Dr Klaus Bung, Institute for Dynamic Language Learning, 68 Brantfell Road, Blackburn BB1 8DL, England
t: 01254-261 009 m: 07729-90 60 30 e: info@rtc-idyll.com w: rtc-idyll.com

Klaus Bung, PhD (Cantab)

Principles of an algorithm which facilitates the learning of Sanskrit vocabulary and grammar, and ensures 90% retention

Table of contents

Abstract

As a rule, teachers and learners grossly underestimate the number of revisions which are necessary for successful learning, and they know absolutely nothing about the correct timing of revisions. They then blame the resulting failures on the non-fact that languages are difficult or that the learners lack talent or dedication. Neither claim is true. No language is difficult if handled with the right methods. Every student who seriously wants to learn a language can do so successfully, provided he is given the right tools and uses them as instructed. Talent does not come into it. Diligence and self-discipline does.

This paper describes explicit procedures (learning algorithms) which can be taught to learners and help them to efficiently absorb vocabulary, grammatical examples, rules of sandhi, foreign scripts and factual information. Learning algorithms shift the emphasis of work from teaching to learning, from the teacher to the student, who is responsible for his own progress and is given the learning algorithms as his most important tool. No physical tools other than pen and paper are required. The algorithms discussed control initial learning, leading to a retention span of 5 to 15 minutes.

They then dynamically stretch this span over a period of 9 months or longer, increasing or decreasing the revision intervals for each item (e.g. vocabulary item) depending on the learner's performance. These algorithms are therefore called “dynamic” and “adaptive”. Learning algorithms are the engine at the core of the IDYLL METHOD ® . In opposition to the silly advice “Revise as often as possible” which teachers often give to their students as a recipe for success in language learning, the IDYLL METHOD ® proclaims “Revise as LITTLE as possible (but as often as necessary)”. Another maxim of IDYLL is: “You can minimise the time you invest in learning by revising before you forget rather than after you have forgotten, and by revising as late as possible but not so late that you fall into the abyss of forgetting” (since revisions done before forgetting take much less time than revisions done after forgetting). The target standard is always 100%, and the actual retention attained is always 90%. Working to these high standards actually minimises learning time. Certain constants in the procedures can be adjusted (external adaptation) to allow for difficult languages, or slow learners, or for people who are fast learners and fast forgetters. The paper gives examples from Sanskrit vocabulary, grammar (sandhi), and learning the Devanagari script. Most of the information about the IDYLL METHOD ® (including this paper) is available in print or on the web (www.rtc-idyll.com) and learners are invited to visit the site regularly and immediately benefit from the information which is available there free of charge.

My personal Sanskrit experiences

In Gita 6:37ff Arjuna questions Lord Krishna about the fate of people who have started practising yoga but not managed to achieve perfection, drop outs of yoga and the spiritual quest, comparable to drop-outs in language classes. Lord Krishna re-assures him. After death, the sincere but only partly successful student will spend some years enjoying the bliss he has earned. Then he will be reborn into a family of yogins or scholars who are endowed with wisdom. There he regains the mental impressions which had developed in his previous life and with this as his starting point he strives again for perfection. By his former practice he is carried on irresistably. (Gita 6: 43-44; transl. S Radhakrishnan)

If this applies not only to buddhi but also to Sanskrit language skills, then there is hope for me yet. I am the person who truly needs the consolations of Lord Krishna. After countless false starts, with and without classes, with and without teachers, having used every textbook under the sun, from Father Antoine (Societatis Jesu) to Thomas Egenes (disciple of the Maharishi). I have been in classes chorally reciting the declension and conjugation tables horizontally and vertically, without much effect. Classes have closed, with me being the sole survivor. I had to abandon my studies repeatedly because of pressing business commitments and the need to learn ever new modern languages because of the requirements of the next business project. This is the reason why all that has remained of Sanskrit in my memory is the "Tvam eva mātā", the Gayatri mantra and the immortal sentence "Rāmā vanam celati". Will that suffice to get me into paradise, or will, when my turn comes, the shahada be required?

Cartesian language learning

When I started learning Sanskrit, I did not know what I know now about efficient language learning, and when I knew, I no longer had the time to make learning Sanskrit a priority. You, however, fortunate enough to have Sanskrit in the centre of your work, and your students, will be able to benefit from what I have discovered.

The algorithms about which I want to talk today are part of the Cartesian approach to language learning, which is characterised by the following features:

1. The main effort is shifted from teacher to student; it is a learning method, not a teaching method. The responsibility for successful learning is with the student and only to a limited extent with the teacher. The teacher becomes an informant, not the driving force of the process. Like Ekalavya, the student becomes a kind of suction pump trying to get out of the teacher and out of books as much information as he can. This information (= skill) then has to be absorbed and retained by the student, and our algorithms control in every detail how this is done.
2. The subject matter (in our case vocabulary, grammatical forms and sentence fragments) is broken down into small fragments, called items. This is typical for the Cartesian method.
3. The items are arranged into increasing order of difficulty (Cartesian method).
4. The various part-skills which constitute mastery are carefully and rationally balanced (an engineering job) so as to achieve the intended goal and guarantee success. Nothing is left to chance. Problems which arise are resolved by detailed analysis.
5. Some of the techniques used are algorithms and core parts of the method. Others are in the nature of preferences and recommendations.

