

George,

I really like the changes you made to this draft of your paper. I can tell you are passionate about this and I am impressed with how well you utilized your research here. Good work!

This essay would have been stronger if some of the small typos and other errors were edited out of the paper.

There also could have been more discussion about how the hypercar industry works with the large manufacturers and provided some more specific examples as to how this relationship works.

I would like to use this essay as a positive example for future classes. If you agree to this, please email me a corrected copy of the paper at your earliest convenience.

Let me know if you have any questions.

APA formatting	15 of 15
Development and understanding of topic	20 of 20
Effectiveness of Required Sections	15 of 15
Reliability of Sources/Citations	20 of 20
Grammar/Style	18 of 20
Improvement	10 of 10
Final Grade	98 of 100 A

Dan

Why do Hypercars Matter: The Explanation of What Goes on in an Automobile Enthusiast's

Mind

George W. Pappas

Eng. 102.030

Inst. Dan Portincaso

APA Academic Debate Research Essay – Final Draft

April 17, 2017

Abstract

In the automotive world, there is a debate about why Hypercars matter. This paper takes on the task of explaining what a Hypercar is and why they are needed in the automobile industry. The most well-known examples of Hypercars come from Porsche, Koenigsegg, Ferrari, and McLaren. All four of these Hypercar manufacturers have innovated the automobile industry in different ways. These innovations include the use of carbon fiber, 3D printing, and regenerative braking; all of which will trickle down into the automobiles that are for everyday use.

Why do Hypercars Matter: The Explanation of What Goes on in an Automobile Enthusiast's Mind

The Koenigsegg One:1; built through 2014 – 2015, is an extreme automobile that can hit 400 km/h (about 249 mph) in 20 seconds flat, it can stop from 400 km/h in just 10 seconds, and it has a max lateral g-force of 2.0 g. (One:1, n.d.). This is a car that only seven people in the world will be able to own. Not because buyers cannot afford the car, but because Koenigsegg Automotive will only produce seven of this specific model. This record-breaking automobile is the very definition of what a Hypercar is.

What are Hypercars

Hypercars are the fastest, the quickest, best handling, best performing cars on the road. These cars have a combination of sleek style and outrageous performance that evokes emotion in the viewer and the driver. They are not made for simply going from point A to B; these cars are built for true, and very rich, automotive enthusiasts.

Hypercars are the cutting edge of the automobile industry, and for good reason. With common cars and common sport cars, the manufacturer has a budget; this limits what kind of technology they can put in their cars. Gale Halderman, the original Ford Mustang designer, sums it up best when he says “Designing a good looking car is absolutely easy as pie. Designing a car, that the company can afford; the manufacturing guys can assemble; the engineers can engineer; that’s damn difficult” (Gelb, 2015). This is unlike the manufacturers that build these cutting-edge automobiles called Hypercars. These manufacturers have no budget; their only goal is to make their car as best as it can possibly be in every aspect. This allows them to innovate and refine every inch of their car from the aerodynamics to the drivetrain.

Hypercars are tomorrow's technology, put into an automobile today. They are the perfect combination of engineering and art to create one cohesive road and racetrack conquering machine. In many ways, they are an elegant street legal racecar. Hypercars are an example of what humans can do with materials that they pull out of the ground; by using the technology and knowledge that engineers have gained overtime, they develop these astonishing machines that, in the automotive world, is science fiction brought to life.

Leaders in the Hypercar Industry

Within the last ten years, manufacturers such as McLaren, Ferrari, Porsche, and Koenigsegg have created and defined what a Hypercar is and, most importantly, what a Hypercar is capable of doing.

The Porsche 918 was the first plug-in hybrid Hypercar created. Its 608 horsepower 4.6-liter V8 engine combined with its 154 horsepower "hybrid module on the rear axle" and its 127 horsepower "electric motor on the front axle" all add up to give the car a reasonable 887 horsepower drivetrain (Introducing the Porsche 918 Spyder). This, along with the all-wheel drive system, rear wheel steering, and active aerodynamics, allow the Porsche 918 to rocket out of the slow speed corners and turns of a racetrack; thus giving it a better lap time on some tracks ("2015 McLaren P1," 2015). It has a starting price of \$847,975 US dollars and currently holds fourth place at the Nürburgring racetrack in Nürburg, Germany (Gall, 2013; Top 100 Nürburgring Lap Times). This track is considered by many car enthusiasts to be the standard of all tracks. It is where all automotive manufacturers want to test their car to see how they compete with their competitors. The Porsche 918 also holds a lap time of 2.39 minutes on the Circuit of Spa-Francorchamps racetrack; only one second slower than the McLaren P1 (Spa Fransorchamps lap times).

