

Analysis of NHRA Bracket Racing Reaction Times

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Abstract

This study of winning reaction times in Elapsed Time Bracket Racing in the National Hot Rod Association used elimination data, consisting of more than thirty five thousand total runs, gathered from ten of the 117 NHRA member tracks in 2013. Nearly eighteen thousand "winning" runs were used for analysis of the following questions: (1) Are the mean reaction times of the three classes (sportsman, pro, and super pro) different; (2) Do reaction times change from earlier rounds to later rounds. A 2x3 ANOVA was used for analysis and the Fisher's LSD test was used for the post hoc analysis of differences among classes. In all cases the results were statistically significant. Super pro reaction times were twenty thousandths of a second faster than pro, which was twenty thousandths of a second faster than sportsman. The results of this study serve to validate and distinguish the separate classes of competition. Further investigation is necessary to better understand the relationship between reaction times and track as well as round interaction with tracks and classes.

Keywords

NHRA, drag racing, reaction time, E.T. Bracket, super pro, pro, sportsman

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INTRODUCTION

The research presented focuses on driver reaction time as one of the key components of winning in elapsed time (ET) bracket drag racing. The review of literature explains key concepts related to bracket racing and this study. The implications of the findings are discussed in terms of marketing bracket racing and managing bracket racing events.

The Track Management Perspective

A drag racing facility operator needs a “show” to attract spectators and racers. The weekly ET Bracket Racing “show” at a typical National Hot Rod Association (NHRA) member track consists of three primary classes of vehicles: sportsman, pro, and super-pro. The NHRA develops the rules and guidelines for drivers and vehicles in competition based on the particular class and the corresponding elapsed time range of the vehicle (J. Hullinger, personal communication, December 14, 2013). The track operator establishes a specific entry fee and payout schedule for each of the classes. Managing the weekly program to maximize car counts in each class contributes to a positive cash flow with regard to entry fees versus payouts (B. Bader, personal communication, December 14, 2013).

Bader suggests understanding the unique differences in the three classes beyond the rulebook aids the track operator in making decisions concerning the show that can affect the bottom line, such as altering entry fees and payouts. Each class has rules governing electronic technology that can be used to enhance starting line performance (NHRA, 2014). While any competitor can achieve a near perfect reaction time on occasion, racers generally agree that the starting line technology permitted in each advancing class contributes to better and more consistent reaction times. This perceived difference often prevents racers from competing in an advanced class (K. Dinkel, personal communication, February 8, 2014). For example, a sportsman class racer is not allowed the same technology of the pro class. Super Pro racer K. Dinkel explains that while the sportsman racer may be fast enough to enter the pro class, the racer will not likely do so as the sportsman vehicle is not equipped with the allowable starting line technology, putting the racer at a disadvantage.

If each class does have a significant difference in reaction times, that knowledge would be useful in the management of the facility. Both Hullinger and Bader believe knowing there is, or is not, a significant difference in reaction times between classes can help a track manage what classes to offer racers in a weekly program.

Need for the study

Racers are concerned about both the dial in and the reaction time as factors for winning. In a personal interview, sportsman racers believed the pro racer has a reaction time advantage due to starting line enhancements allowed in the rules for the class. Many magazine articles, internet blogs, and manufacturer websites proclaim that electronic technology, specifically designed for starting line enhancement, leads to faster and more consistent reaction times. Examples of these suggestions can be found in the magazine, *Drag Racing Online* (Nicholson, 2001), an internet blog on “Cutting a Light” (358T, 2004), and the website for Biondo Racing Products (Biondo Racing Products, Inc., n.d.). Track operators may use these same claims to make decisions about marketing programs to racers and spectators.

Problem Statement

The researchers of this study, also avid drag racing fans, found no studies of actual track data relevant to bracket racing. Amid conventional wisdom and speculation regarding reaction times, published research does not indicate the relationship between winning reaction times and variables such as class and round.