Teaching algorithms and learning algorithms

An algorithm is a mathematical or computational procedure which is explicit and effective and which, given the same input (starting conditions), always produces the same result, in our case 90% retention of all items which have gone through the procedure (algorithm).

The concept of algorithm (subject matter algorithm) has been introduced into education mainly by the Russian psychologist L N Landa, and the German cybernetician Helmar Frank (computer controlled teaching algorithms). Klaus Bung (1972) introduced subvariables into Frank's model of the didactic variables, and developed the concept and distinction of subject matter algorithm (eg grammatical rules), teaching algorithms (specifying the actions of a teacher or a teaching machine/computer) and learning algorithms (specifying the actions of the learner, trying to master the subject matter algorithms).

To keep this exposition simple, we restrict our subject matter to vocabulary. We will later show that our learning algorithms can be used with equal effectiveness for other types of subject matter.

The IDYLL METHOD®

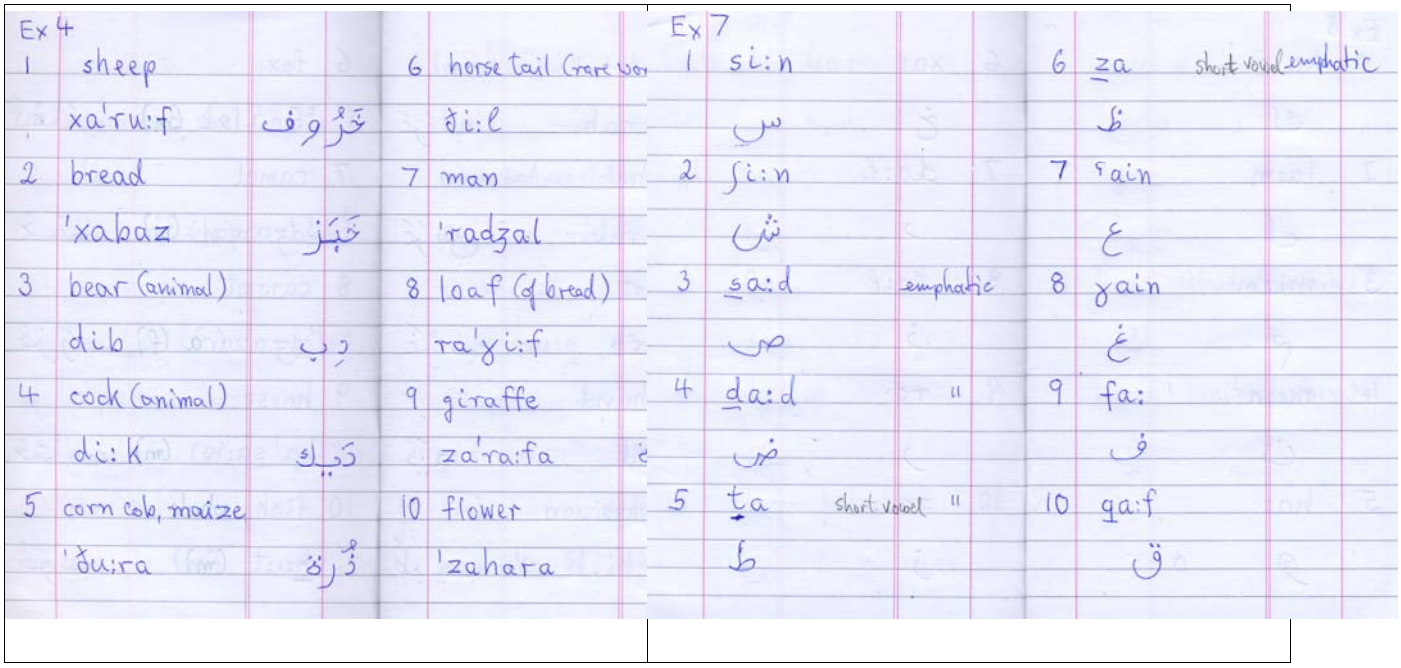
The learning algorithms whose principles I have to describe in this paper form the core of a comprehensive system of language learning known as the IDYLL METHOD® . This system prescribes a standard layout for any subject matter to which learning algorithms are to be applied.

Whatever I say here is meant in the strict sense of my words, it is not approximate, it is not in the nature of a recommendation.

The words are divided into exercises of 10 items. The student does not proceed from one exercise to the next unless he has mastered it. Mastery is defined as: the student has given 10 correct answers (responses) in succession, i.e. 100% success.

Before we proceed, let us look at one exercise. The student has to learn 10 Sanskrit words by translation them from source language (e.g. English) into target language (here: Sanskrit). There is a typed Sanskrit exercise in the Appendix. I had no handwritten Sanskrit example available, and I

am therefore giving one from Arabic. In the first example, the student translates English words into Arabic and learns writing them in IPA and in Arabic script. In the second example, he is given the Arabic letter names in IPA and converts them into Arabic script. Usually the student will have handwritten exercises in front of him which he has written out himself, a preliminary stage of learning.



The student never spends time just looking at text (or mumbling words, or mentally "concentrating on them") in order to learn them but is always active trying to answer one question after another always in writing, an observable activity, which can be subdivided, when required, into the skill of writing each letter. In our example, the student translates words from English into Sanskrit). He is "doing one item after another." He covers the model answer with a slip of folded paper, writes his own response on this paper, and pulls it down to reveal the correct answer. He determines whether his answer was right or wrong.

