels;
ii what seems to be a critical period is actually the time span prior to the AO point where average L2 learners' UA levels begin to be perceivable as non-nativelike.

non-nativeness, they are seemingly nativelike. In addition, this account helps to explain why the pattern in figure 17.3 has as yet only been hinted at as a possibility, perhaps due to the fact that it does not appear to correspond to observations in everyday life. Thus, the seemingly conflicting data can be given a unitary interpretation, provided that a dimension of "non-perceivable non-nativeness" is included.

In the next section, an attempt is made at integrating the various observations and perspectives into a composite picture that incorporates the interactional effects of the factors that seem to be decisive for the ultimate outcomes of second language acquisition.

5.3 The composite picture

Figure 17.5 presents a "consensus model" of what we believe constitutes our present knowledge. It is intended to exhibit and consolidate the existing

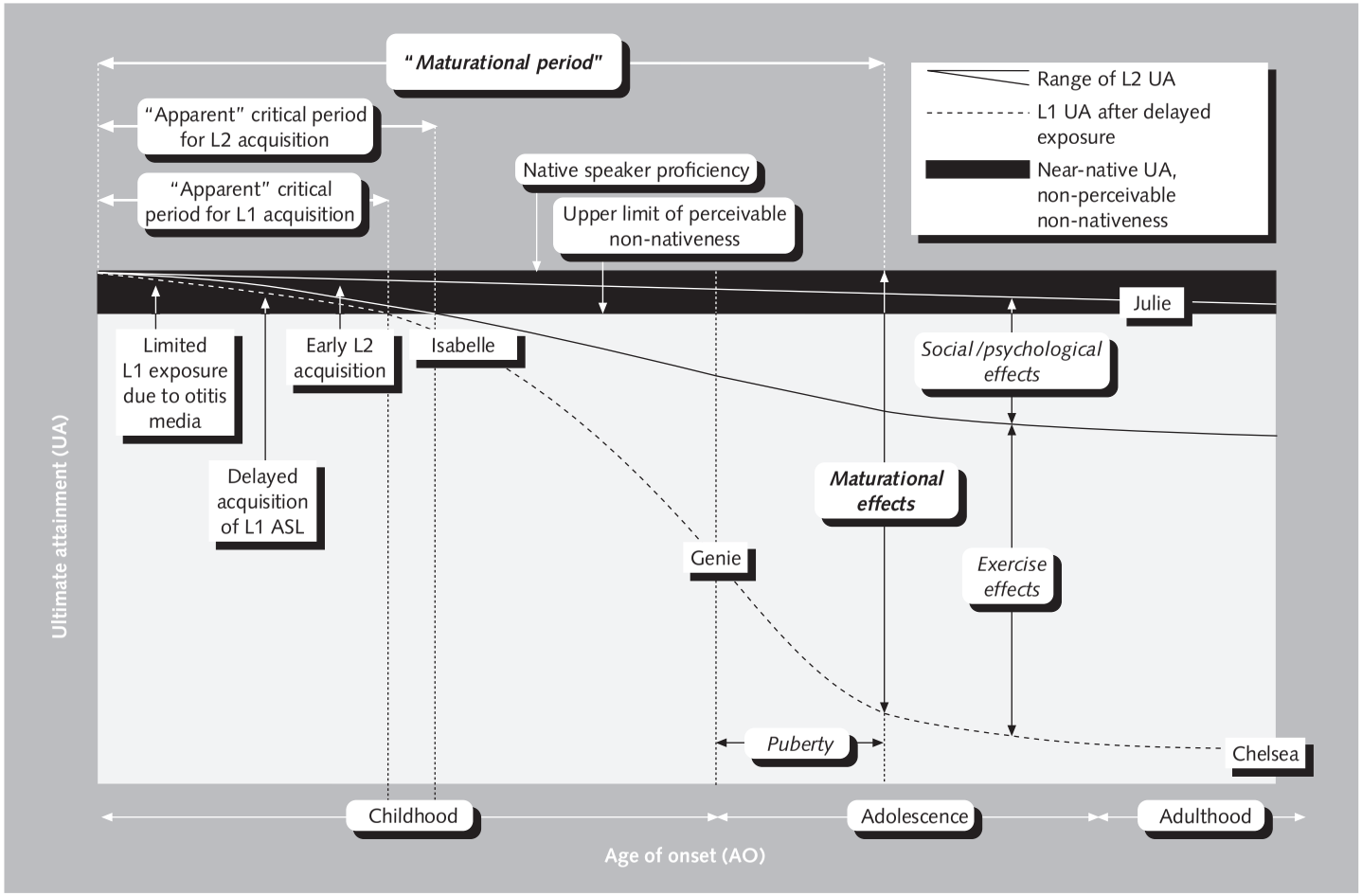

Figure 17.5 A model of the interplay between maturation, exercise, and social/psychological factors

empirical facts and the relationships among them. We believe that such a model has the potential of providing us with an interpretive framework for simultaneously appraising the empirical and theoretical status of our field. Although maturation seems to play a major role in language acquisition, as we see it, other factors also contribute to actual ultimate attainment in individual cases. The question is how to characterize the *interplay* between maturation and social/psychological factors and how to make them fit into the composite picture.

In figure 17.5, possible proficiency levels range between zero (absolute bottom of the graph) and native proficiency (absolute top). In other words, logically, one could identify an infinite number of proficiency levels in between. As in the schematic representation in figure 17.4 above, the black layer at the top of the graph in figure 17.5 represents *near*-native proficiency levels. The upper solid curve represents ultimate outcomes of individuals (e.g., Julie) whose learning is characterized by exceptionally advantageous circumstances. These are exceptional individuals who – although not completely nativelike – could not easily be identified as non-native speakers, and who instead *appear* to have attained a nativelike command of the L2. The lower solid curve represents ultimate attainment levels that are reached by non-exceptional learners when learning conditions are ordinary, that is, non-deficient. The area between the two solid curves thus represents the range of attainable L2 proficiency levels. The dashed curve in the figure represents delayed L1 acquisition.

