

Oversteer and Understeer

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I've been getting a lot of questions about this topic again so here is a newer version of an article I wrote back in 2003: **What is the difference between oversteer and understeer?** The answer is deceptively uncomplicated with a bit of thought.

Oversteer is the tendency for a car to dive into a turn quicker (more) than you expected. In a Porsche this tendency is most often displayed in the early 911's where the rear of the car will swing to the outside of the turn. But in fact, most cars can display oversteer under the right conditions. Anyone who has flung a car around in a wet or snow-filled parking lot can attest to what oversteer feels like when his or her parent's car "swaps ends". Some call this "doin' doughnuts". It's great fun and good training for driving under wet and icy conditions as long as you don't get caught!

Although a firmly planted car is most often the faster one, in competition oversteer can be used to "set-up" a car for an upcoming "element" (usually a corner) of an autocross or track course.

Understeer is the tendency for a car to NOT turn when you tell it to do so. Frankly this can be a more frightening condition than oversteer depending on whether you have the room to go off of the road or track. This can be seen in both street and track cars, but is particularly annoying if there is a car (or some other object) in the path as you go wide in a turn.

What factors contribute to these conditions? Several things about your cars effect whether it will understeer or oversteer, and how much.

1. Balance: How much weight is on the front wheels compared to the back wheels. 924's, 944's, 928's are nicely balanced having close to 50/50% weight distributions. The 914's are next with approximately 45/65% front/rear distribution and the 911 and 356 come in with the most difference at nearly 40/60% with the most weight toward the rear of the car. Balance is considered by many to be the single most significant contributor to oversteer or understeer. Cars with a 50/50 weight distribution are referred to as "neutral". Once a car is neutral, or close to it, oversteer and understeer can be easily induced with skillfully applied throttle and braking, making **Power** a determining factor as well. Power can be used in any car though, as a handling tool. Right and left side balance is an issue as well and makes the car handle differently between the two directions.

For example: A car with radically non-symmetrical "corner weights" could execute a right turn much easier than turning to the left. This effect is much more pronounced when the chassis is very stiff and we have low-profile tires.

2. Tires and shocks:

Tires: The quality of your tires has a huge impact on the stability of the car to track reliably through a corner. Tire conditions such as compound and temperature tread pattern, air (or nitrogen) pressure, and age (heat cycles in racing tires) all come together to give you anything from poor to great traction. The combination of these factors has a direct effect on your ability to control over and understeer. Attention to tire pressures is critical to good performance.

Shocks: These suspension parts dampen vibration and oscillation of your suspension. Passenger-car shock absorbers control the rebound of your suspension back to its original position after the springs are compressed by bumps in the road. Many high-end racing shocks actually dampen in both directions and are tunable. In an engineering sense (mathematically) shocks are actually part of the spring system.

3. Springs: One can tune the amount of over or understeer by changing the spring rates on either end of the car. The effects are discussed below in the "Changing what you have" section.

4. Anti-sway Bars (also called "sway bars"): These suspension members control how much of the "load" put on either the right or left wheels is transferred to the other side of the car. This can help keep the tires on "unloaded" side down on the road. Most production cars (including Porsche) come with non-adjustable anti-sway bars on both the front and rear of the cars. Racing cars have adjustable bars to make changes. In general a larger bar, or stiffening an adjustable one has the same effect as installing bigger springs on that end of the car.

5. Chassis stiffness: All of the factors above contribute to the handling of your car but changes in them will have progressively less effect in a car that is not stiff. In the older cars the coupes are the stiffest with the Targa models next and the Cabriolet as the twistiest of the bunch. Even the coupes can be improved upon however by the inclusion of roll bars and more so with complete roll cages. Once any car has a complete roll cage it is very sensitive to changes in the preceding items. The newest cars are so stiff that except on the track you wouldn't need a rollcage since computer-aided design has allowed engineers to do marvelous things with sheet metal.

6. Polar Moment: Total weight and the distribution of it about the center of the car have a big effect on the speed at which the car will rotate into oversteer. This is referred to as a "polar moment of inertia" where the word "moment" derives from the word momentum.

Mid-engine cars, like the 914, Boxster (986), 904, 917, 956 and 962 typically have the lowest "moment" since the highest concentration of mass (or weight) is between the wheels. Like a figure skater spinning fast with his or her arms folded into their chest these cars will tend to spin quickly if pushed

(or braked) into oversteer. But they are the quickest cars in transition from right to left and back again and can often maintain a higher speed through the turns before they spin. As stated previously, the 924,944, and 928 are very evenly balanced.

They, like the 356, the 911 and even VW beetles however have a larger moment of inertia because much of their weight is located at the front and back of the car. This is much like the figure skater spinning with their arms stretched out, which tends to be at a slower rate. Although they will spin earlier than a mid-engine car, there is more time to react to it.

Changing what you have: Fine Ron, how do I decide what to change?

If your car is over or understeering more than you wish then the general guidelines are as follows:

1. To induce oversteer because your car won't turn in quickly enough:

- Stiffen the rear of the car with bigger springs, shocks, anti-sway bar, or some combination of these or. . . .
- Soften the front of the car with smaller springs, shocks, anti-sway bar, or some combination of these

2. To induce understeer because your car is "tail happy", reverse the above:

- Stiffen the front of the car with bigger springs, shocks, anti-sway bar, or some combination of these or. . . .
- Soften the rear of the car with smaller springs, shocks, anti-sway bar, or some combination of these

Factoids:

1. Making a change at one end of the car will affect the other end to some extent. Sometimes you have to make changes at both ends at once (not at the same time!).

2. Understeer can be overcome slightly with track tires by "sawing" the steering wheel back and forth while you are in the turn. Top speed around large radius turns can be increased with this method once you are in the turn and stable.

3. Oversteer and understeer can be modulated to "some degree" by simply adjusting tire pressures. Depending on your tire's size, rubber compound, aspect ratio, and the camber of your wheels (basically all those things mentioned above) you can get the car to handle very differently by changing the tire pressures a pound or two up or down. The effects are best measured if you make BIG changes rather than small ones. That way you are sure to feel them.

That's about all we have space for in this edition of the newsletter. Feel free to send questions via email or phone.

Keep the shiny side up!!!