On the basis of this evaluation PAPA (the Pen And Paper Algorithm) knows approximately the retention time the student has achieved. IDYLL tests not only correctness but also retention time. A correct response after 20 seconds is treated differently from a correct response after 15 minutes, 2 days, or after 4 months.

Why is PAPA a "dynamic" learning algorithm?

PAPA determines in which sequence the items have to be tackled (i.e. how much time in seconds, minutes, days, or months, has to elapse between each revision of the same item.) Times are approximate but determined by precise rules.

If the student gives a correct answer after x time, PAPA increases the interval before the next revision. If the student gives a wrong answer after x time, PAPA decreases the interval, and continues doing so until the student begins to give correct answers. Such algorithms are called adaptive because they respond to the student's behaviour. The system is called "dynamic" because

the intervals are continuously changing, up or down, like a thermostat.

The intervals are controlled at the macro-level with the help of a revision diary which determines the intervals between learning sessions in terms of days, weeks and months, increasing or decreasing them as required.

The intervals are controlled at the micro-level within one learning session (duration of 30 to 60 minutes), in terms of seconds and minutes (varying from, say, 20 seconds to 3 minutes, the time it takes to do one run through an exercise). This is done through a decision mechanism (learnt by the student as part of his training in using the IDYLL METHOD ®) which determines, on the basis of the learner's correct or incorrect responses, which item is to be tackled next, i.e. in which sequence the items are to be tackled. These sequencing decisions automatically determine the timing (revision intervals).

The initial objective of PAPA is to achieve a retention of, say, 20 seconds for one item, which is like putting a car into first gear. In other words, PAPA attempts to get a correct response 20 seconds after the learner has last seen and copied the correct answer. PAPA then tries to stretch this retention time to, say 3 minutes, 15 minutes, 1 hour, 24 hours, etc, to 4 months. This is like putting a car gradually from first gear into fifth gear.

Variants of PAPA

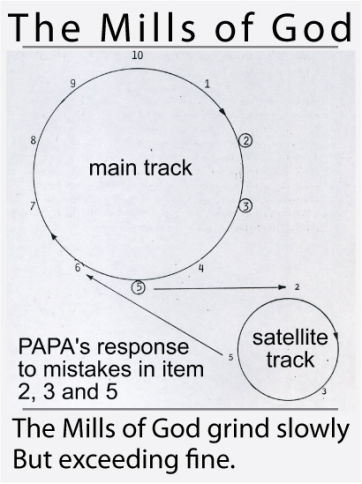
There are two variants of this algorithm. VOCPROC is easy to learn but less efficient. PAPA is more difficult to learn but extremely efficient. It always pays to let students learn PAPA. But it is good policy to teach them VOCPROC as an introduction to the IDYLL METHOD ® (the micro level), then teach them REV, the revision algorithm, which stretches the retention time from 24 hours to 4 months, and the Extraordinary Rendition Procedure (ERP), which deals with items which are trying to slip through the net, i.e. which one particular learner finds extraordinarily difficult. There are precise rules for dealing with such items (e.g. words or grammatical forms). Recalcitrant items are so ground down by the Extraordinary Rendition Procedure, that eventually these difficult items are the easiest, the tamest, and eat out of the learner's hand. It is impossible for a difficult word, or form or rule to resist extraordinary rendition. "On this path no effort is ever lost and no obstacle prevails". (Gita 2:40) This promise applies to our language learner too and it gives him confidence.

VOCPROC vs. PAPA

VOCPROC is simple: The learner tackles one item after another, from 1 to 10, and again from 1 to 10, until he has made 10 correct responses in succession. You can imagine the items as numbers 1 to 10 on a circular track. The learner keeps going round and round practising until he has mastered the exercise.

VOCPROC is an algorithm, but not a dynamic one; it does not adapt to the learner's performance. It uses only the "main track" (which accommodates 10 items). Once the student has mastered an exercise through VOCPROC, this exercise is passed to REV, the retention algorithm, which is adaptive, and is easy to learn.

PAPA is dynamic and controls the learner's behaviour at the micro-



level, i.e. within one learning session. The goal is the same as that of VOCPROC, namely to obtain 10 correct responses in succession from the student, i.e. to get the student to exhibit a retention time from between 1 and 3 minutes. But PAPA achieves this in a more sophisticated way (and more quickly) than VOCPROC.

In this paper I will describe only the principles of PAPA and not the technicalities. Learners have to understand, and be in sympathy with, the principles. Otherwise the technicalities will appear tedious, and the learners will not follow the very precise instructions of the algorithm.

Any deviation, however small, from the literal application of the algorithm will destroy its effectiveness, which has been tested over and over again, and cannot be improved at the whim of a teacher or a learner who have only a partial understanding of the system as a whole. Deviations which appear trivial to the learner can be fatal for the algorithm, which depends on all its components being exactly where they are expected. Analogy: two trapeze artistes. Each of them depends on the other being exactly where he is expected. If one partner varies his position even slightly, the other one can fall to his death, no matter how good an artiste he may be himself.

PAPA is very much an exemplification of the Cartesian principle that problems have to be divided into manageable chunks. The IDYLL METHOD ® says in addition that no task is so easy that it cannot be made even easier (by further division) if a learner requires it (i.e. "no obstacle prevails").

Principles of PAPA: Divide et impera

So the task in front of the learner is not to learn Sanskrit (or Chinese, or Arabic or Tagalog) but to learn ten words. That is manageable.