Although the cases of delayed L1 acquisition are very rare, they nevertheless give us a clear indication of how an already established L1 positively affects the acquisition of an L2. The difference in figure 17.5 between native proficiency levels and the non-native levels of Genie's or Chelsea's L1 attainment is a reflection of maturational effects alone (cf. Eubank and Gregg, 1999, p. 78). In contrast, the difference between Genie and any 13-year-old L2 learner, or between Chelsea and L2 learners of her age, would be due to the positive effects of *exercise*. As was mentioned earlier, there is an obvious interplay between maturational and exercise effects that, on the one hand, prevents late second language learners from reaching completely nativelike proficiency levels, but, on the other hand, allows them to reach significantly higher levels than late L1 learners (as evidenced in Mayberry, 1993); something that neither the *maturational state hypothesis* nor the *exercise hypothesis* – in their pure forms – can account for.

As was argued in a previous section, maturation can account for the overall and linear decline in learning potentials with increasing AOs (for all kinds of learners), whereas the variability between exceptionally successful and non-exceptional L2 learners of the same starting age is accounted for best by non-maturational factors. Thus, the distance between native proficiency and *any* non-native curve at *any* AO point in figure 17.5 represents the negative effect of maturation, whereas the range of non-native L2 levels represents the effect of social/psychological factors. In other words, social/psychological factors may explain why one 25-year-old starter reaches higher levels of proficiency than another 25-year-old starter, but cannot explain why 4-year-old starters

generally perform better than 25-year-old starters – only maturational factors can. The empirical data on delayed *first* language acquisition are very sparse, and therefore we are not able to tell whether social/psychological factors would result in the same kind of inter-learner variability in the first language context.

