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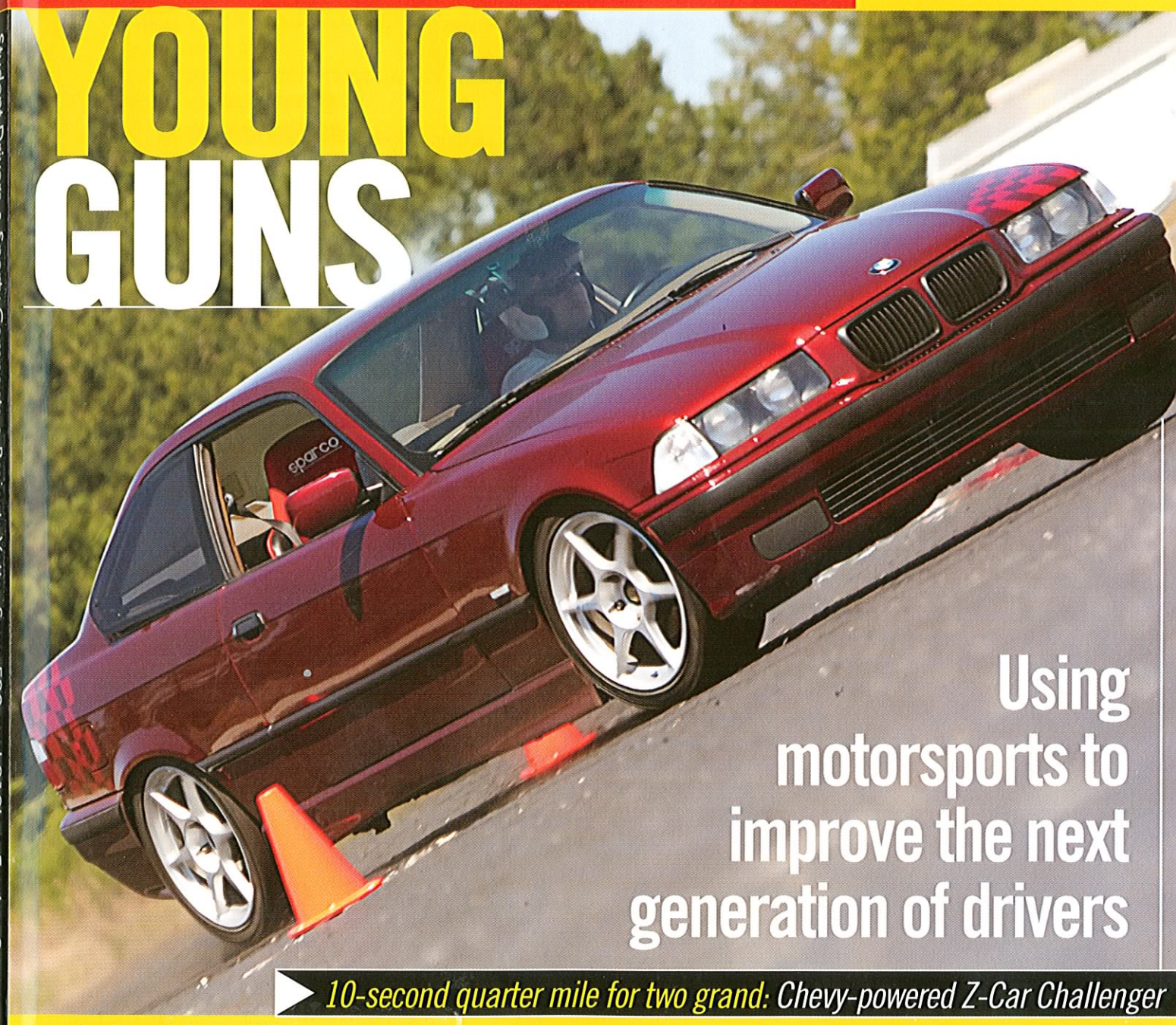