On the main track, PAPA looks for three words which the learner does not know (i.e. gives wrong responses to). These three words are then placed (by the system) on the satellite track.

Physically they stay in the IDYLL Workbook (see image above). The task at hand has now been reduced from 10 items to 3 items, from the main track (testing track) to the satellite track (intensive track). Psychologically the student can relax. He may be phased by the task of learning 10 words, but not by the prospect of having to learn 3 words. (Removing stress is an essential part of the IDYLL METHOD ® and helps to make it so effective.)

Even better: The student's task is not to learn all three items. All he is expected to do is to give one correct response, to remember just one of these items, any item, for just 20 seconds. No student can say that this is too difficult, especially as he can go round the satellite track at leisure and as often as he likes.

If the three items on the satellite track are 2, 3 and 5, the student tries 2, 3, 5, 2, 3, 5 etc etc, until he has given one correct response, which proves a retention time of, say, 20 seconds or less for that item. There are now only 2 items on the satellite track (and a record of them is kept there). PAPA therefore sends the student back from the satellite track to the main track. The student continues working his way around the main track and tries to find another unknown item (item with an incorrect response). The student is happy when he makes a mistake because this is his entry ticket for the nice and leisurely satellite track. He knows that the satellite track is his short-cut to success. O felix culpa! As soon as the student has a total of three incorrect items (e.g. two still remaining on the satellite track from his last visit there, plus the one just found on the main track, testing track), he returns to the satellite track and tries to eliminate one of the three items, a stress-free but very

effective task.

This dynamic interaction between the main track and the satellite track is continued until the student has reached his objective for this learning session: 10 items correct in succession. This means that for each item in the exercise a retention span of, say, 3 minutes (i.e. the duration of doing the whole exercise once while giving only correct responses) has been demonstrated. You might call this "second gear" when driving a car.

PAPA (interaction of main track and satellite track) and the objective of mastery (10 items correct in succession) applies not only to initial learning but also to each revision.

In the IDYLL METHOD ® there is no difference between learning and testing. Every learning session has the form of a test: questions and answers which gradually move up from guessing to unshakeable knowledge. This reduces tension and ensures that the algorithm continuously monitors the learning activities of the student. It also ensures that the student does not spend a minute more on "learning" (whatever that might be) than is absolutely necessary. The moment he passes one of his continuous "tests", he can stop work or move on to the next exercise (= test).

The learner's first round on the main track is a sequence of guesses with a, say, 2% probability of success. This probability increases with each round of the guessing game until the learner has learnt to guess the answers of one exercise with a 90% probability of success. If the student is dead-sure about one item (e.g. fire = agni), then we say that he can guess the answer with a 99% probability of success. Whatever answers we give in life, even from profound “knowledge”, our answers are always guesses - with varying probabilities, and never quite 100%. The sun will probably rise again tomorrow morning, but even James Naughtie on 6 Dec 2010 (BBC Radio 4) was wrong about the name of Culture Secretary Jeremy Hunt (http://www.rtc-idyll.com/shell_dyll/contents/english_usage/2010_12_06_berkshire_hunt.html) Learning can therefore be seen as systematically increasing the probability of correct guesses.

There is also no difference between the rules which apply to initial learning or to revisions (after days, weeks or months): The same learning algorithm is used (PAPA), the target standard (mastery = 100% correct answers in succession) for the revision is the same. The student continues with the exercise until he has "mastered" it. The expectation is also the same: 90% retention on average. Each item that has failed (when the revision intervals have reached a specific point: R7) is copied into ERB (the Extraordinary Rendition Book), which causes 11 additional revisions distributed over nine months (but no howling and gnashing of teeth). Here again our motto "And no obstacle prevails" applies.

Because of Extraordinary Rendition, it cannot happen that the 1-item per exercise failure rate (forgetting) which the system permits gradually build up a large collection of unknown items.

Learning is obviously much more fun if the student experiences almost nothing but success, and feels in full control of the subject he is studying and can, like Arjuna, walk full of confidence into any exam at any time, without special revision just before the exam, and if, moreover, learning itself is so extraordinarily easy.

From the bird's eye perspective, what is happening is that the algorithms are looking for "easy meat", for soft targets, items which are easy to learn, and get them out of the way. Over a period of about nine months a residue of obstinate items (refusing to be remembered) is filtered out and

subjected to ever increasing pressure to submit (to be learnt). The more obstinate the item, the greater the pressure. There is no point in applying this pressure, these extraordinary techniques, to soft targets which do not require them. Since no item is ever allowed to escape for good (call it the Inspecteur Javert syndrome [Les Misérables]), this happens not only in the short-term, hours and days, but also in the long-term, after an interval of many months.

Provision for special learner types

It is one of the outstanding features of the Gita that it provides different paths to the ultimate goal for different kinds of seeker, and also provides for failures (drop-outs and the like). The IDYLL METHOD ® makes similar provisions, not all of which can be discussed here, but which can be found in the published literature or are taught in our seminars.

I will mention here only the provisions for altering the size of the main track and the satellite track. When my experiments with PAPA first started, ages ago at Arizona State University, the large track contained 30 items, i.e. proof of mastery was "30 items correct in succession", which meant that the retention span achieved during initial learning was very long but also very difficult to reach. Students often had to do 30 items again because of only 1 mistake. This had certain advantages but the current version of a 10-item main track with a 3-item satellite, has proved most effective over the years - for normal language pairs and for normal learners. So that is the standard, but we deviate from it when we have good reason.

