International Journal of Scientific Trends- (IJST)
ISSN: 2980-4299
Volume 3, Issue 3, March, 2024
Website: https://scientifictrends.org/index.php/ijst
Open Access, Peer Reviewed, Scientific Journal

A Critical Period for Acquiring a Second English Language

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Abstract:
Children learn language more easily than adults, although when and why this ability declines remains unclear for both empirical reasons (insufficient research) and conceptual reasons (I am confident that students who begin learning at different ages cannot independently itself to identify changes in basic learning abilities). We address both limitations with a dataset of unprecedented size (669,498 native and non-native English speakers) and a computational model that estimates the underlying movement trajectory. Develop ability by separating current age, age of first contact, and years of experience. This leads us to take the first direction, and he, like the graph, and discovers that this is what he is. DESLINES StefeDILU. This conclusion is true not only for "difficult" syntactic phenomena, but also for "easy" syntactic phenomena, which are usually mastered in the early stages of development. The results support the existence of a well-defined critical period for language acquisition, but the age of shift occurs much later than previously thought. The size of the data set also provides new insight into several other unresolved questions in language acquisition.

Keywords: Language acquisition; Critical period; L2 acquisition

Introduction

People who learned a second language in childhood are difficult to distinguish from native speakers, whereas those who began in adulthood are often saddled with an accent and conspicuous grammatical errors. This fact has influenced many areas of science, including theories about the plasticity of the young brain, the role of neural maturation in learning, and the modularity of linguistic abilities. It has also affected policy, driving debates about early childhood stimulation, bilingual education, and foreign language instruction.

However, neither the nature nor the causes of this "critical period" for second language acquisition are well understood. (Here, we use the term "critical period" as a theory-neutral descriptor of diminished achievement by adult learners, whatever its cause.) There is little consensus as to whether children's advantage comes from superior neural plasticity, an earlier start that gives them additional years of learning, limitations in cognitive processing that prevent them from being distracted by irrelevant information, a lack of interference from a well-learned first language, a greater willingness to experiment and make errors, a greater desire to conform to their peers, or a

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greater likelihood of learning through immersion in a community of native speakers. We do not even know how long the critical period lasts, whether learning ability declines gradually or precipitously once it is over, or whether the ability continues to decline throughout adulthood or instead reaches a floor. Learning ability vs. ultimate attainment

As noted by Patkowski [1], researchers interested in critical periods focus on two interrelated yet distinct questions:

1. How does learning ability change with age?
2. How proficient can someone be if they began learning at a particular age?

The questions are different because language acquisition is not instantaneous. For example, an older learner who (hypothetically) acquired language at a slower rate could, in theory, still attain perfect proficiency if he or she persisted at the learning long enough.

The question of ultimate attainment (2) captures the most public attention because it directly applies to people's lives, but the question of learning ability (1) is more theoretically central. Does learning ability decline gradually from birth, whether from neural maturation, interference from the first language, or other causes? Alternatively, is there an initial period of high ability, followed by a continuous decline, or a decline that reaches a? Or does ability remain relatively constant with adults failing to learn for some other reason such as less time and interest.

Unfortunately, learning ability is a hidden variable that is difficult to measure directly.

Studies that compare children and adults exposed to comparable material in the lab or during the initial months of an immersion program show that adults perform better, not worse, than children, perhaps because they deploy conscious strategies and transfer what they know about their first language. Thus, studies that are confined to the initial stages of learning cannot easily measure whatever it is that gives children their long-term advantage. (Note that strictly speaking, these studies measure learning ***rate,*** not learning ***ability.*** While these are conceptually distinct, in practice they are difficult to disentangle, and the distinction has played little role in the literature. In the present paper, we will use the terms interchangeably.)

Thus, although the question of learning ability (1) is more theoretically central, empirical studies have largely probed the more tractable question of how ultimate attainment changes as a function of age of first exposure (2). Here, too, there are a number of theoretically interesting **possibilities. The hope has been that identifying the shape of the ultimate attainment curve might tell us** something about the shape of the learning ability curve. Unfortunately, this turns out not to be the case. Despite the similarities between the two sets of hypothesized curves, they bear little relationship to one another: The same ultimate attainment curve is consistent with many different learning ability curves.