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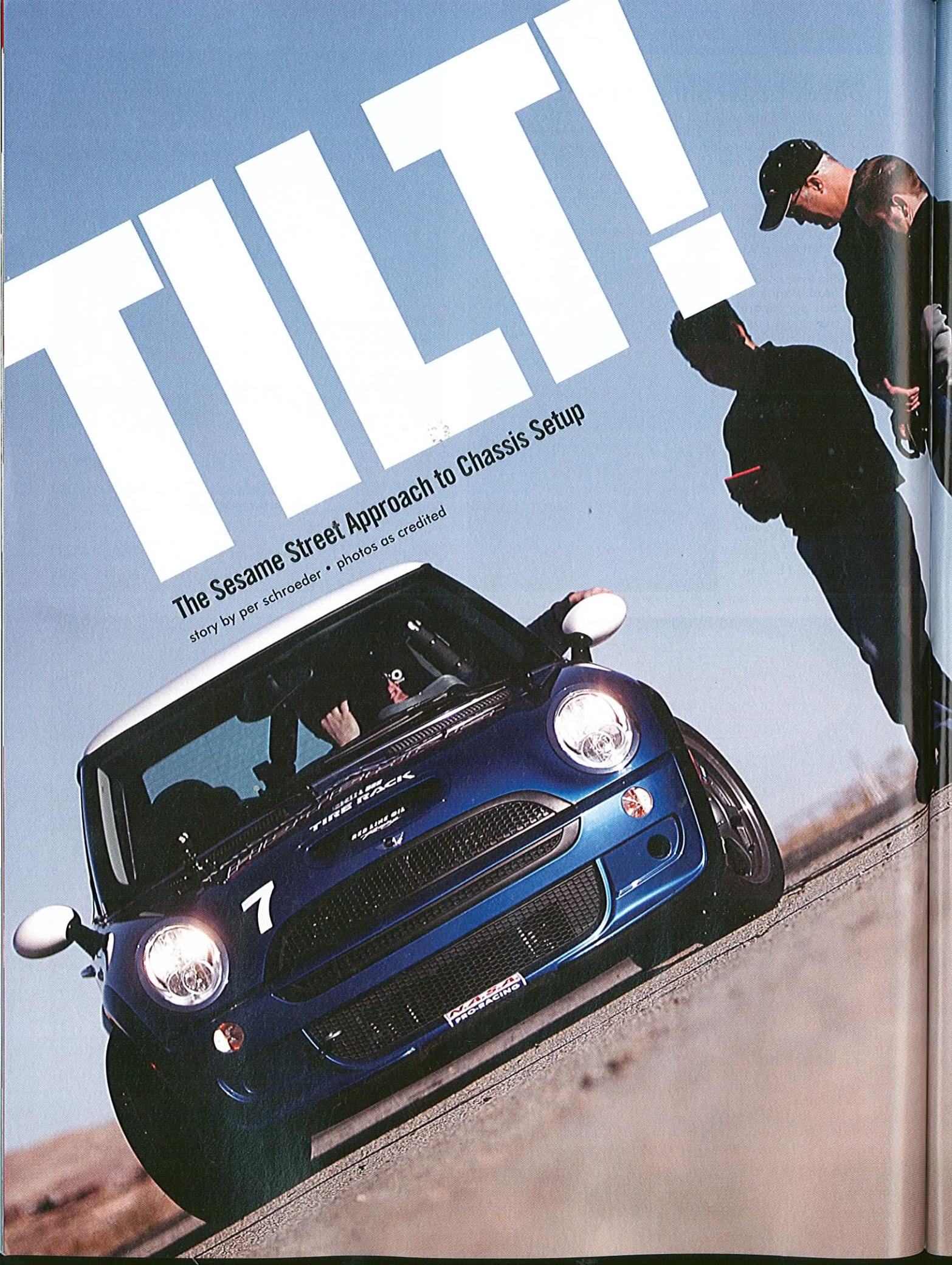
TILT!

The Sesame Street Approach to Chassis Setup

story by per schroeder • photos as credited



antonio alvendia photo

"School House Rock" might have had the cool name, but "Sesame Street" really rocked our worlds when we were youngsters. Jim Henson's puppets combined with entertaining lessons to shape our early lives. Not only did "Sesame Street" make us laugh, but it probably helped us more than our early formal schooling. We're even pretty sure that Bert and Ernie's domestic arrangement didn't turn us into creative-subversive types. (That was probably Mom's John Denver tapes.)

We especially liked the character Count von Count.

The Count liked to count things, and he did it obsessively. He counted bats, fruit, fruit bats, whatever. He taught us tykes about numbers through practical application and use. It was easy as one, two, three; three! Ah ha ha ha ha!