The 10-item main track is accompanied be the 3-item satellite. The size of these tracks can be adjusted to suit certain learners or certain language gaps.

Adjustments for difficult languages

Language gaps: If L1 (source language) and L2 (target language) (e.g. English and Spanish) are closely related, there is a small language gap and L2 can be said to be easy, or "normal". The values 10 and 3 for the main track and the satellite track respectively have been tested for a normal language gap.

Sanskrit, Hindi, Urdu and other Indo-Arian languages are comparatively distant from English and therefore may be treated as "difficult" languages. When dealing with difficult languages, we change the values of the tracks: main track = 5 items, satellite track = 2 items. PAPA rules remain unchanged (except that these two constants are altered). The effect of reduced values are that there are more intermediate steps before full mastery on the 10-item track is achieved. The intervals between revisions become shorter, and initial retention becomes easier and therefore faster.

The standard exercise is divided into two halves, 1-5 and 6-10. The student continues working through 1 to 5 until he has achieved mastery. He slips into the satellite track as soon as he has found two unknown items (2 mistakes). Once 1 to 5 has been mastered, the learner tackles 6 to 10 in the same way. THEN he tackles 1 to 10 in the "normal mode" (track size of 10 and 3). This is like helping someone, e.g. an apprentice burglar, to mount a wall by putting many small steps in front of it, but eventually the apprentice, if he wants to be recognised as a master burglar, has to jump over the wall without these helping steps.

The situation will be different for a speaker of Hindi (native speaker, or someone who has already learnt Hindi well). For him Sanskrit will be "normal" and track size 10 and 3 will apply from the beginning.

Adjustments for slow learners

The same adjustment can be made to help people who, for whatever reason, find learning a so-called “easy/normal” language difficult. Let's call them "slow learners". If such a learner finds normal track size (10 and 3) frustrating, he can switch to track size 5 and 2.

For most English learners, Spanish will be normal (easy). Most Spanish learners will find Italian normal/easy. But if any such learner has difficulty with the normal track sizes, he can switch to the easy (smaller) track sizes. In brief: slow learners or "difficult" languages are treated in the same way.

Adjustments for fast learners and fast forgetters

On the other hand, there are certain learners who are fast learners and fast forgetters. I have had such people in my courses on the IDYLL METHOD ® . Some computer programmers were of that type. They were very fast in achieving mastery in initial learning. But an hour later they would have forgotten what they had learnt, whereas more normal learners would remember the predicted 90% or more after one hour.

The fast learners might be given an exercise with 10 unknown items, go round the main track once, and in the second pass get every item correct, whereas a normal learner might have to go 5 or 8 times round the main track before achieving mastery.

An hour later though, the normal learner will remember 90%, whereas the fast learner (e.g. computer programmer) will remember only 50%, which in the IDYLL METHOD ® is quite unacceptable. Such learners have to be forced to do more repetitions (especially of “known” items) on the main track before mastery can be declared.

The PAPA rules are so designed that the few obstinate items in an exercise force the student to practise also the known items, thus ensuring that they are better anchored in his memory. (This is sometimes called "overlearning", a rather misleading and woolly term. In the IDYLL METHOD ® there is no OVERlearning but only the correct amount of revision to achieve the objective.)

Before we release the fast learner (computer programmer) from the main track, he has to demonstrate twice the normal retention span for all items, i.e. when the duration of a main track is, say, 5 minutes, the normal learner who gives 10 correct responses in succession provides evidence of 5 minutes retention of each item.

To ensure that the fast learner (computer programmer) does well during the later revisions, we must force him to demonstrate a longer retention span than the normal learner. We achieve this by doubling the size of the main track. The size of the satellite track remains unchanged. So for the computer programmer the track sizes are: main track = 20, satellite track = 3.

The fast learner will combine two 10-item exercises to get one 20-item exercise, e.g. Exercise 10 and 11 will be combined. The procedure is then as follows:

- Mastery of Exercise 10 (This means that the main track size is, at this stage, normal: 10 and 3)
- Ditto Exercise 11
- Then Exercise 10 and 11 in succession (This increases the main track size to 20, with size 3 for the satellite track).

Mastery can be claimed only when the student can make 20 correct response in succession. If he makes one single mistake, however small, he has to go through the whole track again. This can happen repeatedly, just because of one mistake, and perhaps each time in a different item because of lack of concentration. etc. This ensures that the fast-learner cum fast-forgetter gets the number of revisions of all items that are required for long-term retention.

Algorithms eliminate desire, fear and anger

The objectivity of the learning algorithms helps to remove the three great enemies of successful language learning: desire (greed), fear and anger (Gita 4:10 - rāga, baya, krodhās).

Desire causes the learner to want to progress too fast (unrealistic expectations). He will then be frustrated and disappointed when he cannot learn and remember at that speed. Analogy: If a train journey in India takes 38 hours, that's what it takes. I will not fret but will take enough food and water and learn Hindi so that I can enjoy the company of the other passengers. I cannot change the railway timetable (corresponding to the laws of human memory): I must adjust my behaviour to it.

Desire also causes the teacher (often constrained by an unrealistic syllabus) to force a class through a course, thinking he has done his duty if he has "covered" (presented) the subject, even if the students have not learnt it. The algorithms represent an immutable railway time table. Like it or not, you can not learn faster than what the algorithms say. You can only pretend to be learning as many students do. The speed of light, for example, is an absolute. You can not beat it, therefore you should not desire to do so.

