A Talent for Language

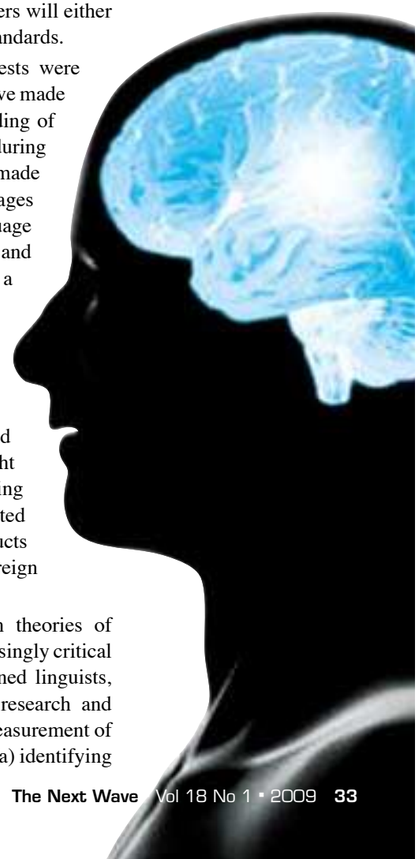
What makes a sports champion? Is Tiger Woods—the only golfer to hold all four professional major championships at the same time—the sport's greatest because he was born to golf, because he trained hard every day for years, or because he had the help of an expert coach? Most people would claim that athletes need all three of these factors for success: *talent, hard work,* and *good coaching*. Is the same true for successful linguists? What makes a linguistic champion? Are hard work and good coaching sufficient, or is a special talent for language necessary? Researchers at the University of Maryland Center for Advanced Study of Language (CASL) are trying to answer these questions through a set of related studies on *foreign language aptitude*.

Aptitude refers to a person's inherent capability or underlying talent. If a classroom has ten students, all with the motivation to work hard and the same opportunities to benefit from good teaching or coaching, students' results will still vary based upon aptitude. John B. Carroll, a distinguished psychologist and co-developer of the Modern Language Aptitude Test (MLAT), defined foreign language aptitude as an "…individual's initial state of readiness and capacity for learning a foreign language, and probable degree of facility in doing so" [1]. To study aptitude scientifically, researchers must determine how to rigorously define concepts such as *state of readiness* and *capacity for learning* and how to measure these abilities reliably.

Attempts to define foreign language aptitude and determine its subcomponents had begun by the 1920s in the United States [1]. During subsequent decades, several tests were developed, with the support of the military, for purposes of personnel selection and placement into foreign language training. These include the Army Language Aptitude Test (ALAT), the Defense Language Aptitude Battery (DLAB), the Modern Language Aptitude Test (MLAT), and the VORD [2]. (VORD requires test takers to apply rules to artificial language segments presented in context. *VORD* is the word for word in the artificial language, which is based on Turkish, a language typologically different from Western European languages.) Currently, the DLAB and the MLAT are the most widely used tests for US government (USG) purposes. Although these tests are useful for establishing cutoff scores for basic language study and for supporting hiring decisions, they may not predict with enough accuracy which learners will succeed and which learners will either drop out or fail to meet proficiency standards.

During the years since these tests were developed, cognitive psychologists have made substantial progress in the understanding of human memory and learning. Also, during this period, significant advances were made in understanding how foreign languages are learned. The field of Second Language Acquisition (SLA) was established, and SLA research findings prompted a paradigm shift in language teaching methodology. Contemporary approaches emphasize developing communication rather than the study of language as object and, thus, incorporate interactive and experiential learning tasks. In light of these scientific advances, existing aptitude tests have become outdated in terms of their underlying constructs and their congruence with how foreign languages are learned.

Based upon these advances in theories of language learning, and upon the increasingly critical need for a large number of well-trained linguists, the USG has asked CASL to lead research and development efforts to improve the measurement of foreign language aptitude in terms of (a) identifying



A New Aptitude-Screening Test

The Pre-DLAB is a short screening test that predicts who is likely to attain the DLIFLC entry cut-off score on the DLAB. The Pre-DLAB can be administered in less than 30 minutes, in any setting, to thousands of people (e.g., each year over 500,000 people take enlistment tests at Military Entrance Processing Stations). Since the DLAB takes 90 minutes, it will be more efficient if only those who pass the Pre-DLAB screening test move on to take the DLAB during the recruitment process.