Research Questions

This study's focus is on winning reaction times. Based on interviews with track operator Bill Bader Jr. (personal communication, December 14, 2013) at Summit Motorsports Park in Norwalk, Ohio, and the NHRA Division 3 Director, Jay Hullinger (personal communication, December 14, 2013), the researchers focused this study on the following questions:

- Is there a difference among the means of winning reaction times of the three classes (sportsman, pro, and super pro)?
- Do winning reaction times change from earlier rounds to later rounds?

Assumptions

- The ten tracks selected for the study are representative of all 117 NHRA member tracks in 2013 as explained in the methodology.
- The tracks selected follow NHRA rules for the set-up of the timing equipment producing comparable results from one track to another (NHRA, 2014).

Limitations

- Track data from all 117 NHRA tracks were not available.
- Only winners were used.
- Winning reaction times over 1 second were excluded.
- Winning reaction times equal to or less than 0.000 were excluded.

REVIEW OF LITERATURE

Drag racing in North America has grown since the late 1940s into an extremely popular spectator and participant sport. By 1995, drag racing was attracting more than 10 million spectators annually (Thomas, 1995). By 2014, the National Hot Rod Association (NHRA), the largest motorsports sanctioning body and the foremost promoter of drag racing in the world, reported an avid fan base of 18.9 million and a total fan base of 78.5 million across the United States (NHRA, 2015). In 2010, NHRA reported 80,000 members and over 300,000 participants at more than 120 member tracks (NHRA, 2009). Drag racing was reported as the second most popular motorsport and the third largest sport in America (Hier, 2011).

The basic premise of drag racing in the early days could be described as, accelerate in a straight line from a standing start and get to the finish line before the other driver (Kirrane, 1997). In that era, the starter, the person who was responsible for lining up the two competitors would move to a position about 15 feet in front of and between the two and then start the race with a dramatic wave of a green flag. At the finish line were two judges who wave a flag for the winner. Fast forward to present day and drag racing could be summed up as, rev your engine, watch the "tree," anticipate the green light, mash the gas, and hope you have a better run than your competitor to turn on the win light. It may seem to some that that is all there is to drag racing (Post, 2001). Anyone behind the wheel or under the hood knows there is a lot more to it. Even in 1954, Yates

(1954) wrote that drag racing calls for everything that the Indianapolis 500 driver must have: sound judgment, an ear for motor adjustment and a cool head.

The evolution of drag racing was fueled by the addition of electronic timing systems and the construction of new dragstrip facilities throughout the US until the economic downturn in the mid-1970s (Byrd, 2013). Drag racing surged ahead once more with technological advances of electronic controls in essential automotive systems. Thoughtful crafting of rules allowing aftermarket technology in certain classes helped stimulate the participation of racers and attracted new spectators to the show. Handicapped racing is now the most popular participant form of drag racing in the NHRA and is where competitors' vehicles are "equalized" by means of a handicapped start (NHRA, 2009a). With the NHRA Elapsed Time (E.T.) Bracket Racing classes, virtually anyone can be competitive in practically any type of vehicle (NHRA, n.d.). By benefit of a time handicap, the drivers and fans get an invigorating "bam-bam," quick succession, start followed by the breath-holding excitement of a photo finish where the driver who gets there first without "breaking out," violating their handicap, is the winner (NHRA, 2014).

Many variables such as speed, dial-in, and reaction time of both the car and the driver have an effect on winning or losing (Green, n.d.). Temperature, humidity, altitude, lighting conditions, and track preparation affect the racing environment (McKenna, 2008). These variables are not included in the study. While many variables may have an effect on winning, this study is focused on winning reaction times of three classes of elapsed time bracket racing.

Elapsed Time Bracket Racing Explained

The theory of bracket racing is simple: a pair of similarly equipped vehicles is handicapped at the starting line by virtue of a staggered start so that they reach the finish line at precisely the same time creating a near photo finish (Miller, 2012). In theory, a vehicle that can traverse the distance in 7.00 seconds could be paired with a vehicle that could travel the distance in 6.00 seconds and both could reach the finish line at the same time if the 7.00 second vehicle was given a 1.00 second head start. A handicapped start system according to a dial-in was developed to do just that (NHRA, 2009a). Although there are many more rules for bracket racing, the following rules are important to this study (NHRA, 2014).