Fear causes the learners to expect failure, not to trust in their own learning skills, wasting energy on repeating "I cannot do it". These fears tend to be self-fulfilling. The algorithms set the student a simple goal, which he knows he can achieve, namely to answer correctly just one question on the satellite track. He need not worry: "What comes after that, and what after that". He needs to learn only one word, and can trust that the algorithm will tell him, unambiguously, what to do next. (Even when the student has missed out on some revisions, the algorithm prescribes the optimal remedy.). The student can focus on that one word. Concerning the other words he can say: "We will cross that bridge when we come to it, the algorithm will take me across that river, or even that ocean". He can trust the algorithm like a child can trust his parents. Working with the algorithms has something of the calming effect of meditation exercises (dharana / concentration). The student is concerned only with the here and now. His task is not even to write one word, his task is only to write the next letter. Fear will cause him to worry about the future, and whether he will perform well. The algorithm removes this fear by letting him do only one thing at a time.

Anger is a most dangerous emotion for adult language learners. Instead of following the simple instructions of the algorithm in case of a mistake (write down the number of the mistake, cross out the error, copy the correct answer, move on to the next item), many, if not most, untrained students respond to a mistake by passing judgement on themselves or on the system: "Your system does not work. You see I told you I can remember nothing, I am bad at language learning. This language is impossibly difficult." They are reflecting on their failures (wasting time and energy). I never

promised these students that they would not make mistakes. What I promised was that I would diagnose their weaknesses and eliminate them. IDYLL welcomes mistakes. It means that they can be eradicated. Mistakes are a symptom of ignorance. Even if the mistakes are not made (e.g. because a question is not posed), the ignorance is still there. If I make a mistake, I am happy since the mistake diagnoses a weakness. Mistakes are the rungs on the ladder to success. Once I can get a student to trust in the algorithm, his anger will disappear and he will gain at least 30% in his learning efficiency.

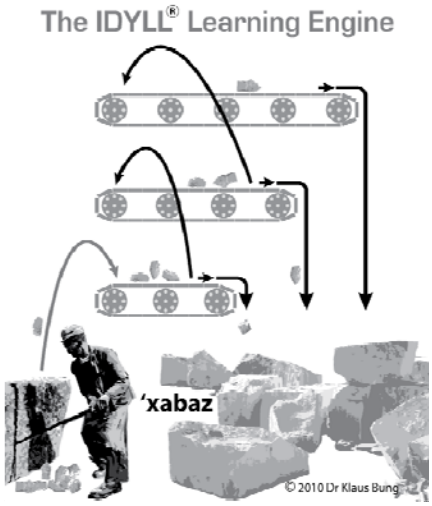
Silly advice often given to language learners

Books on study methods often refer to the concepts of long-term and short-term memory. These concepts are so coarse that they cannot help learners in the slightest. There is no such thing as a short-term or long-term memory. Any dividing line is arbitrary. And no useful learning advice can be based on such concepts. The IDYLL METHOD ® by contrast is based on a more realistic and useful memory model which assumes infinitely many memory layers, each of which associated with a different retention time. (Bung 1991a). The Memo-Sutras contained in Bung 1991a state succinctly the assumptions of that model, and all practical consequences (such as those explained in this paper, including the ideal revision times (and how to learn more by revising as little as possible) can be derived from it.

It is the task of the learner to heave each item first into a memory layer with a short retention span (e.g. 20 seconds) and then do each subsequent revision at a time when it maximises the increase of memory span (jump from one memory layer to another). This will make the time taken for each revision as short as possible and enable the student to revise as seldom as possible.

We do this by revising as late as possible (i.e. make fewer revisions) AND as early as necessary to avoid forgetting. For this purpose, the ideal time for revision is just before the projected time of forgetting (which is computed by the IDYLL algorithms at the level of 90% retention), i.e. we revise when we expect that the learner still remembers 90%. If we revise too late, the student will forget too much (make more than 10% mistakes), if we revise too early, the student will have wasted time and the jump to a deeper memory layer will be smaller (i.e. increase in retention span will be smaller). The revisions must take place when there is at least a CHANCE of making a mistake, but only a 10% chance. Even mistakes have a right to exist: we welcome them - in moderate numbers, in the right proportion. Like immigrants, they are the spice of life. The IDYLL revisions therefore must take place very close to the abyss of forgetting - as close as possible but not too close. "This is a path most difficult to tread, sharp like a razor's edge" (Katha Upanishad 1:3:14).

The memory layers we have been talking about do, of course, not physically exist but are only a model based on our observations of the functions of remembering and forgetting. Another model, more concrete and less likely to cause confusion between model and physical reality, is a system of conveyor belts.



Men work in a quarry to break up huge blocks of stone into manageable sizes. This work, which is not algorithmic, neither in the quarry nor in the study, has close analogies to the early tasks in language learning, which has to be done by the teacher (or textbook author), or by the student himself if teachers and

authors have not done an adequate job. Details of this work have been, or will be, discussed elsewhere.

Initial learning corresponds to the act of lifting the stones onto the lowest conveyor belt. Each revision lifts the stones from one conveyor belt to the next higher one, with a longer "running time", i.e. the distance between the required revisions increases. Any student of yours can easily see that. If the student is not in position at the end of each conveyor belt to move the stones to the next belt, the stone will drop back into the quarry and the whole process has to start again, a silly and completely avoidable waste of time, and also frustrating and demotivating. But this is what most language learners do and what most language teachers do not prevent. No wonder that language learning is unpopular and considered difficult. The IDYLL algorithms predict when each stone is about to reach the end of its belt and has to be lifted to the next.