Here is why learning ability curves and ultimate attainment curves should not be conflated: If, hypothetically, learning ability plummeted at age 15 but it took 10 years of experience to master a language completely, then ultimate attainment would decline starting at an age of exposure of 5 (since someone who began at 6 years old would learn at peak capacity for only 9 of the 10 years required, someone who began at 7 years old would learn for only 8 of those years, and so on). It would be erroneous, in that case, to conclude that a decline in ***ultimate attainment*** starting at age 5 implied that children's ***learning ability*** declines starting at age 5. Conversely, showing that people who began learning at a certain age reached native-like proficiency merely indicates that

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they learned fast enough, not that they learned as fast as a native speaker, just as the fact that two runners both finished a race indicates only that they both started early enough and ran fast enough, not that they ran at the exact same speed.

As we have seen, to understand how language-learning ability changes with age, we must disentangle it from age of exposure, years of experience, and age at testing. Unfortunately, this challenge is insuperable with any study that fails to use sufficiently large samples and ranges, because any imprecision in measuring the effects of amount of exposure on attainment, the effects of age of first exposure on attainment, or both, will render the results ambiguous or even uninterpretable.

Moreover, an underlying ability curve can be ascertained only if the measure of language attainment is sufficiently sensitive: If learners hit an artificial ceiling, any gains from an earlier age of exposure or a greater amount of exposure will be concealed. Indeed, the concept of native proficiency entails ***extreme*** levels of accuracy. An error rate that would be considered excellent in other academic or psychological settings, such as 0.75%, represents a conspicuous immaturity in the context of language. For example, over-regularizations of irregular verbs, such as ***mimed*** and ***breaked,*** are among the most frequently noted errors in preschoolers' speech, despite occurring in only 0.75% of utterances.

These basic mathematical facts raise a significant practical problem: Detecting an error that occurs as little as 0.75% of the time requires a lot of data: A preschooler has to produce 92 utterances to have a better than even chance of producing an over-regularization. Thus, to detect even "conspicuous" errors, such as childhood over-regularization, we need to test many subjects on many items.

Below, we describe a study of syntax that attempts to meet these challenges using novel experimental and analytical techniques. To foreshadow, the age at which syntax-learning ability begins to decline is much later than usually suspected, and it takes both native and non-native speakers longer to reach their ultimate level of attainment than has been previously assumed. While both findings are unexpected, we show that the apparent inconsistencies with prior findings can be explained by the much higher precision afforded by our methods. Indeed, the findings below should not be surprising in retrospect. More importantly, these findings appear robust and emerge in a variety of different analyses.

1.1. Procedure

Potential subjects were invited to take a grammar quiz, the results of which would allow a computer algorithm to guess their native language and their dialect of English. After providing informed consent, subjects provided basic demographic details (age, gender, education, learning disability) and indicated whether they had taken the quiz before. They then completed the quiz and were presented with the algorithm's top three guesses of their native language and their dialect, which was based on the Euclidean distance between the vector of the subject's responses and the vector of mean responses for each language and dialect. Participants found this aspect of the quiz highly engaging, and the quiz was widely shared on social media. For instance, it was shared more than 300,000 times on Facebook.

After seeing the guesses, subjects were invited to help us improve the algorithm by filling out a

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demographic questionnaire. (Although early answers were used to tune the algorithm, the algorithm's accuracy quickly plateaued and was not tuned further.) This included all the countries they had lived in for at least 6 months, and all the languages they spoke from birth. Participants who listed multiple countries were asked to indicate their current country. For some countries (such as the USA), additional localizing information was collected. Participants who did not report speaking English from birth were asked at what age they began learning English, how many years they had lived in an English-speaking country, and whether any immediate family members were native speakers of English. Approximately 80% of subjects who completed the syntax questions also completed this demographic questionnaire. The data reported here come from those subjects.