Using the test specifications that were developed during previous research, new items were written at Second Language Testing, Inc. for certain sections of DLAB, taking care to match the new items to the aptitude constructs underlying the original test. CASL then conducted a study with 500 university volunteers who took both the DLAB and the prototype Pre-DLAB. Findings showed that the initial form of the Pre-DLAB accurately predicts a cut score of 95 on the DLAB. Moreover, the Pre-DLAB test does not require audio equipment, thus it is adaptable to administration in a wide range of settings. This pre-testing greatly increases the military's or USG's ability to identify talented language learners.

potential for language expertise, (b) mitigating attrition from language training, and (c) casting the net more widely to increase the number of individuals tested for language aptitude. In response, CASL has undertaken research on language aptitude:

- To predict the ability to reach high-level proficiency in a foreign language through the creation of the High-Level-Language Aptitude Battery (Hi-LAB), an innovative test that measures the ceiling on potential and predicts the maximum level of language-learning success
- To update aptitude testing in and mitigate attrition from basic language programs at the Defense Language Institute Foreign Language Center (DLIFLC) by updating DLAB to DLAB 2, comprising measures of aptitude, personality, and motivation
- To manage the tremendous increase in the amount of aptitude testing that must be done to identify candidates for foreign language training at DLIFLC by developing and validating Pre-DLAB, a short screening test that can be easily administered to thousands of military recruits

Hi-LAB – finding language experts

Existing aptitude tests were designed to predict early rate of learning and successful attainment of intermediate level language proficiency. Such tests can be very useful when managers must decide who should be selected for basic language training. However, many learners perform well in early training, but never reach the higher levels of proficiency necessary for many jobs. The scientific explanation is known as the *critical period effect*. Time, money, and effort could be saved if testing were able to identify which beginning or intermediate level learners would be most likely to overcome the critical period effect and achieve high-level competence in a foreign language, given extensive training.

Hi-LAB, a new test currently under development at CASL, is designed to identify individuals with the capacity to reach advanced levels of foreign language proficiency. High-level language aptitude is defined as a measurable *ceiling* on language-learning ability, holding equal all other factors such as motivation, stable personality characteristics, and opportunities for instruction or immersion. Hi-LAB constructs (Table 1) were motivated by theories of learning and memory

Constructs		Brief Definitions
MEMORY		the capacity to process and store input with active trade-offs among these components:
Working Memory	Short-term Memory Capacity	the small amount of information that can be kept in an accessible state in order to be used in ongoing mental tasks
	Executive Capacity & Control	a set of processes that, collectively, regulate and direct attention and control voluntary processing
Long-term Memory	Rote Memory	explicit, intentional long-term memory storage that results from rehearsal
ACUITY	Perceptual Acuity	an individual's capacity to detect difficult-to-perceive auditory or visual information
SPEED	Processing Speed	speed of an individual's perceptual, motor, or decision responses
PRIMABILITY	Priming	the extent to which prior experience facilitates subsequent processing
INDUCTION		the process of reasoning from the specific to the general, i.e., noticing similarities among several instances and drawing a generalization based on these similarities
	Implicit Induction	acquiring the statistical patterns contained within complex input without the learner's conscious awareness
	Explicit Induction	acquiring the patterns in input through conscious awareness and reasoning
PRAGMATIC SENSITIVITY	In Research & Development	the ability to hypothesize connections between context and use: registering and tracking salient context cues; detecting miscommunication
FLUENCY	In Research & Development	the ability automatically to plan and articulate speech

Table 1: Hi-LAB Components

Age and Foreign Language Learning

Studies reveal a tight correlation between age of first exposure to a foreign language and overall success to Level 4 in that language throughout the neurological critical period [3]. At around puberty, the age-success correlation falls off sharply, as shown schematically in Figure 1. Nonetheless, some individuals do appear to attain near-native expertise [4]. What characterizes the individuals who become experts in a foreign language as adults and, more importantly, can they be identified at the outset of learning?

derived from research in cognitive psychology and by theories of second language acquisition. Multiple measures of each construct, developed or adapted by CASL, are undergoing usability, reliability, and validity testing with government, military, and university populations. During this iterative testing process, factor analytic procedures are used to identify the most useful measures for inclusion in the operational version of the test [5].

