No 9 THE QUESTION OF BALANCE

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1. Today for our last talk of this session, I thought it would be interesting to look at the question of balance which is very much at the heart of what we do as AT teachers.
2. Walter used to recommend a book by his friend Tristan Roberts who was Reader in Physiology in the University of Glasgow. Roberts spent his scientific life studying the question of balance in human beings and animals. He wrote a book called *Understanding balance: the mechanics of posture and locomotion.* It is 350 pages long and while it tells you all you are ever likely to need to know about the mechanics of balance it is hard going even for a trained engineer.
3. Walter used to recommend it to us, I suspect more out of loyalty to Roberts than any great belief many of us would read it. But whatever about that particular book, the question of balance is most important to us. So today I am going to try to simplify it down to some basic facts and how they fit in with the work we do and with monkey in particular.
4. Gravity is at the heart of any discussion about balance and the Technique. Lessons would be very different on the moon where gravity is about a sixth of what it is on the earth; pupils would hit the ceiling as they come out of the chair.
5. And in the absence of gravity, there is neither up nor down and the question of balance is meaningless. Think of astronauts floating about in the space station and how one might give them a lesson.
6. We could go into a lot of technical detail on the workings of gravity but the discussion would have to very rigorous and complicated if we wanted to satisfy Dr Roberts. Instead we are going to stick with what he calls *"schoolbook representations of the problem".*[1] In other words we will be looking at a plain ordinary understanding of how gravity works for AT teachers and their pupils on the surface of the earth.
7. For us, gravity is the force which pulls things towards the centre of the earth. If I drop an apple, it falls downwards as Newton is said to have noted. If I have a weight and I hang it from my finger by a string, it is attracted towards the centre of the earth.

[1] Roberts (1995) p14

8. This means that the line from my finger, the string, is pointing towards the centre of the earth. This, in fact, is what we call the vertical. A line is vertical when it lies along a radius from the centre of the earth.

9. When a carpenter or someone doing wall-papering wants to get a vertical line they make use of this and hang a heavy weight at the end of a piece of string and line up the paper against it.

10. This is called a plumb-line. For those of you who like your word derivations, it is called that because the weight used by builders and decorators was usually made of lead, for which the Latin word is plumbum.

11. Now we come to the question of being in balance. Another word for being in balance is being in equilibrium – it means the same thing but is the way scientists tend to express it.

12. So what does it mean to be in equilibrium or balance? It is surprisingly difficult pin this down exactly but in a broad sense we can say it means being in a steady state of resisting the pull of gravity.

13. When an object stops resisting the pull of gravity, it falls down. It is particularly important for human beings to be in a state of not falling because if we do fall we are likely to bang vulnerable bits of ourselves against something hard and suffer damage. Children and old people are particularly susceptible to this.

14. Researchers like Roberts have given a lot of thought to how to define a state of balance or equilibrium in a more scientific way than just not falling. One thing they do is make a distinction between what they call stable equilibrium and unstable equilibrium.

15. We can see this if we think of a pyramid. If we balance it on its point, and displace it even slightly, it falls over. It is in a state of unstable equilibrium. If we put it on its base and displace it slightly, it goes back to its original position. It is in a state of stable equilibrium.

16. The same applies to us. If I balance on one foot – or one toe – I am in a state of unstable equilibrium. But if I spread my feet apart, I am much harder to push over. I am in a state of stable equilibrium.

17. But notice that there are degrees of stable equilibrium. If I am standing with my feet close together, I am in a state of stable equilibrium but I can be more easily displaced from it than if I have my legs wide apart. I will come back to this at the end.

18. For now, I would like to look at the centre of gravity which is a very useful concept when we are discussing balance. I wanted to get a precise definition and I looked it up in a physics textbook which said: *The centre of gravity is that point at which the whole weight of an object may be thought to act.*

19. We don't want to get too metaphysical about this. If we take something apart, or dissect a person, we won't find a little identifiable thing called the centre of gravity – though you will see it marked on some anatomical charts of the body. The point is that, for certain purposes, things behave as though their whole weight were acting through a particular point.

20. I think a useful way of thinking about it is that the centre of gravity is the point of support around which an object balances or does not rotate. For example, if I take a piece of wood and support it here, it does not rotate whereas if I support it here it does rotate. I therefore know the centre of gravity is above this point.

21. The support does not need to be from below. We can also hang an object and since the force of gravity acts vertically downwards, we know the centre of gravity is vertically below the support.

22. This also gives us a way of finding the centre of gravity of an irregularly-shaped object like this piece of cardboard. I hang it from a hook and use a plumb-line to find the vertical. We know the centre of gravity must be on this line vertically below the support.

23. Hang it from another point, check the vertical line and we know the centre of gravity must be on this line. It must therefore be where these two lines intersect.

24. It is more difficult to find the centre of gravity in a human being by hanging them up from hooks and seeing where the vertical passes. Classical ballet goes part of the way when the male dancer supports the ballerina in a horizontal position. If he has his hand directly below her centre of gravity, she will not tip away from the horizontal.