Dial-In Explained

The dial-in is a best guess to the hundredth of a second as to what time a racer's vehicle can run (NHRA, 2014). Typically, two rounds of practice are given to each competitor so they may best judge their performance on that particular day under the current conditions of the track and weather (McKenna, 2008). When eliminations are ready to begin, the track announcer will call the racers to the staging lanes. Depending on the individual track rules, the vehicles are paired in the staging lanes. A racer may decide what the dial-in should be before being called to the staging lanes or they may delay, but they must decide before exiting the staging lanes (Crossroads Dragway, 2014). Once the racer decides what the dial-in should be, the racer writes the dial-in on the vehicle's windshield and side windows according to the particular track rules. The tower personnel input the racer's number and dial-in into the race computer. The race computer determines the staggering of the bulbs on the tree to give the appropriate head start to the slower vehicle.

Staging

After the dial-ins are loaded into the race computer, the command is given to stage the pair of vehicles. Both vehicles will typically complete a burnout in the designated area to clean the tires and warm the surface of the tires in preparation for launch (Miller, 2012). The vehicles will proceed to the staging line to activate the Christmas Tree (NHRA, 2014b).

Christmas Tree

The Christmas Tree, or tree, is the starting signal to the racers (NHRA, n.d.). Each side of the tree consists of a set of pre-stage and stage bulbs; three amber bulbs; a green light; and a red light (NHRA, 2009a). The pre-stage bulbs are the topmost set of bulbs and typically consist of two 60-watt yellow incandescent bulbs. The stage bulbs are next and like the pre-stage consist of two 60-watt yellow incandescent bulbs. The next three bulbs are large amber LED floodlights. LED bulbs are used instead of incandescent bulbs due to the time it takes for incandescent bulbs to produce light after the application of voltage (Slavik, Flannagan, Sato, Traube, & Aoki, 1993). Once the first amber LED bulb is lit, the following two are lit in sequence 0.500 seconds apart. The green floodlight is lit 0.500 seconds after the last amber providing the racer did not leave the stage beam. If the vehicle moves too soon and trips the stage beam before the green light cycles on, the green light will not illuminate and a red light will be lit in its place. In handicapped racing both competitors must turn on the stage lights to activate the tree. The three ambers then countdown to go for each competitor based on the difference in dial-ins (McKenna, 2008).

Breakout Explained

Dialing a vehicle can be tricky. At first read, a racer may simply attempt to put a slow dial-in on the car to get a big head start. This might be considered cheating. In drag racing, it is often referred to as sandbagging (McKenna, 2008). A racer might sandbag if they would rather race almost to the finish line and then let off the gas and either coast or apply the brakes through the finish line. To combat the tendency to dial-in slow, if the racer goes faster than the dial-in, the racer breaks out and is eliminated (NHRA, 2014).

Reaction Time

A timing sensor, or stage beam, determines precisely when the vehicle leaves the starting line. (Miller, 2012). A pre-stage beam helps the racer position the vehicle at the same starting point by letting the racer know when the vehicle is close to the staging beam. The pre-stage beams and stage beams are placed one and one-half inches above the racing surface and seven inches apart (McKenna, 2008). The goal for every racer is to have the better reaction time without tripping the red light. The key is to stage the car exactly the same way every time and take off at the same point every time to keep the reaction time as close to 0.000 seconds as possible without going under, which causes the red light to come on. In this system, the best reaction time is a 0.000 seconds, which means the front tires uncovered the infrared or laser stage beams at precisely the same time as the green light was activated (Miller, 2012). Note that the green light typically takes a few thousandths of a second to activate. Also, note that the tires had to roll through the stage beam before the timer started. In essence, this means the driver had to step on the gas and release the brake before the green light glowed (Hand, 2010).

Winning

A racer attempts to leave the starting line as soon as possible and run as close to the dial-in without breaking out (McKenna, 2008). Reaction times determine who left the line first in

relation to when they were supposed to leave (NHRA, n.d.). The track timers start when the stage beam is tripped and end when the finish line beam is tripped. There are two keys to winning: a driver's reaction time and their dial-in (Miller, 2012). As long as neither driver red-lights or breaks out, the first one to the finish line is the winner. If both drivers red-light, the first driver to red-light loses. In this situation, there may be an advantage to being the faster vehicle as the slower car leaves first (Hand, 2014). If both drivers break out, the driver who breaks out the least is the winner. The 'first-or-worst' rule applies: a red-light always loses to a breakout (NHRA, 2014). If breakouts are the only fouls, the worst breakout always loses. The situations described above that tends to make the data non-normal.

