Fly Casting and Sensory Motor Learning

by

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Introduction

This is the third instalment of my efforts to identify scientific knowledge which helps to understand and improve casting and to make that knowledge accessible. The Einstein Series[1] deals with mechanics (physics) of fly casting which tells us what we need to do to be efficient. Biomechanics[2] begins the next phase which is about how to use our bodies to do what we need to do. Sensory Motor Learning[3] takes us further along the road because it's about how to teach our bodies to perform the necessary movements.

The means by which we humans perform all movements is wondrous. Even the little things we take for granted after learning them as infants are marvellous in their ingenuity and complexity. The simple acts of standing up and remaining upright are not really simple at all. Much as I am intrigued and delighted by the design, structure and function of the Sensory Motor System (SMS), this is not the place for great neurological and anatomical detail even if I felt fully competent to write at that level. Accordingly, and to our mutual relief, I will focus mainly on what the SMS does and how it learns to do things rather than on how it does what it does.

Before I started this project I had only the vaguest notion of how movement is performed. If asked I would probably have offered that muscles were sent command signals to act and the SMS was the command and control centre. The inadequacy of that description is not due to inaccuracy so much as to gross oversimplification. Man as machine is on a par with brain as a computer. Without writing a PhD on the subject there are some things that need to be said about how and what it does in order to make greater sense of how to optimise our ability to learn movement and perform it better.

Muscles, Nerves and Movement

We glimpsed some of the complexity of movement previously in describing muscle movement from a biomechanical perspective. Raising an arm requires far more than the contraction of the muscles which lift it. Other muscles must extend to permit the movement and still more muscles must move to adjust our balance. Most of these muscle movements will be made unconsciously. Without unconscious muscle activity conscious movement would be either impossible or at best ungainly.

1   https://thecuriousflycaster.com/physics-for-fly-casting/
2   https://thecuriousflycaster.com/biomechanics-for-fly-casting/
3   https://thecuriousflycaster.com/fly-casting-and-sensory-motor-learning/

Lifting an arm and consequently starting to fall over is not much use to us.

So, right off the bat we see that movement as performed and facilitated by muscles connected to bones is controlled both consciously and unconsciously. We can then say that some aspects of a voluntary movement are automatic. It gets better.

At some point you have probably had your reflexes tested. Sit down, cross your legs and relax. The doctor then takes an odd little hammer and gives you a sharpish whack on the knee just below the patella. Hey presto your lower leg extends with a short involuntary kicking motion. Unconscious and involuntary movement occurred, literally a knee jerk reflex action.

You can do it without the doctor using just the blade of your hand. Then, in the same position, but without the whack, you can also produce almost exactly the same movement as a conscious and voluntary choice. Same muscles, tendons and bones but different neural pathways. Yes, we have two neural pathways, one connecting to the sensory motor centres in the brain and one connected to the spinal column. The brain and the spinal column are the central nervous system. The rest of our nerves are called the peripheral nervous system.

When we think of the brain we are probably visualising the cerebrum but actually the brain has three parts. The brain stem sits on top of the spinal column and below the cerebrum. The third part is the cerebellum which sits at the rear and underneath the cerebrum, adjacent to the brain stem. The cerebellum is densely packed with neurons. It weighs only about 10% of total brain but has roughly half of all the brain cells. Its functions are extremely important to any voluntary movement, like fly casting. That's because it is the control centre for sensory and motor signals, including balance, and because it also stores patterns of movements, as well as helping out with fine tuning of movements. It is the central exchange and co-coordinator of movement.

In evolutionary terms the sensory motor cortex is the new kid on the block. It is part of the new brain. The cerebellum and brain stem are parts of the old brain which we share with many other species. The two neurological systems have to function in concert and the cerebellum takes care of that job. The new brain can direct and override some of the functions performed otherwise unconsciously. It is yet far more complicated than this but that will do for now.

The capacity for voluntary movement, almost endless in its invention, is our very

special gift. We humans are not confined to the genetically programmed repertoire of reflex movements to which many other species are limited. They are born with a set range of possible movements performed unconsciously. We can learn new movements throughout life. We can automate those learned movements to the extent that they become like new reflexes. That's the good news. The bad news will come later.

Overall though, we might observe that learning movements as reflexes has the very practical advantage of being able to do them faster and better when they are performed unconsciously rather than consciously.

Sensing and Movement

Muscles and the tendons connecting them to our bones are not just motors and cables. They both contain sensors which convey information via the peripheral nervous system to the central nervous system. They are sensory organs.

It's not just that contraction of your biceps initiates a message to extend your triceps or vice versa. Our vast array of movement sensors transmit information about the extent of load imposed and effort being exerted, where things are and where they are going. This exchange of information is a constant flow in both directions. Forget switches and wires. Think rivers within the same valley flowing in multiple directions at the same time. The cerebellum has a lot of work to do, hence the density of its neurons.

