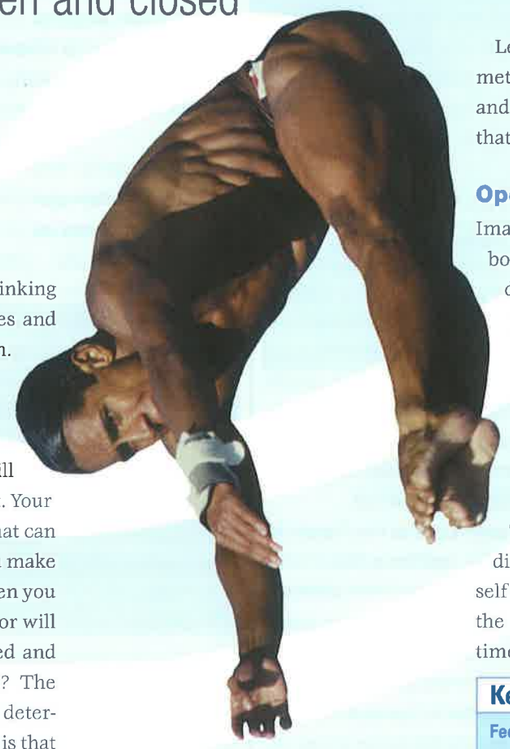
Motor control

Open loop versus closed loop control

Di Skelly looks at the differences between the two methods of motor control in sports movement — open and closed loop control.



Spend a few moments thinking about the physical activities and sport that you take part in. Try to visualise yourself performing a physical skill from one of these activities. Now ask yourself whether you execute the skill correctly each time you perform it. Your answer will probably be no! So what can you do to correct the mistakes you make — can you rectify the problem when you are actually performing the skill, or will you have to wait until it's finished and sort out the problem next time? The response to this question will be determined by how fast the movement is that you are doing.

For every physical skill there are two ways to control it — one is called **open loop control**, the other is **closed loop control**. The control method will not be chosen by you, but will be dictated by the type of movement that you are doing.

Let's have a look at each of these methods of controlling the movement and hopefully even sort out the mistakes that you may be making during the skill.

Open loop control

Imagine yourself standing on a diving board ready to make a dive. You have decided what sort of dive you are going to do and you have set the dive in motion. What happens if, during the dive, you feel that your body position is not in the correct shape or alignment to enter the water smoothly? Can you alter your body position *during* the dive? Think about the speed at which this dive is being performed and ask yourself whether you will have time to make the changes to your body shape in the time available. Quite simply, you will not have time to do anything about it — even though you probably know that things are going wrong.

Key box 1

Feedback This is information received after the response to help correct errors. For beginners such feedback may come from an outside source, for example a coach. This type of feedback is called **extrinsic feedback**. **Intrinsic feedback** comes from within the performer, who is able to correct errors using a feel for the task gained from experience.

When can you rectify your mistakes?

Even though you may have received **kinaesthetic feedback** (internal feedback) during the dive telling you that you are doing something wrong, because the skill is a *fast* skill you cannot make use of this information to adjust your body during the dive itself. You will need to wait until you have completed the dive and use the feedback you get afterwards to help solve your problems. Maybe you entered the water at a slight angle rather than vertically, or perhaps you made too much splash on entry. Information of this nature is called **knowledge of results** and it is this information, plus the internal feeling of not being vertical that you had during your dive, that you will use to adjust your technique. All this feedback — information about how you performed the dive — will be stored in your **long-term memory** ready for when you need it. The only problem is that you will not be able to use this feedback to help you until the next time you perform the dive. This is **Level 1** control — where the movement is controlled subconsciously and there is not time during the skill to make a judgement and act upon it to change the skill.

Key box 2

Long-term memory This is the part of the memory system that can store a lot of information throughout the lifetime of the performer. This information is often stored as a well-structured set of movements that specify the components of the task, called a **motor programme**.

Closed loop control

Have you ever watched an Olympic gymnast performing a balance on the beam and wondered how she stays on the beam when she overbalances badly? Or what about when you have been walking along in snowy weather and you suddenly start to slip on an icy patch. Why didn't each of these cases result in a fall? The simple answer is that both movements are governed by **closed loop control**.

What is closed loop control?

When you have performed a movement several times, the information about how to complete it is stored in your long-term memory as a **memory trace**. The gymnast will have a memory trace of the balance and you will have a memory trace of walking. Not only does this memory trace provide information about the movement itself, it also stores details about what it feels like to do the movement, such as the **internal feelings** we have about our balance, touch and **kinaesthesis**. The more experienced the performer, the more accurate and stronger the memory trace will be.

