Other types of feel

So far we've looked at feel as some form of feedback, relating the response to some rider initiated control action, but there are other factors which determine the overall feel of a bike. This can be as elementary as: Does the bike suit us ergonomically? Does it feel comfortable? There are other, more psychological factors at work. Do the controls work in a way that matches our intuitive or learned expectations? We have seen that counter-steering is by its very nature, a counter-intuitive feature and must be learned, whether consciously or not.

Funny handlebars

A little over twenty years ago I became very interested, quite by chance, in how some rather seemingly minor changes in control action could completely change the balance and steering feel. I had thought for a long time that the traditional, more or less, horizontal orientation of the handgrips was not the best for ordinary street riding. Stand up and let your arms hang loose by your side, now raise your arms up in front of you and I bet that most of you will find your hands pointing approximately vertical and you'll have to twist your arms to put your hands into the normal handlebar position. I reasoned that this twisting had to increase discomfort and tiredness.

So I made a special pair of bars to test my ideas, shown in photo 1. It really was great, I found it so comfortable and it reduced wrist ache on several long journeys. In total maybe about twenty or thirty people tried it and all but one or two loved it. I actually ended up converting several customers' bikes. Apart from the increased comfort there was no apparent change in the steering feel of the bike. Since then and quite independently, many mountain bikes have adopted a similar idea.

A little while later I was engaged in the design of some new motorcycles, named QL and Q2, with what is often called hub-centre steering. It was obvious that these wouldn't need a conventional steering head tube, and all the attendant frame structure, except to support the handlebars. There was no question that these machines wouldn't have the upright hand grips, and with a little bit of lateral thinking I arrived at a design that used two separate vertical levers pivoting about a horizontal axis across the bike, as shown in photo 2. These were linked together and to the steering system at the wheel. The linking was done such that a given steering angle required the same amount of movement at the hand grips as before. When stationary it felt – well just normal.

Photo 1. **Simple modifications to otherwise normal handlebars, resulted in increased comfort but with no degradation in steering feel nor performance. It was found that to exploit the comfort benefits it was necessary to adjust the fore and aft angle of the handgrips to suit each rider. The sideways angles was not critical.**

When I first rode it, there was a certain strangeness about the feel at low speeds which seemed to disappear above 10 mph or so. It wasn't any problem for me and after a couple of months of riding it almost exclusively I felt completely at home with it. However, I asked many others to ride it and the reaction was very mixed. Some people just could not even go one yard. I watched carefully and it was as if they just lost all tendency to counter-steer. Others wobbled about a lot when starting off but maintained balance OK. once under way. Still others like myself had no real troubles. The skill and experience levels of the different riders didn't seem to affect which group they fitted into. I'd fitted my long suffering BMW with the prototype suspension system for these tests and despite my confidence that this was not the problem, many pointed a finger to it. To cut a long story short, I converted the bike back to a handlebar system that pivoted about a relatively normal vertical axis, whilst retaining the new front suspension and vertical hand grips. the transformation was immediate and amazing. Even I, who had hardly ridden anything else for a while, found a sudden increase in confidence that I hadn't realized was lacking. There wasn't anybody who had problems riding it now.

The only thing that had really changed was the trajectory of the handgrips, but that was quite minimal for the steering required for normal riding. The change was obviously enough to cause differing levels of confusion in the minds of the various riders. Technically, the bike remained almost the same, a two inch movement on the same side handgrip would produce the same steering effect. There was just a small difference in the man / machine interface.

Photo 2. **Still using the semi-vertical handgrips as shown in photo 1. this test used two separate, but linked, vertical levers in place of normal handlebars. The comfort was still there (note the relaxed position of the rider's hand) but the steering feel of the bike changed. Strangely, some people were incapable of riding it at all. The author and the experienced Terry Snelling, tester for the other MCN (the English MotorCycle News), had no such problems as this shot shows. Using the same prototype front suspension system, conventional feel was restored when the levers were replaced with handlebars similar to those shown in photo 1, although retaining the semi-vertical handgrips.**

Photo 3. **Enjoying the QL (Quantum Leap). The handlebar experiments were designed to test various possibilities before the author committed to building the real thing, around 1984. Despite the bulky appearance this machine was very light-weight, aerodynamic and had excellent handling. The under-seat fuel tank freed covered luggage space in front of the rider and the tail section swallowed even more. Designed to pack a lot of miles into a day in comfort, but with sports handling rather than that of heavy touring bikes, it exceeded my expectations in all regards.**

Photo 4. **The second in the series of Q bikes designed and built by the author, this picture shows the radically styled (for the mid 1980s) Q2. A semi-vertical handgrip is clearly visible as is the so called hub-centre steering system. The Q2s were made in response to requests for a flash bike with many of the features of the preceding QL. Several examples of each model were built for customers.**

Recumbents and more funny handlebars

A few years ago I built a long wheelbase recumbent bicycle. These machines present some design challenges because the steering head tube is several feet in front of the rider. Various steering solutions have been adopted, including under-seat handlebars. Based on my previous experience with funny steering systems I decided to do a series of tests to find out which gave the easiest control and most natural feel, before I built the final machine. I also wanted to get the widest range of opinion and my teenage son would bring home several of his mates to test whatever I asked them. In fact we were all in close agreement about the feel of the different systems.