Once we learn to do something, like standing upright, the muscles and tendons develop presets of tension to automate the activity. This is neural memory rather than muscle memory. As far as I can see no two people stand with exactly the same posture or cast with exactly the same style. Their presets are different. We can change these presets to improve both our posture and our fly casting.

Movement occurs in four dimensions, the three dimensions of space (height, width, depth) and also in the dimension of time. Huh? Yep another nod to Einstein. Sometimes we can watch our movements and sometimes we can't. Try this. Close your eyes and touch the tip of your nose gently with the tip of your index finger – dominant or non dominant side. Try touching your nose faster or slower but maintain the same gentle contact. If you can do this easily, as I can, keep your eyes closed and stick your index finger gently into your ear – either side of your head.

Your ear drum is in far less danger than your dignity.

Speed is distance divided by time. To vary the speed of a movement requires a knowledge of both variables. Receptors in our muscles, tendons and joints provide information to the central nervous system on where our body parts are located in space and thus in relation to each other. Effectively the body is mapped and the relative positions of the those parts are plotted in real time. This is done unconsciously in the main and is known as proprioception. The information can be combined with other senses including those of sight and balance.

OK, so before parts of your brain start exiting your ears I'll stop there. What I'm trying to get across is that the SMS is more than motors, circuitry and switches. Sensing and movement, voluntary or reflex, are organically integrated and to a large degree functionally interdependent. The simpler machine metaphors may give us something to relate to, but fall well short of capturing the bigger picture, to say nothing of its wonder. Let's move on now to more directly relevant implications of voluntary and automatic movement (and sensing), all of which we use in fly casting. Equally, it is vital that we manage and optimise the relationship between conscious and unconscious movement which is enabled by the SMS. Understanding a bit about what is going on will help.

First Efforts to Second Nature

The knee jerk reflex represents movement activation at the deepest level of unconscious and involuntary processing. Such reflex movements are fully automatic. We were born with them, like swallowing or coughing when things "go down the wrong way". Everything else, like standing, walking, riding a bike or fly casting we have to learn by starting at the most conscious and voluntary level of movement control. These are our first efforts and they tend to be a bit clumsy and faltering. We fell over as infants and children when learning to walk and then to ride a bicycle. We duff casts when we begin fly casting. Stuff happens.

As we get better at performing all these movement tasks something very important is going on. We are progressively automating these movements by automating all the sensory and motor processes they require. They become second nature. Exactly how this transition happens I can't tell you because it hasn't been definitively explained. However, fwiw, I think the smart money is on the cerebellum and something like (re)distributed processing. For our purposes that doesn't matter

so much because we do know what it takes to make it happen. We learn by doing. We automate movement by repetition of the movement and more repetition automates it more fully which is to say that we can create new reflexes – not at the depth of knee jerks but headed very much in that direction.

One very neat way of looking at all this is that some movements are learned by evolution and we inherit those genetically. Other movements are learned during life and we invent, share and refine that knowledge collectively and individually. In both cases automation is the winning strategy. Second nature indeed.

As with many things this learning can be achieved without science but as we saw with biomechanics, science can lend a hand in reducing the iterations of trial and error so let's consider a little of the available scientific knowledge.

Fitts Law

Paul Fitts was a psychologist who studied and modelled human movement back in the 1950's. He produced a mathematical formula for the relationship between the accuracy requirements of a task and the speed at which it can be performed. Specifically, the law states that the time required to move to a target is a function of the ratio of the target distance to the target width. In other words, there is a trade-off between accuracy in acquiring a target and the speed at which we move to acquire it. A bigger target is less demanding of accuracy so we can move to it more quickly.

Of course speed can be increased, with less adverse affect on accuracy, as the movements involved become more familiar and more expertly performed. Fitts' work has had a massive influence in many fields from aircraft safety to human and computer interaction and, in sports science and teaching.

What does this have to do with fly casting? Well, because one of the implications of his work is that we can only consciously process so much information within a given time frame. Put another way, we only have so much attention space and when it's full, it's full. If more of what we are doing is automatic then we have more cognitive space spare to spend on refinement of our movements.

Fitts and Posner – Stages of Motor Skill Acquisition

Paul Fitts teamed up with Michael Posner and together they wrote Human

Performance[4] (1967). I don't pretend to have read it but I have read about the 3 stage model of motor skill acquisition they came up with. Like Fitts Law it has had a broad and persistent influence in a great many diverse fields. The 3 stages are Cognitive, Associative and Autonomous.