Classes

There are a wide variety of vehicles used in drag racing. From purpose built, long and narrow dragsters to street legal stock vehicles, there is a class in which to compete in the world of NHRA drag racing. The rules of the three classes of elapsed time bracket racing are explained relative to reaction time (NHRA, 2014).

Sportsman

The sportsman class best resembles a stock street-legal vehicle. A racer could buy a brand new vehicle from a new car dealership, drive it to the drag strip, and enter the vehicle in the sportsman class. Drag racing slicks are allowed. No aftermarket starting line enhancers are allowed. The driver leaves the starting line by releasing the brake with the foot and stepping on the gas pedal. No vehicle in this class can go faster than 7.50 seconds in the 1/8th mile or 12.00 seconds in the 1/4 mile (NHRA, 2014).

Pro

In the pro class, vehicles are much faster, but still mostly resemble street-legal vehicles. In addition to other modifications, the vehicles are allowed a transbrake system for improved reaction times. When activated, this transbrake effectively locks the transmission in 1st gear and reverse gear at the same time. When the transbrake button is released, the transbrake solenoid dumps the pressure in the reverse circuit allowing forward movement. This feature allows the driver to have the gas pedal pushed to the floor while not applying the brakes. Instead of starting the vehicle with two feet (one on the gas and one on the brake), in a coordinated action, the driver need only release a button to launch the vehicle (Magnante, 2003). Vehicles in this class must dial-in no faster than 5.70 seconds in the 1/8th mile or 9.00 seconds in the 1/4 mile (NHRA, 2014).

Super Pro

Highly modified vehicles make up this class, which allows dial-ins as low as 4.50 seconds in the 1/8th mile and 7.00 seconds in the 1/4 mile (NHRA, 2014). Along with many performance advantages and safety devices, the driver is allowed another important starting line enhancement: a delay box. The delay box takes into account the differences in the dial-in between the two competitors and the reaction time of the vehicle (Oberauer, n.d.). The driver can program the delay box to delay the release of the transbrake solenoid from the time of activation (Beard, 1999; Biondo Racing Products, Inc., n.d.). The driver can then concentrate on staging the vehicle precisely the same every time and letting off the transbrake button at the moment the driver sees the first amber (Magnante, 2003). Remember, the tree activates each amber bulb in sequence in 0.5 second intervals. Also, in this category, the tree activation is modified slightly. The top amber bulbs in each lane come on at the same time with the difference in dial-in added to the second bulb of the

faster vehicle. Once both vehicles are staged, the tree is activated within two seconds (NHRA, 2014). In this class, the driver concentrates on the top section of the tree, paying close attention to how and when both vehicles turn on the stage lights and then reacting to the first amber that will light within two seconds (Oberauer, n.d.).

METHODOLOGY

Availability of Track Data

For the research to be more robust and generalizable, the track data need to come from a sample of race tracks across the regions. Bracket racing data is difficult to obtain from individual tracks. The researchers queried six drag race facilities in an effort to obtain track data. What the researchers found was that none of the tracks queried kept bracket racing data by rounds. The timing systems simply do not create such data in a readily usable format. In fact, the round by round data is essentially deleted before the next event. The researchers were able to get a local track operator to agree to send a copy of the printed round sheets for each week to the researchers. This method would require the building of an extensive database by hand keyed entry. This was dismissed as too time intensive, not to mention the extreme likelihood of errors due to hand keyed entry.

While discussing the issue with track operators, the researchers discovered a tool that would provide the necessary data. Harry Fair created 1320go.com to report round by round results to racers and fans in real time. The idea is simple. The track's timing system is linked to an internet-connected computer via an appropriate cable which is internet-connected to the server at 1320go.com's headquarters. The track's timing system transmits data for each round, as it happens, to the server, which then updates the website. Racers and spectators can see the data in nearly real time at the event or anywhere in the world via the internet (1320go, 2014).