The first system tested was also the simplest, -- Direct connection. Special handlebars were fixed to the forks in normal fashion but reached back toward the rider and were bent such that the handgrips were across the bike in a position comfortable for the rider. This had an action similar to a boat tiller, the hand grips moved in an arc more or less left to right rather than the usual fore and aft. It was possible to ride this from the beginning with no additional practice, but we all found it quite wobbly and it didn't instil a lot of confidence.

The second system is used on a number of recumbents because it is also easy to implement mechanically. This used a steering column like a car which attached to the forks through a universal joint. Handgrips were in the same location as in the previous test, when in the straight ahead position. The steering column was approximately horizontal giving a near vertical plane of movement of the handgrips, rather like a car steering wheel. I must admit that I didn't approach the testing as open mindedly as I would have liked, but we all have preconceived notions which are hard to blankout. In the event, none of us were able to ride it more than a yard or so in the beginning. A frame mounted video camera showed that nobody was countersteering. Very strange? I practiced for half an hour a day for over a week before being able to travel any distance, even then I had to concentrate hard and think about every action. That said, it must be remembered that many people use this system daily.

The third and fourth systems used remote handlebars with a linkage connection to the forks. In both cases the handlebars pivoted about vertical axis giving a horizontal plane of handgrip motion, similar to a normal bike. In the third case the handlebars pivoted under the seat requiring one's arms to drop down nearly vertical. This is quite a common layout adopted by many recumbent builders. The fourth test had the pivot and handgrips approximately 15 inches in front of my chest, this was the same handgrip position as in tests one and two, and probably gives the closest control action to a normal bike that one can have on a LWB recumbent. Nobody had any problem riding with either of these two designs and the feel seemed quite natural, either one would have been suitable for the final bike. I actually choose the one with the bars in front of my chest simply because I found it more comfortable.

Counter-counter-steering

It seems obvious that counter-steering is a non-intuitive way to have to control a bike, and statistics show that it has been the base cause of more than a trivial number of accidents. It seems unfortunate that physics dictates that it is so. A clean sheet of paper approach to bike design might suggest that we try reversing the way in which handlebars work, a counter-counter-steering in other words. Pushing the right hand side handgrip forward would steer the wheel to the right rather than left as normal. Then to initiate a right turn we would push the left grip and pull the right, which seems more natural. Even if we could surmise that this might work at normal riding speeds where the degree of handlebar movement is small, it would seem that it would be very strange when doing a tight turn at very slow speed, where we would appear to be steering the wrong way.

Many years ago I met a chap who modified the handlebars on a BMX bike, to "opposite sense steering". He used it in a sideshow and offered a prize to anybody who could ride this bike just a few yards. I watched for a long time as each contender had a try and fell off virtually immediately, even if this had been a scientific test it would have been very easy to incorrectly conclude that this bike was unridable, yet the owner could get on and ride it around as easily as we would ride a normal bike, he turned tight figure of 8s, etc. There was also the occasion punter who came along and could ride it.

He only reversed the handlebar direction, none of the other factors affecting balance stability were altered. As we can ride bikes no hands it is obvious that it should also be possible to do the same regardless of the sense of the handlebars. The problem is simply that of a switch in our brains. When most people start to learn to ride a bike they have an initial problem with balance, because countersteering is hardly the most intuitive action, however after a bit of practice, the amount of which depends on the person, the brain suddenly switches phase and we can usually ride a bike for the rest of our lives.

Then when faced with opposite sense steering our brains are simply 180deg out of phase until after a bit of practice. I spent a lot of time talking to this chap and he said that it originally took him about 3 days of practice with this bike and then suddenly one day it all clicked into place, when his brain suddenly changed phase. I didn't think to ask him at the time but I'd be prepared to bet that after a while of ONLY riding this bike if he got back on a "normal" machine he would have great difficulty in riding it without practice. It would be interesting to find out what happens if you swapped back and forth between two such machines, my guess is that the brain would soon intuitively become more open minded and could switch phase as required.

Years ago I read of some experiments where people were given eye glasses which inverted the image. For a few days they'd wander around bumping into things and then one morning they'd wake up and everything seemed up the right way. After some time with these glasses, they were removed and surprise, surprise the world had turned upside down again.

Away the point I'm making is that you have to be very careful with tests involving living creatures, it's very easy to come to the wrong conclusions. The reversed steering bike appeared to be unridable but wasn't. One has to also ask the question "Unridable by whom?"

After seeing this reversed steering bike I was interested in learning more and I reasoned that an easy way to simulate this was simply to ride crossed arms. It took me a few days of daily practice with not riding normally and like the chap described above (and the eye experiments) one morning I could suddenly ride it quite easily. I continued to ride only like this for a few days more and then I changed back to normal riding, within a few minutes I could ride normally again. Obviously the learned responses of many years of riding were not easily un-learned in a week.