There are lots of varying accounts of what these stages mean appearing in sports science and other literature. I quite like this definition from the Oxford Dictionary of Sports Science and Medicine:

"*[There are] three progressive phases of learning a new skill proposed by P. M. Fitts and I. M. Posner in 1967. They are: a cognitive phase during which the performer develops a mental picture and fuller understanding of the required action to form an executive programme; an associative phase during which the performer physically practises the executive programme learned in the cognitive phase; and an autonomous phase during which the performer learns to carry out the skill with little conscious effort.*"

My take on this is that the cognitive phase is concerned with gathering information about what is to be done. It's all about conscious processes. The intermediate or associative stage is about practicing the skill so that it starts to be performed more by unconscious processing and in the final stage we rely almost entirely on unconscious processing.

I wouldn't want you to think that learning to fly cast is a simple matter of progressing through these stage in linear fashion and once for all time. You don't win the game just once and you're done. Rather these stages typify the progression from conscious to unconscious performance of a voluntary movement. As we progressively get better at it we will introduce changes and refinements. These may well require us to revisit the earlier stages in order to improve what we learned to do autonomously. Moreover, not all of us will manage to reach the final stage on all casts and all aspects of our casting.

Over the years I have often and significantly rebuilt my casting strokes. For example, I watched myself on video just a few months ago and realised I wasn't rotating my torso properly on seriously long casts and consequently the extension of my arm wasn't going where I thought it was. Cognitive stage revisited. More practice

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4 Revised edition (October 1st, 1979), ISBN-10 : 0313212457 ISBN-13 : 978-0313212451

sessions to move through the Associative stage and so on, repeating as required.

This brings us nicely to next bit of science which I think can be useful.

Competency Framework

Well known in training circles but unknown to me until it was brought to my attention by one of my reviewers, Vince Brandon, there is a 4 stage framework for competency.

Stage One is unconscious incompetence.

Sounds bit harsh but what it means is that we don't know how to do something and don't know that we don't know, probably because we are uninterested rather than wilfully ignorant.

Stage Two is conscious incompetence.

We realise that we don't know how to do something that we want to do.

Stage Three is conscious competence.

Where we have begun in earnest to learn how to do something.

Stage Four is unconscious competence

Where we have learned to do something so well and automatically that it can be done without thinking about it. Second nature.

Leaving out the first stage, we can see some resemblance in the last three to Fitts and Posner's typology of cognitive, associative and autonomous skill acquisition. In both frameworks the path of progress is from conscious thinking about it to unconscious performance of a voluntary movement.

The second thing to notice, is that this framework is similarly not limited to a single, one way journey of learning. Improvements can be made, effectively by going back to stage two and pressing on to successive stages. Repeat as necessary.

Optimising Sensory Motor Learning

It is pretty obvious that over the years fly casters have paid a lot less attention to biomechanics and sensory motor learning than have sports scientists, instructors and practitioners in many other sports. Just as throwing is throwing, including fly casting, so skill acquisition is universally relevant to performance enhancement in all

sorts of activities including sports. There is a pile of material out there and some of it is both relevant and authoritative. Some of it, of course, is neither. If you decide to go looking, my advice is to concentrate on peer reviewed publications. You can find good stuff on the internet, including Youtube and Vimeo and you can also waste a lot of time watching crap produced by people who speak with far more confidence than authority.

If I decide to keep going with this work, the next logical project to undertake would be casting practice. We'll see what happens about that but for now there are three things I want to cover in this project that make a lot of intellectual and experiential sense to me.

Focus of Attention

Sports science divides where we put our attention into two: internal focus and external focus. Internal focus concentrates on the body movements we should be making. Fly casting literature and traditional instruction is full of this stuff. Do this and don't do that; hold your arm up in the ready position, don't break your wrist, don't grip the rod too tightly, slow down, stop suddenly, and on it goes. My scepticism should not be confused with outright rejection, but my concern is that we can too easily confuse removal of error with achievement of excellence. My preference is to do like the song says, accentuate the positive, eliminate the negative. Mr In-between makes a mess by failing to do both properly.

External focus concentrates on what we trying to achieve, that is, on the intended effects of our movements. For example, in one study of novice golfers making chip shots, the participants performed better when they focussed on things like the trajectory of the ball and the motion of the golf club. Peer reviewed publications support performance gains in accuracy, efficiency, and even maximum power production – in a variety of skill acquisition contexts, including sports – using an external focus.

I'm not saying you can stick a fly rod in a beginner's hands, tell them to make narrow loops and stay smooth and they will be experts in no time. Of course, beginners need to know and be shown the basics of what to do and how to move. What I'm saying is that an external focus leads to better performance sooner. It gives you a learning edge. My very strong suspicion is that it does so because the movements become less conscious and more unconscious, sooner.