Now that we're all grown up, it's easy to forget just how effective those simple lessons were. No matter what the field, sophisticates throw around uppity jargon like monkeys flinging poo at tourists. Even we are guilty of this sin: When we're bench racing, we drop words like "camber" and "pyrometer" like they're common terms that don't need an explanation. While these truly are easy concepts to understand, it's not often that you see the practical application of their use laid bare.

And that's where this story comes in. It's time to back up a bit and revisit some of the basics of vehicle setup.

Let's start with camber and its effect on performance.

The word camber simply refers to angles and curvatures, and can mean anything from the slope of a roadway to the curvature of an airfoil. In automotive terms, camber is often used to describe the lean or tilt of a car's wheels. When viewed from the front or rear of the vehicle, the top of a wheel with negative camber leans in toward the center of the car. A wheel with positive camber leans away from the center of the car.

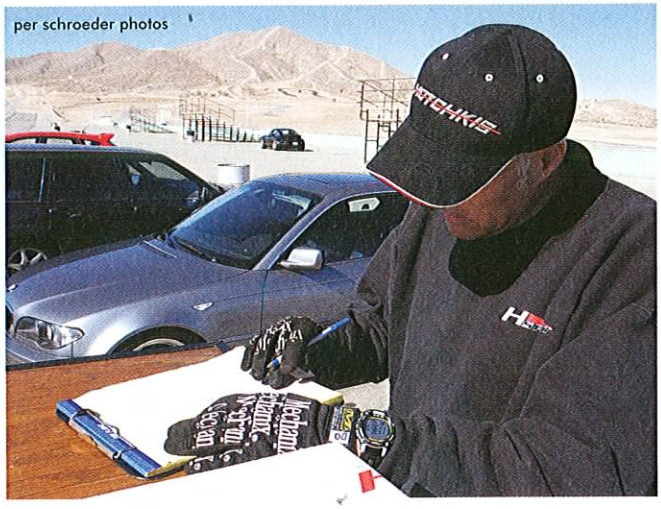
The camber angles of a car's suspension are important because they determine certain handling characteristics. Performance-oriented machines will have more negative camber than pedestrian street cars in order to counteract the natural lean of the chassis that occurs during high-g cornering. How much negative camber a car needs is an often-debated subject at tracks around the country.

Now let's look at a tool that's important when discussing camber. Meet the pyrometer. A pyrometer is simply a thermometer that is designed to measure high temperatures, such as those in a furnace. Pyrometers can also be used to measure the temperature across a tire's tread; hotter temperatures would indicate which portions of the tire are working harder.

While we can make educated guesses as to how much negative camber a car needs, the only way to really nail down the alignment is to do some hardcore testing with a stopwatch, a race track and a pyrometer. The actual process isn't that hard, so let's get started.

Aaron Ogawa and Corey Bedortha (kneeling) adjust the camber on our MINI Cooper S test car. This particular MINI runs Bilstein PSS9 coil-overs, Hotchkis anti-roll bars and a set of their adjustable camber plates. John Hotchkis (below) also helped with the test, taking copious notes throughout the day on how each alignment setting impacted tire temperatures and lap times.

per schroeder photos



Meet Hotchkis Tuning

Brothers Mark and John Hotchkis started their Santa Fe Springs, Calif.-based company in order to bring their extensive road racing experience to the performance aftermarket. Hotchkis Performance specializes in suspension gear for American, European and Japanese cars.

We spent a day at Willow Springs Raceway with John Hotchkis and his engineer, Aaron Ogawa. Our project involved dialing in the suspension of the company's test mule, a 2005 MINI Cooper S. The car was originally prepared for a short-lived spec MINI class, but it now sees duty at West Coast NASA events with various Hotchkis employees behind the wheel. In addition to a full complement of safety gear, their MINI was equipped with Bilstein PSS9 coil-overs, Hotchkis anti-roll bars and a set of the company's latest iteration of competition camber plates.

This last modification allows the camber angle of the front wheels to be quickly changed by simply loosening up a few bolts and sliding the top of the strut in or out. After each camber adjustment, the toe still needs to be reset; for our testing, we kept the total toe-out set at an eighth of an inch. (Toe refers to the relationship of two tires on the same axle when viewed from above.)

The MINI's stock treads were replaced with 17x7.5-inch SSR Competition wheels mounted with 225/45R17 Michelin Pilot Sport Cup tires. This was our first outing on these track tires and we came away impressed. Like the rest of the car, they performed admirably lap after lap.