It seems, however, that the role of social/psychological factors becomes increasingly important with age. At least up to AOs 6 or 7, all learners will automatically reach levels that allow them to pass as native speakers – provided that there is sufficient input and that the learning circumstances are not deficient. The relatively early phase of the maturation process thus allows for learning to result in seemingly nativelike proficiency from mere L2 exposure. With increasing AOs after this age, however, certain social/psychological factors must be increasingly advantageous in order to compensate for the successively negative effects of maturation. That is, 8-year-old starters must have a certain (albeit small) degree of extraordinary motivation (and/or positive affect, input, instruction, aptitude, etc.) in order to reach the same levels that are automatically reached by their 6-year-old friends; the 25-year-old starter will have to encounter a variety of such advantageous circumstances, and to a much greater degree, in order to compensate for maturational effects. In contrast, non-maturational factors seem to play only a marginal role in early childhood: talented and highly motivated 4-year-olds do not have any significant advantage over their less talented/motivated peers of the same age (cf. DeKeyser, 2000). This is not only because the absolute difference between their levels of L2 proficiency will be very small, but also because they will all end up in the near-native layer anyway, thus attaining levels of proficiency at which non-nativeness cannot be detected easily by native listeners.

As in figure 17.4 above, there are no ultimate attainment curves in figure 17.5 that ever touch the ceiling; perfect proficiency in a first or second language is displayed here as never being attained when acquisition is delayed in the least. However, given our present state of knowledge, this aspect of figure 17.5 remains a conjecture that requires extensive empirical corroboration. Nevertheless, given the fact that there are no published accounts of a single adult starter who has reached nativelike overall L2 proficiency, and given the frequent observation of non-native features even in very early starters, we would suggest the *possibility* that absolute nativelike command of an L2 may in fact never be possible for any learner. According to such a view, the language learning mechanism would be designed in such a way that it requires immediate triggering from the environment in order for it to develop and work appropriately; that is, the learning mechanism inevitably and quickly deteriorates from birth if not continuously stimulated.

Finally, the general notion "maturational period," which is depicted here as occurring between birth and (approximately) age 15, has been included instead of specific notions such as "critical/sensitive/optimal period(s)." The continued decline of all curves after age 15 is meant to be interpreted as dependent on non-maturational factors. Note that a "maturational period" concept implies only that maturation *is going on*; that is, it predicts that acquisition will be

increasingly difficult during this period, but remains neutral as to the exact levels of ultimate attainment (since the degree of motivation, talent, instruction, and other compensatory potentials of individual learners is unpredictable from AO). This contrasts with the notion "critical period," which predicts nativelike levels if acquisition begins at any AO within this period. However, as was shown in figure 17.4 above, there are certain time spans that may be interpreted as critical periods. The bottom of the black layer (i.e., the upper limit of perceivable non-nativeness) in figure 17.5 is eventually broken, first by the L1 curve, then by the lower L2 curve. If the bottom line of the near-native layer has been interpreted earlier as (absolute) nativelike proficiency, then there are *apparent* critical periods, within which proficiency levels that are perceived as nativelike by native listeners are attainable. Exactly where (or if) the upper L2 curve crosses the limit of perceivable non-nativeness is still an open question.

In the scenario given here, some of the established research results connected with the topic of the CPH would be seen as an illusion. Many aspects of the CPH would be seriously questioned, although at the same time there would be strong support for the role of maturation in both first and second language acquisition.

6 Future Research: Basic Methodological Requirements

We believe that the most fruitful way to research maturational constraints is to focus explicitly on ultimate L2 learning *potentials* – in late as well as in early starters. Because ultimate attainment studies using randomly selected learners of different ages manage only to demonstrate that early starters generally reach higher levels of L2 proficiency than late starters, future research must continue in the direction developed during the 1990s, namely to focus specifically on the question of whether late/adult starters can ever attain nativelike L2 proficiency. This should be done by continuing the intensive examination of exceptionally successful late starters who appear to have reached nativelike levels of L2 proficiency. However, as has been clear from our previous discussion, the careful investigation of the ultimate L2 proficiency of very young starters is equally important. In other words, learners of all ages who we, as native speakers, cannot immediately identify as non-native speakers should be selected as subjects. Long (1993) points out that screening procedures prior to investigation are important, as "there is no value in studying obviously non-nativelike individuals intensively in order to declare them non-nativelike" (p. 204).