The servers of 1320go.com not only report the run data but also store the data in a retrievable format. Several NHRA race tracks use the service. While not all the NHRA tracks use 1320go.com on a regular basis for bracket racing purposes, more than enough do for research purposes (1320go, 2014).

Track Selection

A full multi-track membership in 1320go.com which includes access to run data from all classes and all tracks using 1320go.com (1320go, 2014) was used to collect data. All NHRA member tracks were parsed out from the list of tracks and sanctioning bodies (NHRA, 2013). Of the 29 NHRA tracks using 1320go.com services, some used the service for special events rather than a weekly program, while others did not use the service at all in 2013. Ultimately, the data revealed that ten tracks collected weekly data for the bracket classes in 2013. All ten tracks were used in the sample. These ten NHRA member tracks represent eight of the eighty-eight 1320-foot, quarter-mile tracks and two of the twenty-nine 660-foot, eighth-mile tracks (NHRA, 2013). The researchers considered these ten tracks a random sample of the whole because the tracks selected were proportionally representative of the number of quarter-mile and eighth-mile tracks, from five of the seven regions in NHRA, and included a wide range of facilities according to the NHRA Division 3 Director Jay Hullinger.

Variables

The dependent variable is reaction time; it is measured on an interval scale. In this situation 0.000 seconds is considered a perfect light. Any number greater than 0.000 seconds indicates the time from green light activation to the tripping of the stage beam. Any negative number indicates a red-light foul start meaning the stage beam was tripped before the green light was activated. The independent variables are class and round. *Class* refers to the three racing classes of sportsman, pro, and super pro; these are ordinal (ranked) categories. *Round* refers to the elimination round or trial. Because the numbers of trials vary, with better drivers much more likely to have more than two rounds (losing drivers do not advance), and because some tracks have buy-backs in rounds one and or two, the first and second rounds were pooled into one group and rounds three and higher into another group. This grouping allows the testing of the effect of being in a higher round compared to a lower without the complications of dealing with nine rounds, each with a diminishing sample size.

The Distribution of Reaction Time

A decision was made to exclude from analysis any reaction times over 1 second, considering them outliers; 99.8% of reaction times range from -0.5 to 1.0, with 9 out of 10 drivers have a reaction time ranging from -0.024 to 0.182 (average = 0.051, median = .031). Based on the researchers' drag racing experience it was judged that most of the reaction times less than or equal to 1 second were honest (but slow) reactions, whereas most of the reaction times over one second were due to problems. Less than one hundred of the reaction times in the sample of almost 36,000 were over 1 second. Therefore, the trimming of these few reaction times had no statistical effect on results. Our research questions were delimited to winning reaction times. While 4% of winning reaction times are less than or equal to zero, those wins are due to single passes or the losing racer red-lighting first. Selecting winning racers with reaction times within the range of $0 < x \leq 1$ resulted in a new data set with a sample size of 17,907.

The distribution of reaction times of winning racers, as described above, is non-normal (see Figure 1). Normal probability plots compare the actual cumulative proportion under the curve to the expected, normal, cumulative proportion under the curve; many persons favor this for judging normality because the person can visually judge how much the actual cumulative proportion is not normal, i.e., how far the plotted points deviate from the expected diagonal. Figure 2 displays the normal probability plot for Super Pro winners. The distribution of each racing class had the same non-normal shape. As described earlier, this non-normal distribution of winning reaction times may be attributed to trying to be as close to zero but not under (red light foul). A natural log transformation of the reaction times resulted in normalizing the distribution as can be seen in the probability chart in Figure 3. Thus, the results of the ANOVA and *post hoc* tests are in the natural log form of the reaction times.

Sample Size and Error Rates

An *a priori* Type I error rate of .05 was used. A sample size of almost 18,000 has consequences for decision-making. With this sample size, the Type II error rate is extremely small, even with a very small effect size. Reaction times of 0.01 seconds or less are of practical significance because margins of victories are measured in thousandths of a second. The

researchers noted many margins of victory *under* .001 seconds. Reaction times and race times are measured to three and four decimal places depending on the timing system in use. Therefore, a very sensitive test is appropriate. The actual effect size, power, and practical significance of the findings will be addressed later.

