Instructions:

Read the article about schema theory and answer the questions at the end.

How can Schema Theory help you learn sports skills?

by Matthew Leitch, 24 April 2011
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Introduction

This article will explain Schema Theory and some related research and observations, then move on to offer guidance on how to learn and teach sports skills more quickly and easily. You will answer questions (provided by Ms. Davis) at the end. The questions are on a seperate sheet of paper.

What is Schema Theory?

In 1974 Richard A Schmidt put forward his Schema Theory to try to explain how we learn and perform 'discrete perceptual motor skills'. (The theory was published in 1975.)

Discrete motor skills are skills that take a short time to perform (the 'discrete' part) and involve using our senses to understand what is happening (the 'perceptual' bit) and then using our bodies to take action (the 'motor' bit). We use lots of these skills in sports like tennis, squash, badminton, golf, cricket, snooker, football, and even darts. The skills include strokes and footwork patterns.

These are not the only skills in sport. For example, cycling, running, and driving a car are skills that are carried out continuously for long periods, so they are not 'discrete' and not covered by Schema Theory.

Many years have passed since Schmidt put forward his theory and many experiments by psychologists have confirmed a number of the more obvious aspects of Schema Theory. Despite its age, Schema Theory remains one of the leading theories in this rather slow moving area of research.

Schmidt's basic observation was that in sports like tennis and badminton we almost never repeat the same action exactly. Even if we just consider one 'movement class' (e.g. forehand drive in squash), the ball is always unique in its height, oncoming trajectory, spin, and so on. Also, we can vary our intentions to hit faster or harder, or to use varying amounts of spin. If two shots look identical (serves for example) even these may be slightly different because in one the player is slightly more tired than in the other, so the player's brain has to push the muscles a little harder.

If most shots are unique motions then what exactly is it that we learn that makes us more skillful? Clearly, it is not a fixed pattern of instructions to muscles. Something more sophisticated must be going on.
Schmidt's suggestion was that our ability to perform a movement class (e.g. hit a forehand topspin, a backhand slice volley, or perform a forward lunge) is represented by three things:

1. a Generalised Motor Program

2. a Recall Schema; and
3. a Recognition Schema.

The Generalized Motor Program

A Generalized Motor Program (GMP) captures the basic form of our movements. If you want to have a swing that looks like a top player then what you need to do is develop a GMP that produces the same motions. Get some coaching, watch videos, work on your form, and you can look the part even if you've never actually hit the ball.
It's called 'generalized' because the program doesn't just produce one specific motion. It can generate a variety of similar motions, such as forehand drives at a variety of heights or with varying amounts of power.
In creating a GMP it is very important to be able to vary motions in a simple and systematic way.

The theory is that the exact motion produced by a GMP is driven by 'parameters' (e.g. required speed, height), which are amounts fed to the GMP by the second bit of the theory, the Recall Schema.

The Recall Schema

The Recall Schema provides parameter values to the GMP after observing your situation and intentions. For example, if your badminton opponent has just cleared the shuttle to the back left corner of your court then a Recall Schema will feed parameters of direction and speed to a GMP for doing a split step followed by a sequence of foot movements designed to get you in position to hit the shuttle.
(Note: Movement around court is also by discrete motor skills. Steps are rather like strokes.)

The Recognition Schema

The Recognition Schema is what allows us to know when we've made an error, just by feel. It is an expected feeling for the movement.

How skills are learned

The original Schema Theory has little to say about how skills are learned, but clearly at the very least we need to:

- develop a stable Generalized Motor Program, which is *parameterized* (i.e. has parameters that control it); and
- develop a Recall Schema that is accurately *calibrated* (i.e. gives correct results) over the full range of conditions in which the skill is to be used.

(Note: Schmidt does not use the terms 'parameterize' and 'calibrate' in the way that I do in this article, but these are very useful terms.)

It's also fairly obvious that trial and error must play a role in this process, with errors prompting adjustments, especially to calibration of the Recall Schema.

Less obvious is the fact that developing a GMP with just a few parameters controlling the way it varies (e.g. 1 to 4 parameters) radically simplifies the problem of developing an accurate Recall Schema. As any statistician will confirm, the more variables there are the harder it is to understand the relationship between them and the more data you need to do it. Without a simply parameterized GMP your brain would have to relate scores of variables together, which is

nearly impossible. Presumably there are alternative ways to parameterize complex sports skills and some will be better than others.