An important innovation in Hi-LAB is that abilities are measured behaviorally, by computerized testing. This direct-measurement methodology provides several advantages over more traditional testing formats, such as paper and pencil tests. Computer-delivery ensures that both accuracy and reaction time (in milliseconds) are available for each cognitive or perceptual task included in the battery. Reaction time is a good indicator of automaticity, a hallmark of foreign language expertise.

Each of the Hi-LAB constructs is hypothesized to be important for moving from intermediate to professional or high levels of foreign language proficiency. Thus, the test is designed to measure "what is left to learn" at this relatively advanced stage of language learning. Some constructs, such as perceptual acuity, are clearly important for the beginning stages of learning as well. For example, beginning learners must learn to hear and produce the sounds of a new language (*perceptual acuity*). Other Hi-LAB constructs may reflect aspects of aptitude that are not predictive of early language success, but that are critical for moving beyond intermediate stages. One example of this type of construct is *pragmatic sensitivity*, which reflects a learner's ability to learn and use the aspects of language that depend on context. For example, a person high in pragmatic sensitivity would be more likely to accurately learn the correct forms of address for persons of differing social ranks or to notice nonverbal signals indicating that the listener has misunderstood something.

Another construct of this type is *implicit induction*, which refers to an individual's ability to

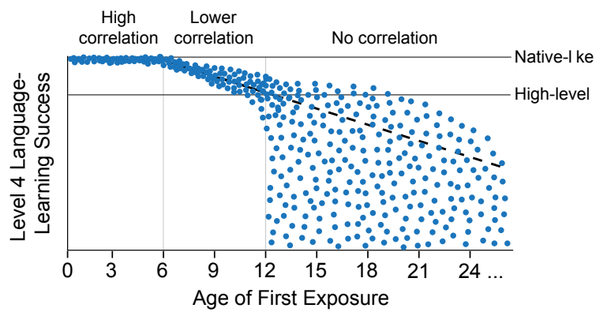
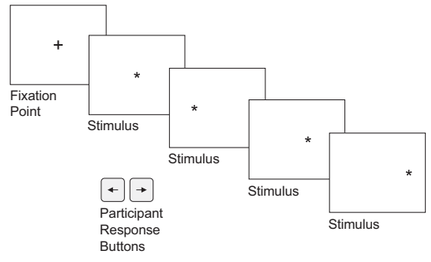


Figure 1: Schematic correlation scatter plot for age/level 4 language learning success



The Serial Reaction Time task asks examinees to respond to the location of an asterisk on the computer screen. The asterisk can appear in one of a number of locations, each with a corresponding response button. Unknown to the examinee, the locations follow a designated 10-trial pattern, in which one location was never followed by the same location more than once. This means that to know the location of the next asterisk, one would need to know the entire 10-trial string and current serial position in the string. After a number of string repetitions, the order is switched to a randomized order which does not follow the pattern before returning to the repeating strings. Scoring of the Serial Reaction Time task depends on the average reaction times during the sequence repetition condition versus the average reaction times during the random condition. The longer reaction times after switching to a random sequence are an indication of the facilitation the examinee experiences when they have implicitly learned, or induced, the sequence of the repeating trials.