The Tom Bondhus experiments

In 1977 Tom Bondhus (the inventor of the ball end wrench) wrote some notes detailing his thoughts on bicycle and motorcycle steering and detailing some experiments on the same subject. I was able to buy a copy of these notes a few weeks back. He was not a skilled motorcyclist and wondered whether his feelings of insecurity were due to his own incompetence or a fundamental failing in a motorcycle. Recognizing the potential problems of counter-steering he initially tried reversed handlebar movement as above. His notes pass over this briefly, saying that there were difficulties with balance.

Bondhus was of the opinion that in order to produce a steering movement a rider would start by leaning his body into the turn and this would lead to subsequent hand and arm movements turning the bars. Now whilst this may apply in some cases, but anyone who has ridden either a recumbent bicycle, a foot forward motorcycle or the BMW C1 motor-scooter with its seat-belts knows that body lean is not an essential part of steering. Anyway, based on this belief his next experiment used handlebars that pivoted about a horizontal axis and so the handgrips moved up and down rather that back and fore. The idea being that as the rider lent to the left, he would push down on the left grip and this was communicated to the forks by means of bevel gears such that the forks turned to the right, to ultimately produce a turn to the left via counter-steering. The following is a direct quote from the Bondhus notes.

This worked fine but for the confusion set up in the mind of the operator, There was a tendency to revert to the old way and the danger of confusion was magnified rather than reduced. Our last development is to rotate the steering axis 70 degrees up, This gives the natural feel with no confusion and allows us to place the handle bars low; so that a maximum amount of force or power is maintained to give safe, stable control. This stability is sufficient; so that the bicycle will not fall down in loose sand or gravel as the conventional bicycle sometimes does. With the new "70 UP" steering, the operator does nothing in sand and gravel but enjoy the ride. The gears make all corrections automatically; to keep the machine perpendicular to the position of the handle bars.

With this "70 UP" steering the least experienced rider can ride as the best in loose sand and gravel without falling.

With this "70 UP" steering one turns in the same direction as the turn to avoid the danger of the confusion that conventional steering has. With this "70 UP" steering the handle bars move up and down, and cause the bicycle to respond exactly like the aileron (bank control) of an aeroplane. The bicycle stays perpendicular to the cross bar on the handle bar as the aeroplane follows the turn of the control wheel. Both turn to follow their bank naturally. Both must have their bank set up before they can turn. My device sets the bank. Turn is automatic.

Enthusiastic stuff, but can it really be that good? I don't know yet. As I commented above I have reservations about the feel on tight corners at slow speed. It's an interesting idea and the only real way to know is to repeat his tests. I intend to do this, firstly on an ordinary mountain bike and if that looks encouraging I'll do the same thing on a proper motorcycle rather than the small mopeds that Bondhus used. Watch this space, I'll report back.

Unfortunately, these sort of tests are fraught with human problems. We are all so conditioned by our prior experience and teaching, that we cannot simply un-learn this and approach the test of a new system untainted. Even if we sought out people who had never attempted to ride a bike before, they could not comment on the differences to a conventional system. If we then asked them to try a conventional system, they would have been pre-conditioned by their experience with the alternative system.

The only way to do the job properly would be to assemble a large group of people who had never ridden a bike and split the group into two. One group would use one only of the two systems (conventional and Bondhus), the other group would use the other system.
Once trained the groups would be put through some manoeuvring and riding tests, and their respective performances monitored. The chances of this happening are nil, and so I'll have to rely on the flawed and tainted judgement of myself and my son's mates.

No, it is not a crashed bike but, on the left, one of the Tom Bondhus test machines, showing the relationship between the handlebar movement with steering.
Above we can see the use of bevel gears to produce the required motion.

Summary

We have seen that feel exists on many different levels. Some aspects are purely subjective, whereas others have a scientific basis and could even be assigned numerical values if we had enough tyre and other data. The characteristics of tyres are largely resonsible for giving various mechanisms for us to develop a feel for the approach to the limit of adhesion, in braking, driving and cornering. The ability to sense this feel varies widely between riders, and this is what often differentiates between top racers. The concept of steering stiffness is important and is the core parameter for providing limit feel as well as a feel for the surface conditions. The main text has considered the tyre characteristics as being relatively steady. In practice, road disturbances are continually changing the ability of the tyres to generate grip, which leads to limit feel being less than ideal.

My own experiments with different steering controls have shown that the delicate mental balance between what feels intuitive and what appears impossible to ride can be very fine. It seems that we can be tolerant of various layouts as long as the plane of handlebar movement remains more horizontal than vertical. This is probably a result of prior experience with the counter-steering and counter-intuitive requirement of bicycles and motorcycles. The interesting Bondhus' experiments seem to indicate that a semi-vertical plane of handgrip movement is OK when combined with a "reversed" action.