Our testing at the Willow Springs facility used their smaller track, the Streets of Willow Springs. Unlike "Sesame Street," with its roadside garbage can/shanty towns and roaming bands of thug-puppets, Streets of Willow is a simple and safe track that has enough runoff room to make it rather easy to complete lap after lap at a consistent ten-tenths.

Each configuration would be run through a four-lap cycle. We'd run the circuit in a clockwise fashion, bypassing the recently added banked turn and blind crest. The Streets circuit has four major right-hand turns and three big lefts; the last turn is a hard right and, as a result, the left-front tire takes more than its share of abuse.

At the end of the fourth lap, we'd pit on the main straight so tire pressures and temperatures could be recorded. Each of the tires' temperatures would be measured in degrees Fahrenheit at three places along the face of the tread: outside, middle and inside. A handheld, probe-style pyrometer would allow us to record the actual temperature of the tread, not just the surface. Once the measurements were taken, the alignment could be reset for the next battery of laps.

One, One Degree of Camber

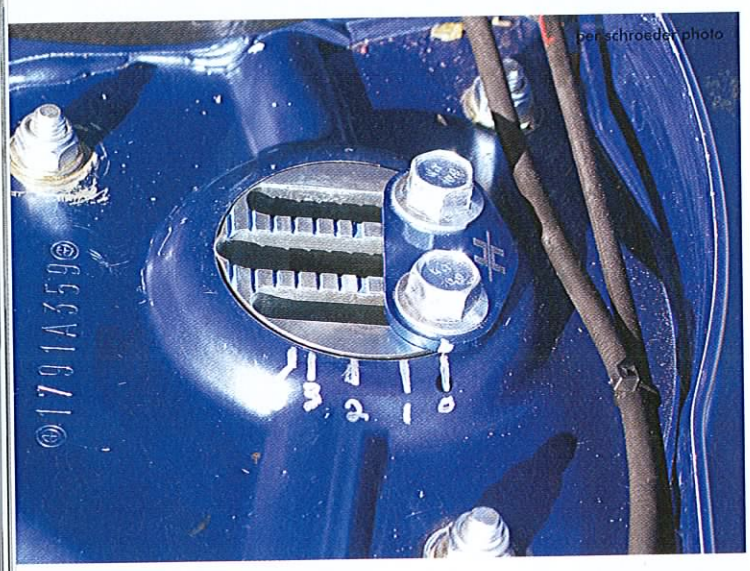
We started out our testing at one degree of negative camber, which is a touch more than the typical MINI factory setting of half a degree. At this setting, the car was predictable and easy to drive on corner entry. The sweeper speeds, however, felt very slow as body roll turned our low levels of static camber into dynamic positive camber.

The tire temperatures tell the story. The temperature spread on the left-front tire showed that the outside and middle edges were considerably

antonio alvendia photo

sources

Hotchkis Performance: car, parts, (888) 750-5854, www.hotchkis.net
NASA: event sanction, (510) 232-NASA, www.nasaproracing.com



per schroeder photo

warmer than the inner portions—there's a more than 40-degree spread in temps between the middle and inside edge. While conventional wisdom would suggest that this would indicate too much tire pressure, stiffly constructed modern R-compound tires aren't as pliable as old-school bias-ply slicks, and as such, don't always bow or flex enough to make this generalization true.

At this point, John recommended that we dial in our camber before we fine-tuned the tire pressures. He suggested that an alignment adjustment is a gross change, while tire pressures will take more fine tuning and will actually affect tire temperatures less.

In our case, the key temperatures we needed to look at were the inside and the middle readings. It was pretty clear that the inside of the tire wasn't working hard enough.

The right-front told a similar, if not quite as extreme, story, with a 25-degree difference between the inside and middle of the tire. Time to bring out the wrenches and dial in some more camber.

outside	middle	inside	inside	middle	outside
1 degree of camber					
	left front			**right front**	
159 F	169 F	125 F	118 F	143 F	130 F
	left rear			**right rear**	
113 F	118 F	101 F	91 F	100 F	93 F

Two, Two Degrees of Camber

At two degrees of negative camber, the MINI began to come alive. Our four-lap average dropped nearly one full second and our last pass was a corker at 63.14 seconds. The car would now hold its line through the track's sweeping right-hand corners and was even starting to rotate its rear end under drop throttle. Now we were having some fun.