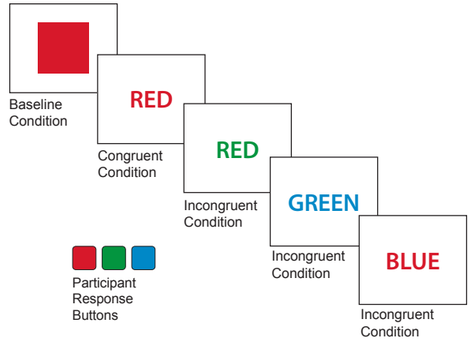
Figure 2: The Serial Reaction Time task measure of implicit induction

learn the statistical regularities in a set of complex data, without conscious awareness or explicit reasoning. Research has shown, for example, that human infants can use this sort of statistical learning to learn where word boundaries are in a string of incoming syllables produced by adults [6]. By deriving these word boundaries from statistical regularities in the language they hear, babies are able to "bootstrap" the process of learning their first language. Psychological researchers have not yet resolved to what extent adults are able to make use of this type of statistical learning. It is possible, however, that individuals who maintain this ability in adulthood will be better able to learn complex, probabilistic aspects of a foreign language grammatical system that are necessary for "native-like" performance. The serial reaction time task, shown in Figure 2, measures implicit induction.

Advances in memory

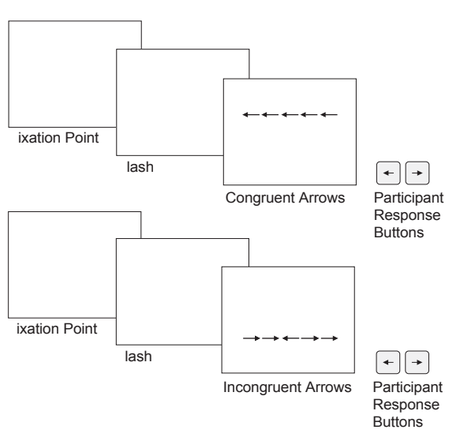
Hi-LAB is the first foreign language aptitude test to incorporate important advances in the understanding of the human memory system. Memory comprises several sub-systems. Previous aptitude tests primarily measured long-term memory, or the ability to store information in a permanent form and recall it after a delay. Like these previous tests, Hi-LAB contains measures of long-term memory, but unlike these older tests, Hi-LAB also includes measures of working memory (WM) with its component systems, *short-term memory* and *executive capacity and control*. The *short-term memory* (STM) system allows a person to hold information in an accessible state for a few seconds, such as when rehearsing a phone number. Hi-LAB specifically taps one STM sub-component, namely verbal-acoustic STM, which aids in the rehearsal or maintenance of unfamiliar words, such as vocabulary in a foreign language [7].

The *executive capacity and control* system controls the focus of attention and includes three separable sub-constructs [8, 9]—*updating, inhibition*, and *task-switching*. *Updating* refers to



The Standard Stroop Task he original Stroop task is a measure of an individual s ability to inhibit the highly automatic skill of reading. xaminees view a series of color words (red, green, or blue) and color swatches (also red, green, or blue). he task is to name the "ink" color in which the color word or the color swatch is printed. or some of the color words, the color in which the word is displayed matches the word (example "R " printed in red ink). his is referred to as the "congruent condition." or other color words, the ink color does not match the word (example "R " printed in blue ink). his is referred to as the incongruent condition. hen the colors are presented as swatches, this is the "baseline condition." he degree of slowing produced by incongruent stimuli, rather than baseline or congruent stimuli, is measured and can be reported either absolutely (number of milliseconds slower for incongruent stimuli) or relatively (proportion of average response time slower for incongruent stimuli). Individuals who are faster to respond to incongruent stimuli are more effective at inhibiting automatic processes that would otherwise interfere.

Figure 3: The Stroop task measure of inhibition [13, 14]



The Attention Network Test (AN) is a measure that combines cued reaction time and the lanker ask. he AN requires participants to determine whether a centrally presented arrow points to the left or to the right. he arrow appears above or below a fixation point, following a brief flash of asterisks that may or may not appear where the arrow is displayed. he central arrow may be accompanied by flanker arrows to the right and left. hen flanker arrows are present, they appear under one of two conditions: *congruent,* where the flanker arrows point in the same direction as the target arrow, and *incongruent,* where the flanker arrows point in the opposite direction. fficiency of attentional networks is assessed by measuring how response times are influenced by alerting cues, spatial cues, and flankers.