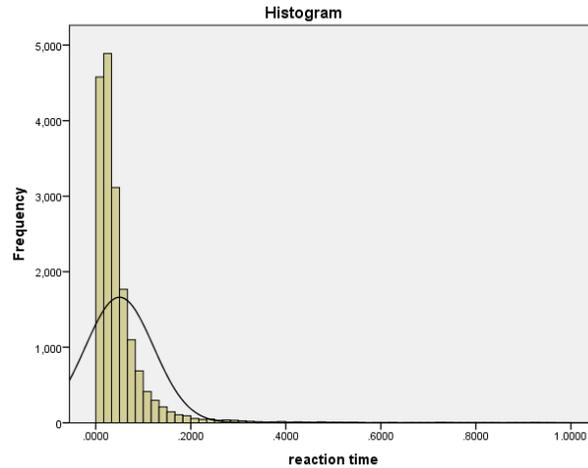


Figure 1. Histogram of Reaction Time: All classes pooled.

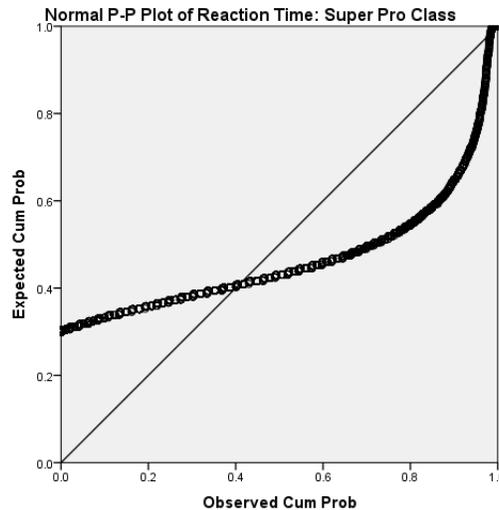


Figure 2. Probability Plot of Reaction Time of Super Pro Winning Racers.

Statistical Method

The null hypotheses that (a) there is no difference among classes, (b) there is no difference between rounds, and (c) there is no interaction between round and class was tested with a 2x3 ANOVA. Homogeneity of variance is an assumption of ANOVA. Using Levene's test of equality of variances, this assumption was not met, $F(5,17901) = 2.414$, $p = .034$. However, ANOVA is robust to this violation, especially when the probability of the main ANOVA model test is extreme,

i.e., either close to 1.0 or 0.0 to several decimal places (which was the case in this instance) (Warner, 2013). Fisher's LSD test was used for the *post hoc* analysis of differences among classes.

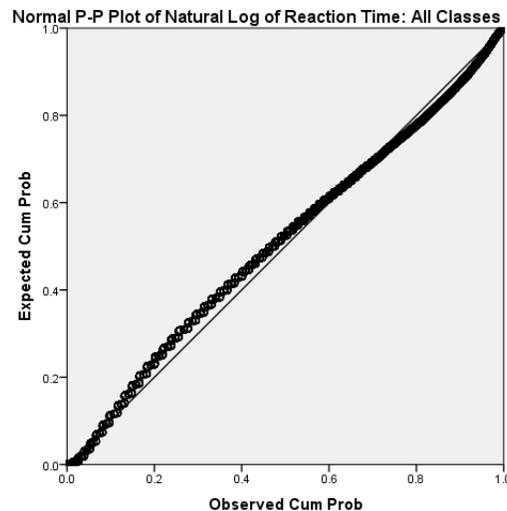


Figure 3. Probability Chart of Transformed Reaction Times for all Winning Racers.

RESULTS

Table 1 displays the means and medians of winning reaction times broken down by class and round. Class was significant, $F(2; 17,901) = 1,214, p < .001$. The partial *eta* squared value of approximately 12% is the variance explained by class after excluding the variance explained by other terms. As a rule of thumb, this is a moderate effect size. The *post hoc* multiple comparison analysis of class found that all classes are significantly different from each other. Pro class winners have faster reaction times than the sportsman class. The super pro class has faster reaction times than the pro class. See Tables 2 and 3.