The endlessly repeated advice from teachers to their students: "Revise as often as possible" is silly nonsense. It guarantees failure: No student working on this basis will make the number of revisions necessary for him to be successful. The IDYLL METHOD ® proclaims instead: "Revise as seldom as possible, but as often as necessary", and our algorithms tell the student WHEN it is necessary.

An attitude that prevails in schools is: "We have to revise because you have forgotten". This is also stupid and wasteful. The IDYLL METHOD ® says: "You have to revise before you forget, and in order not to forget". If a student follows the IDYLL maxim, each revision will give him a feeling of triumph ("Yes, it is true, I can remember everything, I am a good student, language learning is fun"), rather than of regular frustration as in most schools. He will therefore want to study more and do his revisions on time. Moreover his revisions before forgetting take only a few minutes whereas revisions after forgetting take many times more time than the IDYLL revisions.

Subjects to which our learning algorithms can be applied

Our learning algorithms can be applied to any language, to the learning of vocabulary, sentence fragments, sample sentences etc. Some examples are given below. It can also be used for the teaching of foreign scripts. Greek and Russian scripts are too easy and too similar to Latin to require algorithmic treatment, but Sanskrit and other Indian scripts (North and South) and Arabic (and related scripts) can benefit from this approach. Factual information can benefit from the same approach, both during initial learning and during the revision period. Anything that can be turned into a quiz (presented as stimulus and response) can benefit and ensure that the student walks full of confidence into his exam. (See one example below, and more examples on the website). Joining separate words in accordance with sandhi rules is an obvious candidate for algorithmic learning, from the first introduction of these rules, up to the ultimate stages when the student has to get them right even in random order. ("No obstacle prevails", if the student applies these methods.) Examples of such exercises are given in the Appendix.

Subject-matter algorithms are fool-proof procedures which enable a student (or a computer) to convert any given input efficiently and without error into a wanted output. The sandhi rules are obvious candidates for converting from their usual prose or tabular form into subject matter algorithms (Bung and Sánchez 1978). To internalise this procedure, the student is given a large number of examples for each rule. The examples (questions and answers) are written down in the IDYLL format; see Appendix. The student then practises the exercises in accordance with PAPA, works out the solution for each item by referring to his chart (the subject matter algorithm). He continues doing this, again and again, until he gradually becomes bored with referring to his chart (flow diagram) because he can see the correct answer at a glance and is absolutely sure of it. (Bung

1972, Landa 1968 and 1969)

The IDYLL algorithms work well in conjunction with very different teaching methods

The IDYLL METHOD ® is a comprehensive system for language learning and has a preferred answer or solution for almost any problem or task that can arise. However, not all its components are core components. Some components are recommendations or preferences rather that strict rules. This paper has dealt only with the algorithms. The algorithms themselves are strict and cannot be altered without damaging the system, but they can be combined with almost any existing textbook, course material or approach for the teaching of Sanskrit or any other language, and even with the courses in spoken Sanskrit which Dr Shastri is running (Shastri 2010), and make such courses more efficient. It does not matter whether your basic textbook is old-fashioned, or modern, in what sequence the various elements of Sanskrit are tackled. For all these approaches VOCPROM, PAPA, REV and ERP can be used to make them more efficient. The algorithms are flexible in this respect. Like any MP3 player which will play any MP3 file, regardless of its contents, The IDYLL learning algorithms will process any material which has been converted into a question and answer format ("quiz") and laid out in the IDYLL standard format.

The subject matter can be converted into the IDYLL format by the teacher or by the student. If it is done by the teacher, there will be fewer mistakes and, once the material has been prepared, many generations of students can benefit from the same materials. If it is done by the students, each student has to do the "quarry work" (see diagram above), year after year, again and again, and some mistakes will inevitably get into the exercises (unless the teacher checks them), but preparing the exercises, bringing the subject matter into the IDYLL format is useful. It is the first stage of learning for the student, and speeds up initial learning when it starts.

Where can you find more information

More information about the IDYLL METHOD ® and its algorithms can be found on the website: www.rtc-idyll.com .

For the algorithms click on "Practical Advice" and click on VOCPROC and PAPA. These articles are continuously being upgraded and polished to achieve greater clarity for ordinary language learners here and abroad, and are therefore worth visiting regularly. There is still a pile of information on the IDYLL METHOD ® which has to be processed for the website.

If you are interested in the publications on which these algorithms are based, click on Research. This lists print publications of mine. Some are on the Internet and can be found by clicking. I intend to put all the others on the Web but this may take more than a year. Until then you will have to consult them in libraries.

Also click on Theory which will lead to Bung 1991a, a paper given at Prague University (Symposium on Educational Cybernetics), containing the memory model, the Memo Sutras. From the Bibliography of this paper you can trace, stage by stage, all the publications (mine and those of other authors) on which this work is based. This is really the "Manifesto" of the IDYLL METHOD ® .

Most of my publications have been written for academics and teachers, and none, as yet, for language learners, apart from a luxurious correspondence course (English for German learners)

which is now out of print, but samples of which can be found on the website (Bung 1991a). All the popular information for language learners is at present available on the website, free of charge, and when the information there is reasonably complete and polished, it will be published in book form (for ordinary readers/end-users).