An external focus of attention allows you to get a clearer "feel" of the skill when it is executed well. This becomes easier to capture as the movements become more automatic but you can get it and refine it as the skill is being acquired and polished. Getting, noticing and remembering the just right feel is very important. Repeating the movements that felt just right, easy and effortless is the way to capture it. Any experienced player of countless sports would be familiar with this phenomenon; the golf shot, the pitch, the kick of a football that just feels special. Distance fly casters talk about "hooking one up".

Once experienced, my suggestion for memorising it is to conjure a word picture that evokes that feeling as a sensory experience rather than a cognitive one. It's like giving the feeling a name so that it can be remembered and recognised. Each of us will make up a different association that makes sense, pun intended. For example when I want to make a long cast, staying smooth and delivering accurately I tell myself to "cut the cloth". This is my shorthand for treating the sky as a cloth that I cut with the tip of the rod as though using a very sharp knife. The idea of cutting smoothly, effortlessly, straight and completely works for me. If I use key words instead of the image, the words are *"straight, slow, smooth, full"*. Slow at the start, smooth through the middle of the stroke and finish with a full extension of my arm. Back cast and forward cast, same deal.

Implicit in this process is the need to operate within your comfort zone rather than the point where your technique starts to falter. Gradual extension of distance without losing the magic feel will work a lot better than continually trying to cast as far as possible. You want the SMS to learn and thus automate good form. Heaving is not good form.

Your state of mind and emotions are also part of where your attention is focussed and these also affect the muscle and tendon presets I spoke about earlier. Anxiety, for example, will cause the presets to tighten, i.e. you will "*tense up*". If instead of being worried about your performance, you are relaxed and confident that improvements can be made, then you are more likely to make and keep improvements.

Giving Yourself Time – Slow and Slower Motion

It is also easier to capture the feel of good form by "*casting*" in slow motion instead of normal speed. Just as we can see more by watching a caster in slow motion so

we can get a better and more accurate sensory "*idea*" by making a cast in slow motion. If you detach the butt section of the rod, reel attached, and give yourself some slack you can perform the chosen casting movements slowly, adjusting them (more easily) for accuracy that is, making things move smoothly as and when they should. Fitts Law used to advantage. When we deliberately slow down, attention space is freed up to improve "*accuracy*' which in this case means conforming with correct technique.

A similar way of exploiting the speed accuracy trade-off was suggested to me by John Waters who is one of my reviewers. He recommends practice casting at a reduced speed, say 60 -70% of the standard rate, as a means of incorporating improvements to technique. Importantly, everything else stays the same, including stroke and haul length. This might require you to shorten the line up from maximum carry and distance casts. It may even mean making PUALD[56] casts in one or both directions if turnover is badly compromised by reduced tempo of the movements. However, the trick is to change only the speed of the movement as far as possible then build in the changes at the reduced speed.

From slow or slower motion we can pick up speed again to normal pace and repeat the process as required to capture, memorise and normalise the improvements we are after.

You can even pantomime the actions without a rod in hand. Simply rehearsing the movement in your mind will have benefits. Indeed some research has shown that improvements are made just by sleeping on it. During sleep the brain consolidates the learning and re-organises the neurons used to execute the movements.

Habits, Good and Bad

In everyday language the transition from the cognitive to the autonomous stage would be called "*forming a habit*". We have seen how it is possible to optimise SMS learning to form habits faster. That was the good news. The bad news, of course, is that the process does not distinguish between good and bad habits.

We all know from experience that the longer a bad habit persists the harder it is to break. Anyone who has hung out in online forums or asked for advice from a seriously good caster is likely to have heard that getting some lessons would be

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5   Arden's Pick-Up-and-Lay-Down
6   https://www.sexyloops.com/flycast/pick-up-and-lay-down/

useful. It goes almost without saying that they are most useful at the beginning to increase the chances of good habits being formed early. There are plenty of anglers willing to tell you that because they catch fish they don't need casting lessons. Dear reader, I know you won't be one of those because you wouldn't still be reading this if you were.

Bad habits can be broken but it takes focus, resolve, repetition, discipline and, you know, **work**. It means going back to where the problem started and forming a good habit to replace the bad one. Slowing your movements down as suggested above can help. It will take time. If all that means going back to being a beginner then so be it. Fixes? Yes. Quick fixes? No. Besides, it never hurts to go back to basics, for example by casting without hauling, sorting out it properly and then adding the hauls back in.

If it makes you feel any better, I've spent several years ruthlessly getting rid of any unnecessary effort. It has meant finding ways to cast long and accurately without heaving, at all. The positives I accentuate are smoothness, the natural throwing sequence and staying with the just right feel. All these things facilitate casting in a mechanically efficient way. Straight lines rule, OK?