A problem with ultimate attainment studies in general has to do with a tendency among researchers to equate "language" with "grammatical competence." As was mentioned in the introductory section, the domain for maturational constraints should, in our view, be the human capacity for language both at the level of knowledge and at the level of processing. Therefore,

the notion of "language" needs to be defined in terms of "language proficiency," *including* "grammatical competence" (as defined, for example, within the UG framework). Learners' L2 proficiencies should thus be evaluated on the basis not only of their grammatical competence, but also of their ability to utilize such competence, in oral or written production/comprehension, as well as in grammaticality judgment and other formal tasks. Furthermore, it is important to investigate the extent to which advanced L2 speakers can pass as nativelike speakers under a variety of conditions, such as in stressful versus relaxed situations of language production/comprehension.

With the exception of a few studies using test batteries, and thereby covering various aspects of the L2 (e.g., Ioup et al., 1994), most studies have drawn far-reaching conclusions about maturational constraints from learners' performance on a limited set of structures within, perhaps, one sub-component of one linguistic level of the L2, without evaluating the full range of learners' L2 proficiency. In order to avoid such unwarranted generalizations, and be able instead to arrive at a global understanding of this proficiency, researchers should either employ large sets of elicitation techniques for varied aspects of language proficiency, or explicitly relate the specific area investigated to empirical results in the field in general.

Furthermore, the tasks and tests should be highly demanding, in order to distinguish, where possible, between non-native and native subjects (that is, to avoid ceiling effects; cf. Johnson and Newport, 1989, p. 96). It is, therefore, important to include not only core features (such as UG principles or parameters) but also language-specific, peripheral features (such as metaphors, idiomatic expressions, and "unusual" structures), since these are usually predicted as being difficult, if not impossible, to master (Ekberg, 1998; Yorio, 1989). Long (1993) points out that different kinds of forced production, such as elicited imitation, are useful tools for probing low-frequency items that are easily avoided; since such items might never occur in free oral or written production, "it would be unwarranted to assume either (a) lack of knowledge on the basis of non-use, or (b) that error-free performance on what the learner did say or write can be interpreted as nativelike competence in all unobserved domains, as well" (p. 209). Moreover, non-nativelike L2 proficiency may also be manifest through very infrequent and subtle phonological deviance (cf. Julie and Laura in Ioup et al., 1994), through the slightly deviant or unusual (although not directly erroneous) use or representation of certain lexical items or grammatical structures (cf. Hyltenstam, 1992; Sorace, 1993), through deviance in frequency of certain words or grammatical constructions (Ekberg, 1998; Hene, 1993), through slightly slower speaking rate (cf. Guion, Flege, Liu, and Yeni-Komshian, 2000), or through small but significant comprehension and perception difficulties that do not occur in native speakers (Hyltenstam and Abrahamsson, forthcoming; McAllister, 2000). In other words, there may well be minor non-native features that are difficult to detect in everyday conversation or with crude testing techniques. Since these kinds of subtle non-native features are most likely present, and since our focus when researching adult

learners' potentials should be on what they *cannot* do (Long, 1993, p. 208), refined analyses/measurements of learner behavior are necessary.

Finally, we see it as an important task for future research to systematically identify and describe the social/psychological characteristics that can be associated with the near-native adult learner. Exactly what psychological traits and social circumstances distinguish such learners from average early starters and other, less successful, late starters? Indeed, as we have mentioned above, several researchers have already begun to investigate such factors: Moyer (1999) singled out high motivation as the determining factor for the exceptional learner in her study of L2 pronunciation; Bongaerts (1999) suggested both high motivation and intensive instruction in pronunciation as crucial factors for reaching advanced levels of foreign language proficiency; Ioup et al. (1994) discussed the psychological profile of Julie, and pointed to both focus on form and a general talent for learning languages as important features; DeKeyser (2000) suggests that high verbal analytical abilities may be a prerequisite for reaching high levels of L2 proficiency in adulthood.

In conclusion, as has become evident from our review of empirical work, no single study meets all of the methodological requirements mentioned above. On the other hand, some studies have successfully met one or two of the requirements (see boxes 17.1–17.3). Ioup et al. (1994) included a relatively large test-battery, embracing various elicitation techniques for different subcomponents of language. White and Genesee (1996) employed rigorous initial screening of near-native and non-native speakers. DeKeyser (2000) attempted to describe a potentially important characteristic of the high-scoring adult learner, verbal aptitude, thereby providing an explanation for the relative success in some late learners. Jointly, these aspects of research design cover many of the requirements outlined above, and the three studies mentioned here illustrate how each of these methodological features can be incorporated in the design of future work.