Round was significant, $F(1; 17,901) = 115, p < .001$. Upper rounds have faster reaction times than lower rounds. Though round is significant, its effect size is weak.

The interaction of class and round was significant, $F(2; 17,901) = 11.8, p < .001$. While all three classes have faster reaction times in upper rounds than lower rounds, sportsman reaction times improve in upper rounds more than pro and super pro. See Figure 4. The effect size of the interaction is very weak.

DISCUSSION

The results indicated a statistically significant difference exists between classes in the order of the allowed starting line technology for each class. While this was hypothesized, the actual difference was far more than expected. The results from early rounds to late rounds are also statistically significant for each class. This was also expected as losers are eliminated in each round leaving the better racers continuing in competition. The authors do believe, based on their racing experience, the relatively small differences in reaction time due to round, e.g., a 0.024 difference

in the mean reaction time of sportsman lower and upper rounds, are of practical significance. As Figure 4 indicates, the sportsman class improved more than pro and pro more than super pro from early to late rounds. This too is expected, because the desired or targeted reaction time is to be as close as possible to 0.000 (without going under) and because sportsman racers are further away from the target, the sportsman class racer has more room to improve than pro and super pro. Likewise, because the margin for improving is less for super pro, as they are much closer to the targeted reaction time of zero, it is logical they would improve the least in later rounds.

Table 1
Means and Medians of Winning Reaction Times

		Mean	Median
Sportsman	Lower Rounds	.086	.031
	Upper Rounds	.062	.047
	All Rounds	.079	.056
Pro	Lower Rounds	.052	.037
	Upper Rounds	.046	.032
	All Rounds	.050	.035
Super pro	Lower Rounds	.028	.019
	Upper Rounds	.028	.018
	All Rounds	.028	.019
All Classes	Lower Rounds	.052	.033
	Upper Rounds	.044	.028
	All Rounds	.050	.031

Table 2
ANOVA Table: Class and Round

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3139	5	628	637	.000	.151
Intercept	180663	1	180663	183446	.000	.911
Class	2392	2	11956	1214	.000	.119
Round	113	1	113	115	.000	.006
Class X Round	23.26	2	11.63	12	.000	.001
Error	17629	17901	.985			
Total	244949	17907				
Corrected Total	20768	17906				

Table 3
Post hoc LSD Multiple Comparisons of Class

(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Sportsman	Pro	.456	0.0189	0.000	0.419	0.493
	Super pro	1.074	0.0198	0.000	1.035	1.113
Pro	Sportsman	-.456	0.0189	0.000	-0.493	-0.419
	Super pro	.618	0.0172	0.000	0.584	0.651
Super pro	Sportsman	-1.074	0.0198	0.000	-1.113	-1.035
	Pro	-.618	0.0172	0.000	-0.651	-0.584

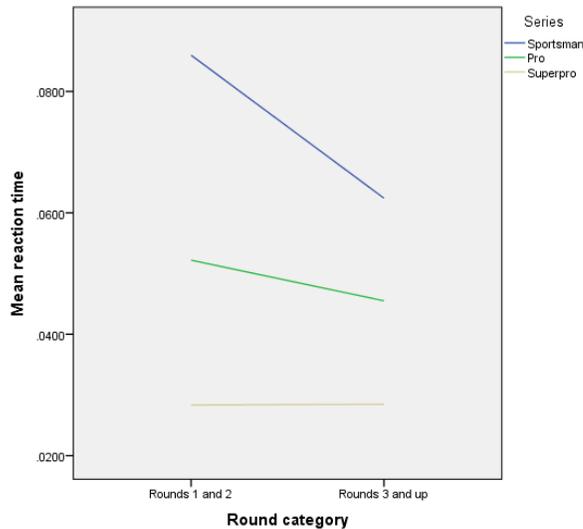


Figure 4
Plot of Class vs Round Winning Reaction Times

As discussed earlier, the technology used to improve and or reduce the variability in reaction times advances at each higher level of bracket racing. The results of the study indicate the levels of starting line technology allowed in each class may have an impact on the improved reaction times. In drag racing, where races are often won by total margins of victory less than 0.001 seconds, and where dial-ins of vehicles are written to 0.01 (hundredth) of a second, a 0.01 second difference in reaction time is of statistical and practical significance.