The McLaren P1 is yet another plug-in hybrid Hypercar. It has a 727 horsepower twin-turbo 3.8-liter V8 engine combined with a 177 horsepower electric engine to achieve a 904 horsepower total. All this power is running through two rear wheels; however, it has more down force because of its rather large active aero dynamic wing which give the car down force at higher speeds (“2015 McLaren P1,” 2015). For all these reasons, the starting price for a P1 is \$1,150,000; unfortunately, they are all sold out (Pund, 2014). Although the P1 does not have a lap time set at the Nürburgring, it has set a lap time at a different race track just an hour west from the Nürburgring. A race track named the Circuit of Spa-Francorchamps; this track is known for its quick turns, high speed straights, and blind corners. With the odds against any car that gets tested at Spa, the McLaren P1 managed to achieve 2.38-minute lap time; beating the Porsche 918 and Ferrari LaFerrari at this track. However, it was unable to beat the Koenigsegg One:1 (Spa Fransorchamps lap times).

The Koenigsegg One:1 is the most radical of all the cars mentioned. It has a one Megawatt (1,360) horsepower twin-turbo 5.0-liter V8 all running through two rear wheels. The Koenigsegg One:1 is known to many to be the first ever Megacar created because of its megawatt of power. Its name comes from the horsepower to kilogram weight ratio that the car has; this one to one ratio of power and weight is what Koenigsegg likes to call the “dream equation” (One:1). With a theoretical top speed (theoretical because it has not been tested for top speed) of 273 mph, it would be the fastest production car ever built (Pattni, 2014). According to Mike Duff from car and driver magazine, the car has a base price of \$2,850,000 US dollars (Duff, 2015). As for a Koenigsegg One:1’s lap time at the Nürburgring, the team was unable to set a lap time because of a recent death of a spectator when a Nissan GT-R flipped over the fence during a race (Spectator killed in Nürburgring endurance race accident, 2015). However, they

still plan to set a lap time with the car as soon as they get the clear from Nürburgring officials (Wade, 2016). In the meantime, the Koenigsegg team decided to set a lap time at the Circuit of Spa-Francorchamps. On the day that Koenigsegg was planning to proceed with their hot lap, the officials at Spa lowered the acceptable noise limit which the One:1 exceeded. With the odds against them, they were still able to beat the previous lap time during a practice run on the first day that they were at Spa (Wade, 2015). They were still able to beat the previous record lap time, which was held by the McLaren P1, by an impressive 5.86 seconds (Spa Fransorchamps lap times). The Koenigsegg One:1 has and will continue to break records as time goes on.

Last but not least, the Ferrari LaFerrari. Out of the other three Hypercars mentioned, this is one of the few Hypercars that uses a V12 engine. Add the 789 horsepower V12 with the 160 horsepower electric motor system Ferrari has, and it creates a 949 horsepower powertrain. All this power goes straight to the two rear wheels which launches it to over 217 mph (Ferrari's Hybrid: 949 HP of Pure Passion). Just as the other cars do, the LaFerrari has active aerodynamics in the front and in the rear. It is also longer than any of the three other cars, but the Koenigsegg One:1 is both taller and wider. The LaFerrari has a starting price of \$1,420,000 US dollars (Quiroga, 2015), but looking at the lap time data, the car does not seem to have the competitive advantage on the Circuit of Spa-Francorchamps racetrack (Spa Fransorchamps lap times). Compared to the slowest of the three previously discussed cars, the LaFerrari is a whole nine seconds slower than the Porsche 918; although this may just be driver error, it still does not look good from a consumer's standpoint.

This is not to say that any single one of these cars are better than the other. Each car has its own unique characteristics and personality. Each car acts differently on a racetrack in hopes that the engineers found the best and easiest way to a record breaking lap time. Racing aside, all

these cars also have a unique style to them that represent the history of the manufacturer. This of course plays a big part when someone will be dropping one or two million dollars on a car, and because beauty is in the eye of the beholder, the manufacturer can only do their best to make sure the car looks good in their eyes. With all this said, it is completely up to the very rich consumer as what car they like best.

The Enthusiast's View

What makes people want to buy these million dollar cars or even have a passion for cars in general?

Any automobile enthusiast would say that a high-end automobile is simply just rolling art. Think about it, what is the definition of art? According to the Oxford Dictionary, Art is defined as “the expression or application of human creative skill and imagination, typically in a visual form such as painting or sculpture, producing works to be appreciated primarily for their beauty or emotional power” (“Art”). To any auto enthusiast, this definition of art can perfectly describe the passion they have for cars.