7 A Final Remark

We started this chapter by stating that both adults, in rare cases, and children, in most cases, seem to reach nativelike proficiency in a second language. We have ended up with a qualified guess that "seem to" is a central part of that formulation. Thus, it may appear that we began with a quite optimistic remark but finished with a pessimistic one. Such an interpretation of our discussion is, however, unwarranted.

Given that maturation has the strong influence on second language outcomes that our review has indicated, it should come as no surprise that nativelike proficiency in a second language is unattainable. More surprising, we would like to claim, are the miraculous levels of proficiency that second language learners (at all ages) in fact *can* reach, despite the constraints that are imposed by our biological scheduling. That maturational effects, to a very

Box 17.1 Assessment of L2 proficiency: the design of a demanding and rigorous test-battery (Ioup et al., 1994)

Speech production:
Audiotaped spontaneous speech (detailed narration of favorite recipe).

Accent identification:
Recorded speech samples of various Arabic dialects, viz. Libyan, Syrian, Palestinian, Kuwaiti, and Sudanese, as well as whether an Egyptian accent was the Cairene variety or not.

Grammatical intuitions:

- *translation:* of constructions reflecting language-specific rules relating to relative clauses, yes-no questions, *wh*-questions, and conjoined NPs;
- *grammaticality judgment*: 37 Egyptian Arabic sentences either pertaining to constraints in UG or following from language-particular rules;
- *interpretation of anaphora*: conjoined sentences, backward pronominalization, and relative clauses, all in conditions of both adjacent and remote reference.

Box 17.2 Selection of subjects: identification and initial screening of near-native speakers (White and Genesee, 1996)

Identification of near-native L2 speakers:
Solicitation through notices posted at the university and in local newspapers; 89 advanced L2 speakers were identified; 19 native English controls were also included.

Initial selection of language samples for evaluation of nativelikeness:
Individual, face-to-face interviews (using selected pictures from the Thematic Apperception Test; Murray, 1971) recorded on tape.

Evaluation for nativelikeness prior to the actual testing:

- A randomly selected portion of the samples were evaluated independently by two native English-speaking judges. Judges were informed that the samples came from non-native and native speakers of English.
- Samples were evaluated for: pronunciation, morphology, syntax, choice of vocabulary, fluency, and overall impression of nativeness. Each of these aspects was independently evaluated on a "non-native"–"native" continuum.
- Only those L2 speakers who were rated within the range of native speakers qualified as near-natives (n = 45); those with ratings below that range were labelled non-natives (n = 44).

Box 17.3 Exceptional learners: identifying learner traits and learning conditions (DeKeyser, 2000)

Research aim: To test the *fundamental difference hypothesis* (Bley-Vroman, 1989).
Methodology: A grammaticality judgment test and a language learning aptitude test were administered to 57 Hungarian learners of English with AOs ranging between 1 and 40.

Results: The grammaticality judgment test results showed a strong, negative correlation with AO, with a small overlap between early (AO<16) and late starters (AO>16). Aptitude scores did not correlate with AOs. Correlations between grammaticality judgment scores and aptitude scores were: non-significant for the group as a whole; non-significant for the group of early starters; significant for the group of late starters. Those late starters (except for one) who scored within or close to the range of early starters all had above average aptitude scores.

Conclusion: Aptitude plays no role in ultimate attainment by child starters, but is a necessary condition for near-native proficiency in adult learners.

large extent, can be compensated for is indeed encouraging. The subtle differences that we have assumed to exist between near-native and native proficiency are probably highly insignificant in all aspects of the second language speaker's life and endeavors, although *very* significant for a theory of human capacity for language learning. The highly successful L2 speakers that we have characterized as having reached "only" near-native proficiency *are*, in fact, nativelike in all contexts except, perhaps, in the laboratory of the linguist with specific interest in second language learning mechanisms.

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NOTES

1 Although acknowledging the numerous complexities associated with the definition, assessment, and social implications of "nativelike proficiency" (and related notions, such as "nativeness" and "native speaker"; see, e.g., Cook, 1999; Davies, 1991), we have chosen to

disregard these complexities, in order to attain a reasonable level of generality in our discussion.