Let's go back to the gymnast. As she is performing a move on the beam she monitors her movements and receives information about what is happening now. This is called the **perceptual trace**. The perceptual trace (the current information) is compared to the memory trace (the stored information). If the two traces match then the gymnast will simply carry on without any adjustment to her movements. If the perceptual trace is not the same as the memory trace then she will have to make some changes to bring them in line. Because the movements performed on the beam are relatively slow, she will have time to make some adjustment during the performance.

What happens next?

The mismatch of the two traces is registered in the **central control mechanism** of the brain and the brain begins the process of rectifying the problem. A message passes through the **effector mechanism** to initiate the changes needed to correct the movement. Impulses travel down the spinal cord and along the nerves to the muscles telling them what they have to do to bring the gymnast back on balance.

Once the message has reached the muscles, the **muscular system** begins to make the necessary adjustments to the body to sort out the problem — perhaps the legs need to be straightened or the arms moved slightly. As these changes to the movement are taking place there is another comparison between the perceptual trace and the memory trace and use is made once again of kinaesthetic feedback to help the performer monitor whether what she is doing now is correct or not. Hopefully having made some adjustments to her move the two traces will match this time.

And there we have it — the complete loop — from kinaesthetic feedback the first time, all the way through the system and back to kinaesthetic feedback. This closed loop system will continue to operate for as long as the movement is taking place — monitoring, comparing memory traces and making adjustments as necessary.

How quickly can the changes be made?

Another aspect we need to consider is how quickly the adjustments to movements can be made within this closed loop model. For this we need to look at **Level 2** and **Level 3** motor control.

Level 2 control has a smaller loop than Level 3 and tends to be used **subconsciously** by more experienced performers. In this case, the adjustments are still made during the skill and kinaesthetic feedback is still used but not as much time is spent on comparison. At this level the message about the adjustments needed go straight to the muscles and almost bypass the brain in what appears to be a virtually **automatic** and immediate movement — with just a *copy* of what has happened going to the brain for future reference. The speed of this

adjustment to movement during the skill using Level 2 closed loop control is only possible with performers who have experience of a movement and therefore a clear idea of how the correct movement should be performed.

Level 3 control is more relevant to a performer with much less experience. In this case a larger loop is used with the brain being more actively involved in initiating the adjustments required. While the principle of a loop is the same, the adjustments and the longer time taken can make the movement appear jerky and lacking fluency – just the sort of thing we would see with someone in the early stages of learning.

Key box 3

Cognitive phase of learning When movement during execution of the task appears to be jerky and lacking control, the performer is probably in the earliest stage of learning the skill, a phase called the cognitive stage. The performer has to concentrate hard to try to understand the pattern of movement required to complete the task. He/she may pause frequently to think before moving.

Closed loop exam answers

You now have the information to answer an exam question on closed loop control. But will you gain the maximum marks available? Let's have a look at the key points you need to include in your answer. This will of course depend on how many marks the question carries. Always try to think through closed loop control in a systematic way and hopefully you will not forget any of the stages.

- A memory trace for a movement is stored in the long-term memory.
- Kinaesthetic (internal) feedback gives information about how the movement feels.
- The current information about what is happening is called the perceptual trace.
- The perceptual trace is compared to the memory trace.
- A match of the traces means no change to the movement is needed.
- A mismatch of the traces will require some adjustment to the movement.
- Instructions to adjust come from the central control mechanism.
- The effector mechanism sends messages to the muscles.
- The muscular system makes the necessary changes to the movement.
- Kinaesthetic feedback completes the loop.

Don't forget the practical example if you are asked to give one.

What will your answer look like?

Read the two sample answers below. Both relate to a question asking you to explain closed loop control using a practical example. How many points from the list above are in each answer?

Answer A

Closed loop means that the performer takes control of the movement and uses the senses such as kinaesthesia to help him produce a movement. This is his feedback. Kinaesthesis tells the gymnast how to stay balanced in the handstand and it feels comfortable for him. If it is not comfortable, then he can change what he is doing.

Answer B

Closed loop theory explains how a gymnast doing a handstand can use conscious control at Level 3 to change the handstand during the movement. She will be making use of internal kinaesthetic information stored in the long-term memory to tell her if the handstand is correct. She will do this by comparing the perceptual trace to the memory trace. If these two traces are not the same, the central control mechanism will send a message via the effector system to the muscles to alter the handstand so that it feels like the one stored in the memory trace. When this has happened more kinaesthetic feedback will occur.

Which answer is closest to the one you would write? If it is A then it's back to the textbooks, handouts and revision notes for you!

We have looked at both open loop and closed loop control. Although it may appear that we use either one or the other of these methods, in many skills we use a combination of both – but that's an issue for another day!

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