Figure 4: The Flanker task measure of inhibition [15, 16, 17]

the process of refreshing the contents of working memory with new, more relevant information [10]. *Inhibition* is the ability to ignore a dominant or automatic response when necessary, a skill that may be particularly necessary for effective bilingual functioning, which involves inhibiting the strong first language in favor of the foreign language [11, 12]. See Figures 3 and 4 for test examples.

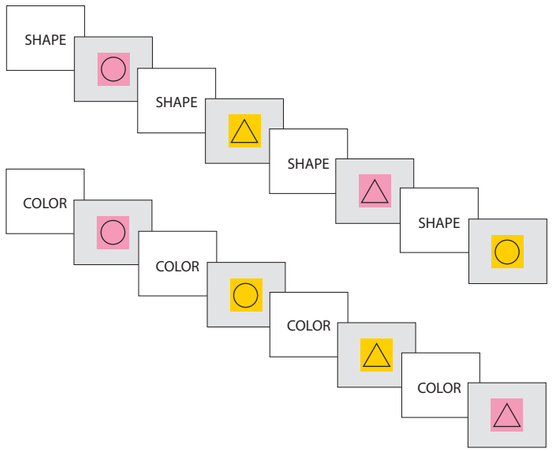
Finally, *task-switching*, the ability to shift between multiple tasks, operations, or mental sets [18], is hypothesized to reflect an aspect of cognitive control that is critical for efficient bilingual lexical selection and for advanced language tasks such as translation or switching between two languages [11, 19, 20]. The color-shape task shown in Figure 5 measures the mental cost of switching from deciding between shapes to distinguishing colors.

By incorporating measures of these sub-components of memory, along with the other constructs measured, Hi-LAB will provide the government with a more sensitive test of foreign language aptitude and one that is geared toward identifying language expertise. While Hi-LAB measures cognitive and perceptual measures of aptitude to predict high-level success, another CASL research and development effort, DLAB 2, incorporates additional, non-cognitive measures to make other predictions about foreign language learning.

DLAB 2—revised Defense Language Aptitude Battery

Learning a foreign language is neither easy nor fast. To succeed, a learner must stick with the program for an extended period of time, push on when progress seems to have stalled, overcome setbacks, and work on maintenance once a goal has been reached. Gaining expertise in a foreign language requires that even the most talented learners commit years to study and practice. As a result, predicting which learners will be successful may require consideration not only of cognitive and perceptual abilities, but also non-cognitive factors such as motivation, interests, beliefs about learning, and differences in personality. CASL is currently examining these issues for the Defense Language Institute Foreign Language Center (DLIFLC) as part of the DLAB 2 project.

The goal of this project is to predict success in learning a foreign language within the intensive, classroom-based, military environment at DLIFLC. Students who succeed in this setting may differ from those who would do well in a language immersion situation or in classes at a university. Success in the DLIFLC environment may depend on a number of attributes other than purely cognitive or perceptual aptitude. Recall the three prerequisites for success discussed initially—*talent, hard work,* and *good coaching*. While the Hi-LAB project focuses precisely on identifying the talent of individual learners, the DLAB 2 project aims to quantify potential for hard work. Thus, in addition to updating the existing cognitive and perceptual measures, this project incorporates a set of non-cognitive measures that may predict which learners will be most likely to persevere in an intensive program and achieve language learning success at DLIFLC. Although these are non-cognitive attributes, they may be included in a new version of the Defense Language



Task-switching ask-switching refers to the process of shifting between multiple tasks, operations, or mental sets. here are significant individual differences in task-switching ability. Some individuals are markedly better at doing two or three things at once than others, controlling for the extent of prior practice and background knowledge relevant to the task situation. In this test, individuals see stimuli consisting of triangles or squares in yellow or pink blocks followed by a prompt. epending on the prompt that is displayed, they must pay attention to shape and ignore color or the reverse, with no prior knowledge about when a switch in prompt will occur. Mean reaction times and accuracy are recorded for the single-task test blocks (shape and color) as well as for the mixed condition that contain switch and non-switch items in random order. Items that involve the same task as the previous item ("non-switch") can then be compared to those that immediately follow a task-switch ("switch"). In addition, non-switch items are compared to the baseline accuracy and reaction time information for each task when performed in the non-mixed condition.