3.3. The duration of learning

Little is known about how long it takes learners to reach asymptotic performance. On the one hand, developmentalists have observed that by 3-5 years of age, most children show above-chance sensitivity to many syntactic. Indeed, our youngest native speakers (~7 years old) were already scoring very well on our.

While certainly an important fact about acquisition, this is the wrong standard for research into critical periods. The question has never been "why do non-native speakers not match the competency level of preschooler?" Many of them do. In fact, in our dataset, even non-native immersion learners who began learning in their late 20 s eventually surpassed the youngest native speakers in our dataset.

Instead, the puzzle driving this entire research domain is why later learners do not reach the same proficiency level of mature native speakers. That is a much higher standard. Many other aspects of syntax continue to develop in the school-age years, and prior studies have not been able to determine the age at which syntactic development concludes. Even for those aspects of syntax that preschoolers are sensitive to, they are rarely at ceiling, and they typically do worse than college-age adults, whether assessed through comprehension, elicited production, or spontaneous. However, while we know that performance continues to improve into the school ages, the literature has little to say about when children attain adult levels of accuracy. Moreover, the common practice of comparing children to college- aged adults necessarily renders undetectable any post-college development.

Even less is known about how long non-native speakers continue to improve on the target language. While a few studies found limited continued improvement for immersion learners after the first five years, these studies had minimal power to detect continued improvement. Specifically, looking at samples of non-native learners who were selected to have at least three years [3] or five years [1] of experience, these authors found that while age of first exposure predicted performance, length of experience did not. In contrast, analysis of US Census data suggests that learning continues for decades [4,5], though the validity of this self-report data is uncertain. Analysis of foreign language education suggests learning in that context may continue for a couple of decades, though this may merely reflect the slower pace of non-immersion learning.

This empirical uncertainty is reflected directly in the ultimate attainment literature. Ultimate attainment analyses require restricting analysis to those subjects who have been learning the target language long enough to have reached asymptote

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While this prolonged learning trajectory was not anticipated in the language learning literature, it joins mounting evidence that many cognitive abilities continue to develop through adolescence and even adulthood, including working memory, face recognition, magnitude estimation, and various measures of crystalized intelligence.

Thus, even native speakers-who are able to make full use of the critical period-take a very long time to reach mature, native-like proficiency. By implication, someone who started relatively late in the critical period-that is, someone who had limited time to learn at the high rate the critical period provides-would simply run out of time

Implications

The analyses above suggest that our findings are reasonably robust, particularly in comparison to those of previous studies. While this inspires confidence, it should also suggest caution: future work that successfully addresses the limitations of the present study may similarly prompt significant revisions in what we believe to be true. Science is the process of becoming less wrong, and while hopefully the revisions are smaller and smaller after each step, there is no way of knowing that this is the case in advance. Thus, confirmation and extension of the present results is crucial, particularly given the novelty of our questions, methods, models, and results.

Nonetheless, we believe it is useful to consider the implications of the present findings, on the presumption that they prove to be (reasonably) robust:

The nature of the critical period for second language acquisition—On the assumption that the present results apply broadly to syntax acquisition by diverse learners, they have profound theoretical implications. Most importantly, they clarify the shape of the well-attested critical period for second-language acquisition: a plateau followed by a continuous decline. The end of the plateau period must be due to changes in late adolescence rather than childhood, whether they are biological, social, or environmental. Thus the critical period cannot be attributed to neuronal death or syntactic pruning in the first few years of life, nor to hormonal changes surrounding adrenarche or puberty. Also casting doubt on the effect of hormones is our finding that girls do not show a decline in learning ability before boys do, despite their earlier age of. Likewise, the critical period cannot be explained by documented developmental changes in working memory, episodic memory, reasoning ability, processing speed, or social cognition, to the diminished likelihood that adolescent and adult immigrants will be immersed in an environment of native speakers and identify with the new culture,[5] or to gradually accumulating interference from a first. In short, these data are inconsistent with any hypothesis that places the decline in childhood - which is to say, every prior ***specific*** hypothesis that we know of. What, then, ***could*** explain the critical period? There are a number of possibilities. For instance, it remains possible that the critical period is an epiphenomenon of culture: the age we identified (17-18 years old) coincides with a number of social changes, any of which could diminish one's ability, opportunity, or willingness to learn a new language. In many cultures, this age marks the transition to the workforce or to professional education, which may diminish opportunities to learn. Note that causality (if any) could run the other direction: cultures may have chosen this age for certain transitions because of age-dependent changes in neural plasticity. Further traction on these issues