Also, imagine the impact of making frequent changes to a GMP. Each time this happens the Recall Schema has to be relearned/adjusted. It probably gets easier each time, and is easier for small changes than for large ones. However, this may explain why some technical changes we make cause performance to drop before it improves. Over the whole period of mastering a skill it may be that a lot of time can be saved by getting close to the ideal GMP very early and having to relearn the Recall Schema only a very few times compared to trying to work with a GMP that is constantly evolving.

Do not assume that all this happens automatically through experience of playing the sport. Thinking about our skills is rarely helpful during a match, but when trying to develop a skill it is essential. For example, there is a huge difference between saying to yourself "Oh damn, I missed" and thinking "Oh, that's the second time in a row I've hit the bottom edge of my racquet trying to get more power. I need to adjust like ... this." Psychologists often call this 'cognition' and it is becoming increasingly clear that cognition helps.

Persistent difficulties in mastering particular skills are common and finding solutions seems to be much like solving a puzzle. Obvious mistakes can turn out to have far from obvious causes.

Some useful research findings

Research inspired by Schema Theory has shown that we do seem to be able to parameterize movements. For example, we can perform handwriting slowly or quickly, large or small, and it still looks like our handwriting.

However, parameters can be more sophisticated than Schmidt originally suggested. For example, we can walk carrying a variety of burdens and this involves more than just increasing the strength of all muscle contractions. For example, swinging a leg forward is the same regardless of the load but pushing a leg back is harder with a heavy load.

It also appears that we perform better in conditions where we have had a lot of practice. For example, taking a free throw in basketball is always done from the same spot and people get especially good at shooting from that spot.

The reason for this is not known, but it is obvious that it is possible for a Recall Schema to be more accurate in some conditions than in others, and it is likely that its weaknesses are going to be in conditions where we have had little or no experience. In other words, we should expect calibration to be 'local', meaning that experience with a particular condition (e.g. combination of height, speed, etc) helps us most to calibrate to that condition and to conditions very similar to it.

Another finding with important practical implications is that the kind of practice that helps most with developing a good Generalized Motor Program is not the same as helps most with calibrating a good Recall Schema. Trying to hit the same way each time without worrying about where the ball goes helps with developing a stable GMP, but an accurate Recall Schema comes from varying conditions from shot to shot. The research is not conclusive and involved skills much simpler than typical sports skills. However, from personal experience you can probably understand what is going on.

Suppose you want to change your backhand slice shot and start performing it in a different way, perhaps with a different backswing. If you rehearse the action with no ball to hit then it's not difficult to modify your form. However,

suppose you try to modify your swing with a ball to hit from the start. It's distracting and it's hard not to just revert to your old swing in your desire to hit the ball successfully.
So, focus on form at first and forget the ball. Then introduce the ball and try to learn to vary your movements correctly for the different conditions of each shot.

Guidelines for successful learning based on Schema Theory

The following suggestions cover five common situations in learning and teaching discrete motor skills, especially for sports:

1. Planning to improve your skills
2. Learning/teaching a new stroke/step
3. Calibrating a stroke/step
4. Interpreting mistakes
5. Warming up for a match

Planning to improve your skills

If you are just starting a new sport, getting serious, or preparing to teach a sport, one of the first steps should be to make a preliminary list of the discrete perceptual motor skills to master.

With racquet sports it is usually fairly easy to make a list of strokes, but more difficult to list all the relevant footwork patterns. Coaching guidance sometimes advises techniques that professional competitors do not use and this may be because the guidance is based more on imagination than observation.

At the other extreme, darts could hardly be simpler. One skill is enough to hit every target on the board, but calibration needs to be perfect.

Your list does not have to be comprehensive and you can change it in future, but it still helps to have some idea of what you are about to build.

Learning/teaching a new stroke/step

The first task is to develop a Generalized Motor Program. Before trying to hit a ball or shuttlecock choose the shape of your skill. Get some coaching advice, watch good players, visit the internet (e.g. YouTube for clips of top players in action), and pick the technique you want to master, noticing details carefully.

Then, without the distraction of the ball or shuttlecock, get used to the feeling of that movement by doing it several times and then many more times as you explore how you would vary the movement for slightly different conditions. For example, a forward lunge might vary from relatively short and slow to very long and deep. It might be preceded by one or even two shuffling steps, of varying length and speed.

You may be able to check in a mirror or using video to see if your technique at least looks right. Dance practice rooms have mirrored walls to make this possible.

Despite all your care this pattern of movement won't be quite right and you are sure to have to make changes in future, but try to make it a good starting point.

Finally, introduce the ball and start to develop a Recall Schema that is well calibrated. (See below for more suggestions on how to do this.)