Figure 5: Task-switching measure of attentional control [18]

Aptitude Battery, because they help to address such a test's main goal—to predict which learners are most likely to succeed.

Like the original DLAB, the goal of the DLAB 2 test is to predict which learners will be able to learn quickly and reach minimum levels of foreign language proficiency to meet DLIFLC graduation requirements, given a set amount of training time This time can vary from 25 weeks of full-time study for a language such as Spanish or French, up to 63 weeks of full-time study for a more difficult language such as Arabic or Mandarin Chinese. An important aspect for success in such an intense program is the learner's ability to remain motivated to work week after week and to overcome the inherent difficulties and stresses involved in long-term language study. Because of these difficulties, student attrition is a major problem, and measures that predict who is likely to "stick with" the program may provide important additional information to the government. CASL researchers have identified and piloted a set of possible new measures and tested them. Each of the measures belongs to one of five major categories:

- Cognitive Abilities—such as general intelligence, memory, attention, and auditory perception
- Learning Orientation—such as preferred learning styles or activities and learning goals
- Personality—such as levels of conscientiousness, anxiety, and openness to experience
- Self Efficacy—such as beliefs in the ability to succeed and the ability to cope with setbacks
- Motivation—such as motivation to achieve, to learn, and to master difficult material

The new cognitive ability measures in DLAB 2 are a small subset of those measures in Hi-LAB and will update this aspect of the test. The addition of non-cognitive measures is expected to directly address course attrition. These measures recognize the fact that adults bring to language study an established set of preferences attitudes, learning strategies, and motivations. If those selected for language training at DLIFLC have what it takes to persevere, plus a talent for language learning, they can be expected to work hard and graduate with at least basic language proficiency [21,22].

The future of aptitude research

There are many additional questions that can be asked about foreign language aptitude and a variety of new techniques that can be employed for aptitude research One of the most promising areas for enhancing the measurement of aptitude is the use of techniques from *cognitive neuroscience*—a field of study that combines psychology with neuroscience through the use of modern technologies such as brain imaging. (See the article "Thinking Out of the Box" in this issue.) These techniques allow for visualizing individual differences in brain structure or measuring changes in brain state while a person completes test tasks. How might these techniques be used to enhance our understanding of foreign language aptitude? One example might be by using these technologies to provide a more sensitive measure of an individual's ability to discriminate foreign language sounds

We know from research on speech perception that infants are able to distinguish sound contrasts important for any of the world's languages [21]. However, by the time an infant is one year old, his brain has "tuned in" to those contrasts necessary for the native language and learned to average

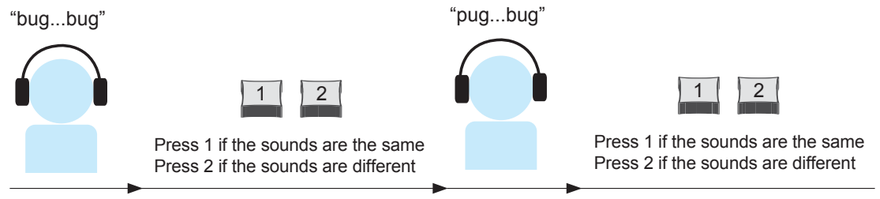


Figure 6: Phonemic discrimination task

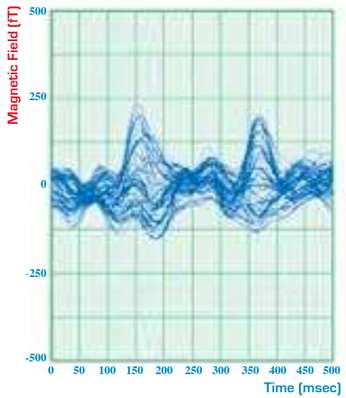


Figure 7: MEG measurement of stimuli

Changes in the magnetic field surrounding the skull measured from onset of a stimulus and continuing for 500 ms. Each line represents the signal (in femtoTesla) recorded from one detector. Signals from multiple detectors are recorded over various areas of the scalp. Peaks in the signal represent purported sub-processes taking place during the brain's recognition of the input stimulus.

over contrasts that are not important for the native language [22]. Thus, older children and adults are often no longer able to discriminate contrasts that are not used in their native language, but that might be very important for a foreign language. Both the Hi-LAB and DLAB 2 projects examine the ability to hear these non-native contrasts by asking test-takers whether two sounds that are difficult to discriminate are "the same" or "different," as shown in Figure 6.