The tire temperatures indicated that the inside edge of the tire was still under-worked, but now the left-front's inside was only 31 degrees cooler than the middle. The right-front was also looking better with a mere 18-degree difference between the middle and inside. It looked like we were heading in the right direction, so we pulled the car behind the wall and adjusted the camber and toe again.

outside	middle	inside	inside	middle	outside
2 degrees of camber					
	left front			**right front**	
155 F	165 F	134 F	137 F	155 F	134 F
	left rear			**right rear**	
102 F	114 F	98 F	113 F	112 F	104 F

Three, Three Degrees of Camber

Three degrees of negative camber sounds like a lot, and while it is for a street car, that's what it takes for track use on a MacPherson strut-equipped racer like our MINI. The body roll that occurs, even with track-worthy spring rates, is enough to make the big camber numbers necessary.

Unlike a double-wishbone suspension, a MacPherson strut suspension will have little or no camber gain during compression. A double-wishbone setup, like that found on a Miata or Integra, will have the suspension incline toward negative camber during compression, which counteracts the camber loss through body roll. So big camber it is for the MINI.

The tire temperatures after this session were now looking pretty good, with the inside and middle of the left-front a mere 13 degrees apart, while the outside temperature was pretty close to the inside. The right-front had just a nine-degree difference. Track times dropped another three tenths of a second on average, and we'd finally broken into the 62-second range.

On the downside, we were starting to get increased wheelspin on corner exit as a result of the negative camber reducing the tire's contact patch.

What About the Rears?

The pyrometer readings of the rear tires on a front-wheel-drive car just aren't that useful for tuning. The rear tires simply aren't being asked to do a lot most of the time and, as such, will typically only see heat on the outside edges. If you try to tune this out with more negative camber or by playing with the pressures, you won't be very successful and the car will handle worse than before.

Our advice is to first set your front pressures and camber figures, then use the rear pressure as a tuning aid to help the overall balance of the car. If there's too much understeer, don't be afraid of high pressures; we've run as much as 60 psi on the rear end of some extra-pushy cars in order to get the rear to rotate to our liking. (Exceed manufacturer specified limits at your own risk.)

There was also consistently more chatter from the MINI's ABS braking system, indicating that our reduced contact patch was also affecting our brake lockup.

Still, faster times are faster times. We decided to max out the available camber adjustment in the Hotchkis camber plates for another go.

outside	middle	inside	inside	middle	outside
3 degrees of camber					
	left front			**right front**	
141 F	151 F	138 F	124 F	135 F	117 F
	left rear			**right rear**	
101 F	110 F	98 F	98 F	103 F	99 F

Three and a Half, Three and a Half Degrees of Camber

A corner had been turned, as dialing in 3.5 degrees of negative camber didn't improve our lap times. While the temperatures were just five degrees apart across the face of the tire—a negligible amount—the MINI was now suffering from massive wheelspin on corner exit despite its limited-slip differential. There was simply not enough tread touching the ground on that inside tire. Stopping distances had also been increased, and we needed to adjust our braking points to compensate.

This is where practical examples diverge from complicated theories. Despite near-perfect tire temperatures, the car was now slower. (Surprisingly, some bits of pyrometer wisdom would indicate that even more negative camber would have been desirable, as the tire would theoretically have more grip with slightly hotter temperatures on the inside edge relative to the rest.)

The secret to this contradiction is that the MINI is a front-wheel-drive car and, as such, has to do more than just corner and brake with the front tires; these tires also have to accelerate the car.

The situation would probably be different if this was a rear-wheel-drive car, as we could most likely just drive around the braking issues while power delivery would be unaffected by the extra negative camber. A front-wheel-drive car with too much negative camber loses momentum on corner exit from wheelspin, and this negates the benefits of increased mid-corner grip.

outside	middle	inside	inside	middle	outside
3.5 degrees of camber					
	left front			**right front**	
131 F	136 F	134 F	120 F	122 F	110 F
	left rear			**right rear**	
109 F	112 F	104 F	107 F	103 F	102 F

Three, Three Degrees of Camber

Before calling it a day, we wanted to finish maxing out our setup. First we dialed the camber back to three degrees and lowered the pressures by two psi up front. We were rewarded with some very fast laps, now breaking into the 62-second range on average. Big grins were also part of the payoff.