The Institute for Dynamic Language Learning (IDYLL ®) offers to conduct courses, workshops, seminars, lectures, for end-users (i.e. language learners rather than teachers), in the UK and abroad, to help them to become more efficient language learners. I will be glad to hear from interested organisations.

Even if you do not run courses on the IDYLL METHOD ® for your students, I recommend that you refer them to the website (click: Practical Advice, especially VOCPROC and PAPA) and let them pick out whatever information they want. All the information is free, and is as clear and detailed as I have been able to make it so far. I will continue to improve it. The only drawback with students relying on the website without attending a seminar or workshop is that they often do not see how stringent the rules are and pick out just a few ideas (with the result that they benefit only 10% when they could benefit 100%) and do not experience even remotely the power of the method, provided it is used exactly. They will not experience the 90% retention because they do not think that it is possible, and they do not appreciate that adherence to the rules is necessary. My greatest problem with learners (and nowadays I have many of these on the Internet, especially from the Indian subcontinent and from Arab countries) is that, at a distance, I cannot easily induce them to read my articles properly and fully and then to put into practice what they have learnt. They are grateful and think they have benefited but I know very well that they have not benefited as much as they could have done. That's why it is in the interest of students to be somehow trained by an expert who fully understands the system.

Conclusion

I hope to have shown in this paper not only a very efficient approach to the learning of Sanskrit, which will help to make the language easier to learn and therefore contribute to the survival of the Sanskrit Tradition In the Modern World (STIMW) but also how much the spirit of Indian wisdom can contribute to language learning and the learning of many other subjects. The Sanskrit Tradition is a driving force in the IDYLL METHOD ® .

Trust in the algorithm is vital. The algorithm is to language learning what dharma is to our general conduct in life. If we want to be successful, then (leaving behind desire, fear and anger) we should concern ourselves only with our duties, i.e. the steps prescribed by the algorithm. These steps are precise, observable and emotionless. It does not matter whether we make mistakes or not, it does not matter what we think of ourselves, or our talents or their absence. We just do our best. All that matters is that we take the next prescribed step. The fruits of our labour (correct or incorrect responses) do not matter, and we should not reflect on them or gag for them, except that they determine the next prescription by the algorithm. Or to put it in a more familiar language: "Do your allotted work" (niyataṁ kuru karma tvaṁ – Gita 3:8) and "To action alone you have a right and never at all to its fruits" (Gita 2:47)

karmaṇyevādhikāraste / mā phaleṣu kadācena

If the student can take these maxims to heart, then the fruit will come on its own accord, in its own good time, when he least expects it, in the form of glorious competence, in Sanskrit, Hebrew, Latin, Greek, Arabic, or whatever language, sacred or profane, he (or she!) cares to choose.

Sample exercises

Vocabulary

Exercise 1			
1	horse	6	house
	aśva (m)		gṛham (n)
2	fire	7	village
	agni (m)		grāma (m)
3	girl	8	four
	kanyā (f)		catur
4	poet	9	he laughs
	kavi (m)		hasati
5	angry	10	they laugh
	kupita		hasanti

Example of an exercise for sandhi

These are random items, which could be used for a final revision of this topic. In practice they can be judiciously organised and graded before reaching the random stage.

Exercise 1: Convert the pada forms into sandhi forms	
1	gacchati + aśvam
	gacchaty aśvam > gacchatyaśvam
2	eva + avaśiṣyate
	evāvaśiṣyate
3	rāmas gacchati
	rāmo gacchati

4	virās gacchanti virā gacchanti
5	rāmas pṛcchati rāmaḥ pṛcchati
etc	

Example: Devanagari script

From Klaus Bung, "The Sanskrit Script: A Programmed Primer" (The Keyword Method) © 1988, 2011 Klaus Bung

Exercise 1	
1 The sacred syllable OM ॐ	6 The god Rama: rāmaḥ रामः
2 r, ra र	7 k क
3 ā(within a word) ◌ा	8 desire: kāmaḥ कामः
4 m, ma म	9 t त
5 ḥ (final), also called visarga ◌ः	10 star: tārā तारा

Exercise 2	
1 n, na न 2 honour, salutation: namaḥ नमः 3 mind: manaḥ मनः 4 j = IPA /ʤ/ ज 5 man, person: janaḥ जनः 6 g, ga ग	7 elephant: gajaḥ गजः 8 virāma, vowel stopper ् 9 song: gānam गानम् 10 d, da ढ , leading to dānam (gift, present), etc etc Note: Once "Rama", the first word, has been mastered, only one new letter per word is introduced. The full manuscript contains an introduction and notes after each item, explaining the new features.

Factual knowledge

Exercise 1

1 Name the authors of the two most popular versions of the Raymayana, one in Sanskrit and the other in Hindi.

Valmiki (Sanskrit), Tulsidas (Hindi)

2 What is the name of the great battle field in the Mahabharata?

Kurukshetra

3 Yudhisthira refused to go into paradise because entry was refused to his faithful companion who had followed him through thick and thin. What was the name of this woman?

It was not a woman, it was his faithful dog. The dog's name was Dharma.

etc

Question 3 was so formulated in order to train the student to resist misleading questions. He must be so sure of his ground (which is possible with our algorithmic methods) that he will insist on being right, even against the examiner. E.g. in maths: "If Henry VIII had 6 wives, how many wives had Henry IV?" Answer: 3.

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