2 See Moody et al. (1996); Wallace et al. (1988).

3 For comprehensive and detailed overviews of rate studies, see, for example, Harley (1986, pp. 25–33); Long (1990, pp. 260–5); Singleton (1989, pp. 94–107).

4 See also Johnson and Newport (1991) and Johnson (1992).

5 The Hungarian Language Aptitude Test, Words in Sentences (Ottó, 1996), which is an adaptation of the Modern Language Aptitude Test, Words in Sentences (Carroll and Sapon, 1959).

6 It is, of course, possible to interpret this learner's high score as an effect of other beneficial factors.

7 EFL = English as a foreign language; FFL = French as a foreign language.

8 The aim of Moyer's study was to investigate the relationship between AO, motivation, instruction, and foreign accent. We will return to her study later in this chapter when we discuss alternative explanations to age-related differences in ultimate L2 outcomes, and the possible interaction between social/psychological factors (motivation, talent, etc.) and maturational constraints.

9 Ringbom (1993) notes that "we have all met or heard people, especially actors and singers, with a singular excellence in producing nativelike speech in fixed situations, even though their actual knowledge of the language may be minimal, even practically non-existent" (p. 7) (for individual adults' phonetic imitation abilities, see, e.g., the studies by Neufeld, 1977, 1978; cf. also Markham, 1997). Moreover, after a sufficient amount of rehearsal, it seems that the odds of sounding nativelike when *singing* in a (highly familiar) foreign language are much greater than when spontaneously *speaking* it. In fact, we would venture the claim that even Agnetha and Frida might, at times, have been mistaken for native singers of English, although, *surely*, no native English speaker would ever make such a judgment on the basis of an Abba interview.

10 Similarly, in an unpublished paper, Zhang (1992) reports on two native speakers of English with seemingly nativelike L2 proficiency in Chinese. Although they passed as native speakers for the majority of a group of native judges, a detailed linguistic analysis revealed subtle cases of divergence from native controls on various linguistic aspects. For example, although they did not violate syntactic rules in their use of pauses and fillers, both subjects exhibited a relatively high frequency of such elements sentence-internally, a feature that distinguished them from the native controls.

11 This screening procedure was very much in accordance with the criteria for subject selection originally proposed by Long (1993, pp. 204–13).

12 For details about these subjects' literacy skills, see Stroud (1989).

13 In addition to these tests, several other instruments were used in this study, including an oral interview, a self-assessment, the retelling of written and oral texts, a reading-aloud task, and a written composition; the results from these tasks will be reported elsewhere.

14 In addition, preliminary analyses of lexical and grammatical errors not discussed in Hyltenstam and Abrahamsson (forthcoming) show the same tendency.

15 Except for one outlier in Moyer (1999) who was rated as a native speaker.

16 An alternative terminology is *optimal period* for language acquisition (Patkowski, 1980). Patkowski uses this term interchangeably with *critical* and *sensitive period*. However, Bialystok (1997, p. 116f) suggests that these terms should not be used as synonyms. As she points out, the use of the terms *critical* and *sensitive periods* entails assumptions about the paradigm from which they are taken, that is, biologically defined bases for second language acquisition outcomes, while an optimal period of acquisition could be used without making claims about a biological cause. She believes that it is reasonable to talk about an optimal time for language acquisition as "such factors as social, experiential or educational aspects of second language learning . . . tend to favor younger learners" (p. 117).

17 For further criticism of non-maturational explanations for age-related differences, see Long (1990, pp. 275–6).

18 That is, characteristics belonging to what is usually referred to as the "Geschwind cluster" (see, e.g., Obler, 1989).

19 Julie's mother reported her to have been precocious in L1 acquisition, and that "she spoke in full sentences at 18 months" (Ioup et al., 1994, p. 93).

20 See Harley and Wang (1997, pp. 40ff) for a more detailed discussion of cognitive explanations.

21 See Bialystok and Miller (1999) and Butler (2000) for similarly linear relations between starting age and ultimate attainment.

22 However, such a linear pattern over the life span does not necessarily need to be interpreted in non-biological terms, as will be evident from the following sections in this chapter.

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