Over 35,000 elimination runs (including both winners and losers) in 2013, from 10 of the 117 NHRA member tracks, across three of the seven NHRA Divisions, were analyzed. The results show winning super pro racers have nearly twenty thousandth's of a second (0.020) better reaction times than winning pro racers and winning pro racers have nearly the same twenty thousandth's of a second (0.020) better reaction times than the winning sportsman racers. To a racer, a 0.020 average starting line advantage can easily be the difference in winning and losing. While one may

presume that younger, less experienced drivers may be more prominent in the sportsman class, this study does not involve age or experience.

Improving the Current and Future Status of the Industry

Bracket racing is the most popular participant form of NHRA drag racing. Bringing statistical evidence to the sport in this form of run data helps to promote and validate the sport. The reader now knows each class has statistically significantly different reaction times. This information could be useful to many stakeholders including the NHRA sanctioning body, track operators, racers, and aftermarket equipment manufacturers. The NHRA rules committee has statistical results to reinforce and validate the rules currently in place to help distinguish classes.

When considering the approved technology for each class, the handicapped system of bracket racing has created an entire aftermarket electronics industry helping drivers take the fullest advantage of the Christmas Tree system for launching their cars (NHRA, 2009a). Aftermarket manufacturers can use this information to tailor the marketing of their products to certain class racers. The information presented may add statistical validity to those claims. In addition, the manufacturers can more effectively market that every racer in a particular class should have every starting line enhancement allowed by the rules.

Racers could use this information to help determine what class they wish to run in and what equipment they wish to install to maximize their starting line advantage. Maybe a sportsman racer will be encouraged by knowing the average reaction time of winning pro racers and will try the higher class because the technology allowed may create the faster reaction time, not necessarily the skill of the driver.

This information is extremely useful for the track operator who continually tries to create a new element to the weekly show. In one example a “King of the Track” program is offered through the NHRA, which provides a unique trophy to each member track for use in a similarly named event. The idea is that there is only one winner for the event among all classes. The track operator has the opportunity to create the rules for operating the event. The track operator may run all the King of the Track participants (consisting of the three classes) together from the beginning of the race. Knowing that there is a statistically significant difference between classes, the track operator may wish to consider running each class separately and then combining the three classes at the end of the event instead of combining all classes at the beginning. Communicating (marketing) the information appropriately to potential participants can help the track operator increase car counts and ultimately improve the success of the event.

In another example, a track promoter, perhaps due to low car counts in a particular class, may be considering combining classes such as sportsman and pro in order to; increase car counts in the class, reduce the total payout for the overall event, and increase or maintain class payouts. This information shows that the sportsman racer would be at a significant disadvantage from the starting line.

The track promoter could use this information to market bracket racing participation to the racers who come out on street nights, fun nights, or grudge racing nights. These racers typically just come out to have fun by making multiple timed passes in their vehicles without actually racing anyone. The reaction time information from this study could be presented to show how quick of a reaction time the average winning bracket racer has in a particular class. The racer who participates on open night might learn he or she has similar reaction times to the sportsman winners. With

encouragement by the management, the open night racer could be converted into a weekly bracket racer contributing more to the bottom line of the successful race track.

Conclusion

The impetus for this study was the scant research available related to bracket racing. This study increases the body of knowledge regarding elapsed time bracket drag racing. Further studies should be conducted to help understand many other factors of bracket drag racing. It is suggested that studies be conducted to determine the variables that influence winning, e.g., the amount of variance attributable to each variable and the optimal variable values to predict a win. For instance, does the right or left lane make a difference in winning? Does the faster dial-in have an advantage? Does the faster vehicle break out more or less than its competitor? An investigation of the distribution of margin of victory could be useful. Finally, an experiment could be developed to determine causality of differences in reaction time between classes, e.g. what effect do drivers play in reaction time compared to the technology.

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