If you try to hit the ball without having thought about variations you will find that the ball is almost never in the position where you know how to hit it! Consequently, learning will be difficult and frustrating, and it will be hard to maintain the form you want. In contrast, if you've already thought about how to vary the movement then each shot is another opportunity to develop your skill.

Calibrating a stroke/step

The obvious guideline is to start with easy conditions and build out from there. Start with low speed, low energy movements that are relatively easy to perform and gradually expand the range of conditions for which your skill is calibrated.

Don't go straight for a full squash drive. Just hit gently at first, then gradually build up the power and pace, keeping your form throughout.

Avoid tinkering with the basic form of the stroke (i.e. the GMP). Keep it stable and try to get the results you want just by calibrating its variations.

If you want to add more power to a movement you have already calibrated for lower power, do not just try to hit the ball harder over and over. Hit some at various levels of power, scattered over your current range, so that you are more aware of how you have to adjust as more power is added. Use that knowledge to extrapolate beyond your existing skill and so gradually expand your range.

It may help to spend some time repeating the same stroke or step over and over with small variations. If you just play a match there is too much variation and too much distraction for easy learning.

People sometimes think that when they do a 'drill' they are repeating the same movement over and over in order to carve it out in their memory and eliminate inconsistency. This is not true. What we need to do is explore variations in conditions and how to adapt to them so that our movements are adapted correctly. Being 'consistent' is really the result of *varying* your movements, though using a stable GMP. In short, it is consistent variation.

Interpreting mistakes

Don't get frustrated by mistakes. Many people scold themselves for being 'inconsistent', 'stupid', or not concentrating when in fact they are just making normal mistakes due to facing unfamiliar conditions or having too little time to work out their response.

There are three common causes for mistakes:

1. There wasn't enough time to compute the movement and perform it.
2. The Recall Schema gave incorrectly calibrated parameter values.
3. The GMP wasn't carried out correctly, possibly because it doesn't work in the conditions experienced.

We need to try to distinguish between these causes so that we know what adjustments to make in future.
If you were rushed then it may be that your error was due to not having finished computing the shot so don't read much into the error. Human decision making takes longer when there are more alternative actions to choose from, and a sophisticated discrete perceptual motor skill involves a lot of choosing. However, with long practice the time required reduces dramatically.

Notice the conditions in which you make each mistake. Was the ball higher than you're used to, or lower, or further over, or were you stretching more? If you play someone who is a better player than you are used to then you will make more mistakes than usual. Their shots are faster and tighter than usual, so you are at the limit of the ranges of your skills. An observer might call your mistakes 'unforced' but this is not really true.

If you miss the ball, notice if you can whether the ball was above, below or to one side of your racquet. Only then can you know in which direction to adjust.

You can learn at least as much from movements that were successful. If you hit the ball, notice exactly where on your racquet the impact was. You want to make contact with the sweet spot as often as possible, so even fine adjustments are worth learning. If you make a move towards the ball and have to make a huge lunge at the end of your movement then this means you probably should have started off with a stronger movement. If you find yourself in anything other than the perfect place for the shot you want to play then notice where you were and how you ought to adjust to be better placed in those conditions.

Finally, was your movement consistent with your chosen GMP? Try performing the stroke again without the ball to see if you could have done it consistently with your GMP, or if the GMP actually doesn't work in those conditions. It may be that it could have been made to work but, for example, you needed to use different steps to get into a better position where your chosen stroke works.

Warming up for a match

Schema Theory and related research says nothing about how often we need to adjust our Recall Schemas but some familiar examples suggest that our calibration may need refining often. For example, professional tennis players like to have a few days to adjust to new surfaces (e.g. clay vs grass) and snooker players like to spend some time on practice tables that match the competition tables.

When warming up for a match go through all your shots, not just to get your muscles warm, but also to sharpen up your calibration.

Article Questions

Answer on a separate sheet of paper.

1. What is a schema?
2. What is a Generalized Motor Program (GMP)? Give an example.
3. What is recall schema?
4. What is a recognition schema?
5. What are the main causes for a mistake? What methods can be used to correct mistakes.
6. Based on what you read, develop a training plan for a novice athlete to develop the motor program of your choice. Make sure you describe:
    a. The GMP and details about how it will be performed.
    b. A specific example of the recall schema and how the athlete will develop it (practice etc)
    c. A specific example of the recognition schema and how the athlete will develop it. How will the athlete benefit from developing a recall schema
    d. A generalized training plan.