Here's the funny part: Our pyrometer readings on the left-front tire were a mixed bag. The difference between the outside and middle of the tread didn't decrease as expected. In fact, they increased. However, the difference between the inside and middle dropped from 13 degrees to just seven.

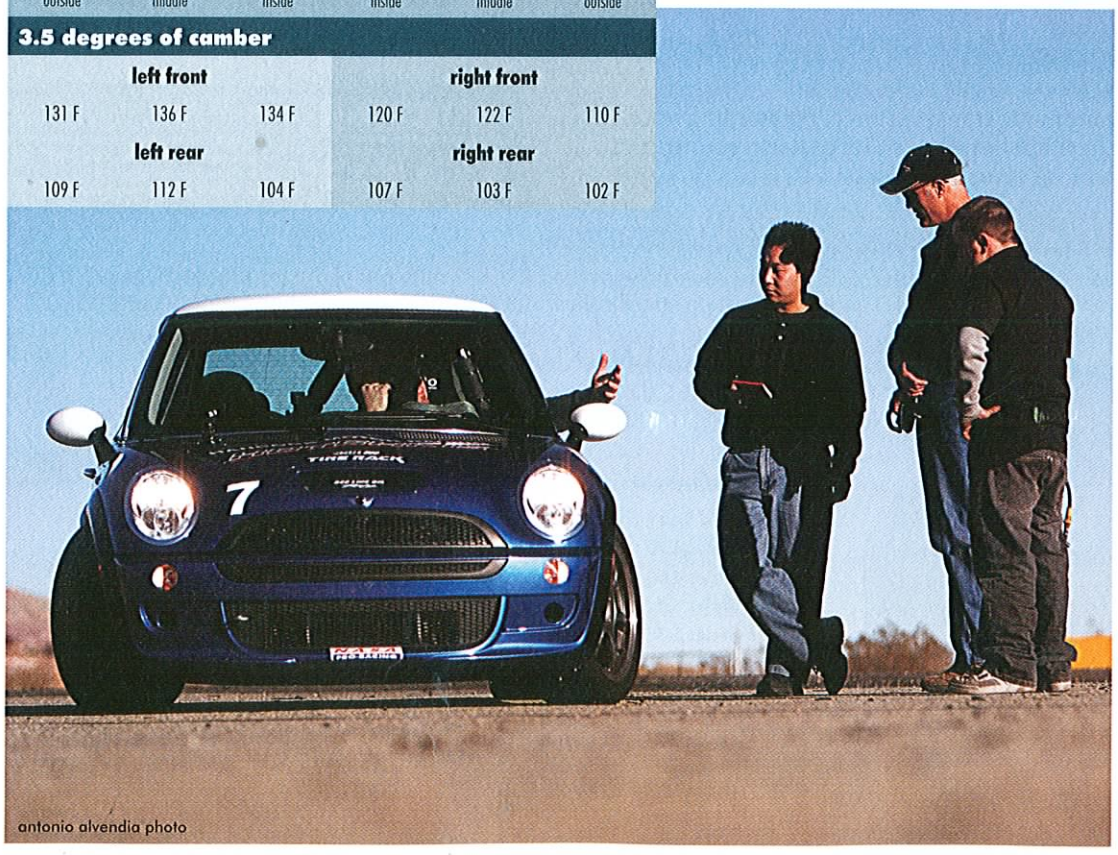
At the end of this Sesame Streets of Willow episode, we can come to the conclusion that testing delivers a lot of numbers to count and analyze. Only one set of numbers really matter, though: The ones on the stopwatch tell the real story.

As the Count would say, "One first-place trophy, two first-place trophies...."

outside	middle	inside	inside	middle	outside
3 degrees of camber w/2 psi reduction					
	left front			**right front**	
144 F	162 F	155 F	139 F	150 F	135 F
	left rear			**right rear**	
107 F	114 F	107 F	116 F	122 F	114 F

Lap Times					
camber	**-1°**	**-2°**	**-3°**	**-3.5°**	**-3° (-2psi)**
	64.67	63.84	63.38	63.24	62.65
	64.40	63.89	63.16	63.00	63.02
	64.48	63.36	63.46	63.32	62.65
	64.41	63.14	62.86	63.4	62.85
mean	**64.49**	**63.56**	**63.22**	**63.24**	**62.78**

All lap times are in seconds.



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