25. Early performances of Wagner's *Rheingold* in which the Rhine maidens were supported horizontally in harnesses as they swam around in the Rhine could also be seen as ways of finding their centre of gravity.

26. But however it is done, and there are mathematical methods as well, the centre of gravity in a human is roughly in the centre of the pelvic girdle.

27. The importance of the centre of gravity is that things go out of balance when the vertical line from the centre of gravity passes outside the base. We can see this with a simple shape like a rectangle.

28. When it is standing on its base, the line from the centre of gravity passes inside the base. When I displace it a little, the line is still inside the base and the piece of wood is still in a state of stable equilibrium. It goes back to its original position when I let it go.

29. When I push it a bit further so that the vertical line comes to the edge of the base. It is now in a state of unstable equilibrium and if I push it a little bit further it falls over.

30. In the case of three-dimensional objects, the base is the portion in contact with the ground. The interesting thing about the base is that it does not have to be solid or continuous. In the case of a stool or a chair the base is defined by the line around the outside of the legs. In the case of people, it is a line drawn around the outside of the feet.

31. Let us now look at a simplified two-dimensional model of a human being – something with a fairly narrow base tapering upward like this. It is a bit like an Egyptian mummy.

32. I have already located the centre of gravity of this model and it is about here. If I hang the model from a hook, the vertical passes through the centre of gravity.

33. But the important thing about humans in comparison with pyramids, is that we can change shape in all kinds of ways. We can stick out our arms or our knees or our bottoms and this changes the position of our centre of gravity.

34. My model is much more limited and can do just one thing. It can stick out its arms. If we look closely, we will see that when the arms goes out, the centre of gravity changes. If it sticks both arms out to the same side, the vertical from the centre of gravity passes outside the base and the model would fall over if I allowed it.

35. Because not falling down and hurting ourselves is so important, we are well equipped with ways of detecting when we are moving away from being in a state of stable equilibrium.

36. One of these is our visual sense. We have a strong inbuilt sense of the horizontal and vertical. Our eyes tell us when we are leaning forward or backward or to one side or the other; in other

words when we are going away from the vertical and towards a state of unstable equilibrium.

37. We can check the importance of our visual sense to our balance by closing our eyes and seeing the effect. Staying in balance is much more difficult than when we have the visual cues from our eyes. Getting a new pair of glasses or contact lenses can also affect our balance.

38. We also have the vestibular system in our inner ear which tells us about the angle and movement of our head. We all know about the importance of the relationship of the head via the neck – we call it the head-neck relationship – is to our balance.

39. Sometimes when our vestibular system is not working as well as it should because we have an inner ear infection or even a heavy cold we can feel our balance is affected.

40. Because staying balance is so important we have a third major system which also tells us about our balance.

41. This is the set of pressure receptors in the soles of our feet. These are called the plantar receptors – the word plantar means *"relating to the sole of the foot".* If we think of the soles of our feet, we realise that they give us a very good sense of the orientation of our body in space. We can tell whether we are leaning forward or back or to one side or the other.

42. Together, these three systems, the eyes, the vestibular system, and the plantar receptors in the soles of the feet, provide the body – or the nervous system – with a continuing and very accurate sense of the orientation of the body in its environment.

43. They also alert us to when we are going off balance. And we have a very quick response to them when they warn us. Our immediate response to a feeling we are going off balance is to stiffen and stop the movement that is taking us off balance.

44. I then take compensatory action. If I am leaning to the left, I stick out my right arm which brings my centre of gravity back inside my base.

45. If I in danger of falling forward, I stick out my bottom which means I have to bend my knees and my ankles. I seem to have got myself into monkey.

46. But it is a rather stiff kind of monkey which is not very good for putting my hands on someone. So I free my neck and allow my body to sort itself out. My weight comes back from by toes. My muscles release. As Dr Roberts might say, my centre of gravity is comfortably back within my base.

47. The use of a nicely balanced and released monkey as a base for gentle movements of my hands and arms makes huge scientific sense.

48. I promised I would come back to the question of stable and unstable equilibrium. We automatically think that stable equilibrium is better than unstable equilibrium. But we need to be careful about that and this is a point that Walter used to make.

49. If we are in unstable equilibrium, it is easy for us to move. Having our feet wide apart makes it more difficult to move from one position to another. We have to make a bigger effort to shift our centre of gravity and bigger effort means more muscle stiffening. Walter was very clear that too much stability in our equilibrium can be a bad thing and he used to extol the virtues of what he called toppleability.

50. There is obviously no strict rule about any of this or the degree of toppleability we should have at any given moment. I suppose the best way of summing it up is to say that we need to have a balanced view about the question of balance.

REFERENCES

T. D. M. ROBERTS (1995) *Understanding balance: the mechanics of posture and locomotion* - Chapman and Hall, London.