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could come from cross-cultural comparison, or comparison of individuals within a culture who are on different educational tracks.

Alternatively, the critical period could reflect interference from the first language, so long as this interference is non-linear rather than gradually accumulating. While it has generally been assumed that interference from the first language would be proportional to the amount of first language learned- something inconsistent with our data-we cannot rule out the possibility of non-linear interference. Neural network models, which are capable of showing interference from a first language. It remains to be seen whether they can successfully model the nonlinearities we actually observed.

Finally, the end of the critical period might reflect late-emerging neural maturation processes that compromise the circuitry responsible for successful language acquisition (whether specific to language or not). While language acquisition researchers often focus on neural development in the childhood years, the brain undergoes significant changes through adolescence and early adulthood. While continued develoment of the prefrontal cortex is perhaps the most familiar, changes occur throughout the brain and along multiple dimensions. Drawing on these and other findings, some researchers have suggested that adolescence may involve a number of different biologically-driven critical.

Little is certain about the relationship between neural maturation and behavioral maturation, other than the likelihood it is complex. Current evidence suggests that critical periods in perception involve a complex interplay of neurochemical and epigenetic promoters and brakes for both synaptic pruning and outgrowth. Given this complexity, and the relative sparseness of the data on neural maturation, it is hard to say whether any of the identified neural maturation processes might correspond to the changes in syntax acquisition that we observed.

It is notable that language learning ability is, out of every cognitive ability whose developmental trajectory has been characterized behaviorally, the only one that is stable through childhood and declines sharply in late adolescence. This observation is consistent with the possibility of language-specific maturation. However, the developmental trajectories of some cognitive abilities, such as procedural memory, have not been well characterized. Moreover, cognitive testing has largely focused on simple abilities that can be measured in a single, short session (e.g., working memory). In contrast, syntax acquisition takes place over much longer intervals and involves learning a complex, interlocking system. Thus, progress on this question will require characterization of a broader range of cognitive abilities, as well as acquisition of other complex systems (e.g., music or chess).

In attempting to gain traction on these issues, there are additional complexities, which future studies should seek to clarify. The duration of the critical period may differ for other aspects of language, like phonology and vocabulary. Moreover, we cannot be certain that syntax learning ability is a unitary construct rather than the combination of multiple factors potentially operating on distinct timelines and affecting different aspects of syntax differently. Second, the exact timing of the critical period may be obfuscated by older learners deploying conscious learning strategies, absorbing explicit instruction, or transferring knowledge from the first language. Some purchase on these issues may come from additional studies, potentially using different methods (e.g., online processing, production, ERP, or longitudinal studies), should obtaining sufficiently many subjects become feasible. Finally, because our dataset consists of people's performance in a second language, it does not directly address the question of how age affects the learning of a first language. It is possible that exposure to linguistic input delays the atrophy of language learning circuitry, in which case the decline in learning ability we have documented would represent the prolongation of a critical period that terminates sooner in people who have been deprived of all language input. Because delayed first-language acquisition is fortunately rare, it would be impossible to achieve a sample size similar to the one here, but our results could be used to guide smaller, targeted studies.

Crucially, the investigation of these issues-all of which have long been of interest but difficult to address-can now be guided by the finding that the ability to learn the grammar of a new language, though indeed compromised in adults compared to children, is largely or entirely preserved up to the cusp of adulthood.

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