The hypothesis is that some adults may retain the ability to distinguish these non-native contrasts even though most people have lost that ability. Such learners may truly have "an ear" for foreign languages. Perhaps an even more sensitive way to test this ability is by measuring changes in the brain's activity when a listener is presented with two difficult-to-discriminate sounds. This measurement can be accomplished using either electroencephalography (EEG), which measures changes in electrical conductance, or magnetoencephalography (MEG), which measures changes in the brain's magnetic field—both measured non-invasively by sensors at the scalp (Figure 7). Discrimination of sounds can then be measured using signals originating from the auditory cortex area of the brain, eliminating confounds with a learner's use of particular response strategies and guessing procedures, and providing a more sensitive measure of discrimination.

An additional future goal of aptitude research might be to match aptitude profiles, personalities, or learning preferences to particular types of instructional methods, thus allowing for the customization of language courses to particular learners. This sort of matching process is not yet widely used, but with increased understanding of the relationship between the variables currently under investigation, it may become an important way to increase efficiency of language training. Furthermore, technology may assist instructors to provide individualized learning plans and activities that assist learners with their weaknesses, build upon their strengths, and help maintain motivation and interest during long-term study by accommodating learners' personalities and preferred learning activities. This type of instructional design would allow the findings from aptitude research to inform the third of our three keys for success—*good coaching*.

Finally, future research might address the issue of *differential aptitude*, allowing for a better matching of student to foreign language. *Differential aptitude* refers to the hypothesis that learners' patterns of strengths and weaknesses, identified through aptitude testing, might make some students more likely to succeed with special challenges of particular languages. For example, some languages require mastery of a new writing system, and these systems may vary in their complexity. Other languages may have a particularly complex grammatical system with the need to learn and correctly use a large number of case endings or verb conjugations, or may require the learner to acquire a particularly difficult sound system, such as a series of tonal contrasts. Imagine the situation shown in Figure 8, where a learner has relatively high general foreign language aptitude and must now be assigned to study either Arabic or Mandarin Chinese. Both are very difficult languages for English speakers to learn, but they present very different challenges. Learner 1, with a high perceptual acuity, might be better suited to learn Mandarin Chinese, whereas Learner 2, with an even aptitude profile, could be assigned to learn Arabic.

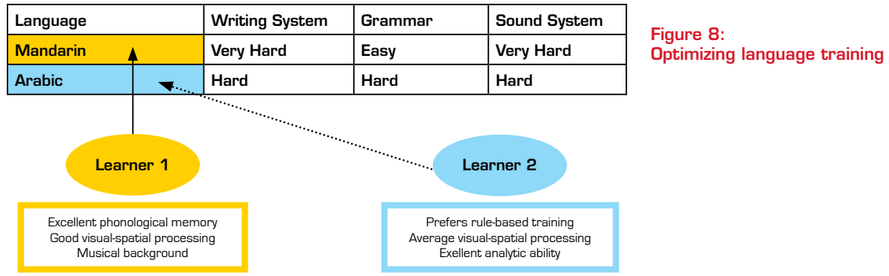


Figure 8:
Optimizing language training

Conclusion

Expertise in critical languages is in high demand. Despite the intense pressure, the demand is difficult to meet. By investigating the components of language talent and ways to uncover them through precise and sensitive measurement, CASL researchers are contributing to meeting the need. Eventually, through optimizing foreign language training in terms of rapid screening, precise selection of individuals likely to succeed, and placement into language programs suited to personal talents, it can be expected that our national language readiness will be greatly increased.

Notes

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