A car is a form of art; the body of the car is a representation of the imagination of the car enthusiast. The engine is a marvel of engineering that just takes the driver’s breath away every time it pushes them back in their seat when the car accelerates. As stated by Horacio Pagani (C.E.O of Pagani Automobile) during an interview, “[...] I discovered the life of Leonardo Da Vinci. [...] a Da Vinci quote which said that ‘Art and science can work hand in hand.’ Reading this was like a door opened for me, a path towards something I could pursue” (Carbonare, 2013, Defining the brand). With that said, many car enthusiasts see automobiles as art and science combined into one form.

When an automobile enthusiast races a well made car, the driver and the car become a team and help each other out through every turn and every straight. They work together to communicate with the road. As the chassis describes the road to the driver with every bump and flaw the road has (“BMW M3: All 4 Generations,” 2013).

A car is not just a dead piece of metal, if done right it is an extension of the driver. The car tells the driver what it wants and what it needs. Whether it be from the sound the engine makes right before it hits redline, letting the driver know to shift (“BMW M3: All 4 Generations,” 2013). Whether it be the steering wheel becoming unresponsive, letting the driver know the car have reached the point of understeer (“Understeer: Your Overprotective Mother,” 2016). Or whether it be the sound of the wheels squealing, letting the driver know the car is on the threshold of grip (“Oversteer: The Party Drug,” 2015).

It is the combination of senses that speak to the driver. It is these good “vibrations” that make a person want to drive and puts a smile on the driver’s face (“BMW M3: All 4 Generations,” 2013). Its these reasons – these emotional connections with a car that makes the driver have a passion for cars.

Innovations by the Hypercar Industry

Recently, Koenigsegg has been the “*poster boy*” of innovation in the automobile industry. They have and still are innovating in carbon fiber, 3D printing, turbo technology, and with the combustion engine as a whole. Carbon fiber has always been used by Koenigsegg, in fact the One:1 is made almost entirely out of carbon fiber; parts of the engine, the body, and even the wheels are made up of carbon fiber (*Carbon Fiber Construction*, 2013).

Innovations in Carbon Fiber

Koenigsegg was the first ever production car company to put full carbon fiber wheels on their automobiles. The wheels were first put on the Koenigsegg One:1 and now they are being put onto Koenigsegg's newest Hypercar the Regera. Because carbon fiber is a very light and strong material, Koenigsegg was able to keep their carbon fiber wheels' hollow, this technology is what they call their Aircore™ technology. The Koenigsegg Aircore™ carbon wheels are made from one of the highest quality carbon fiber materials known to the auto industry, this material is known as prepreg carbon fiber ("Making 280mph Capable," 2014). This material is simply carbon fiber that is preimpregnated with a specific type of resin; it also helps when bonding different layers of carbon fiber. A study done by the *Construction and Building Materials* journal state that "[...] these treatments on fibers improved the interfacial bonding of the final composites to some extent [...] Therefore, commercial carbon fibers are often sized, i.e. [sic] their surface is covered with a layer of resin or nanoparticles" (Gao, et al., 2016, p. 87). When it comes time to shape and bond carbon fiber pieces together, the resin that is covering the carbon fiber needs to melt with the other carbon fiber layers. To achieve this, manufacturers use what is called an autoclave; this process was mainly used by the aviation industry and has been since been adapted by the automobile industry when automobile manufacturers, including racecar manufacturers, began to use the material of carbon fiber in their cars. The process is thoroughly explained by Drakonakis in this excerpt:

The autoclaving process brings the individual prepreg plies together and consolidates them through pressure into a uniform solid material. Elevated temperatures are necessary to initiate and complete the curing reaction for thermoset-based prepgres. This work focuses on an effort to analyze in a fundamental way the applications of pressure and

temperature separately during prepreg consolidation. A controlled pressure vessel has been designed that applies pressure during the curing process while the temperature is being applied locally by heat blankets. This vessel gives the ability to design manufacturing processes with different pressures while applying temperature at desired regions of the composite. The role of pressure on the curing extent and its effect on the interlayer region are also tested in order to evaluate the consolidation of prepgs to a completely uniform material (Drakonakis, et al., 2013, p. 1).

When doing the autoclaving process correctly, the manufacturer is able to have a rigid structure with a very low weight. Unlike other materials, carbon fiber can be layered more than once in certain areas of a part to give that section more rigidity; “out-of-autoclave technologies enabling complex shapes with tight tolerances as well as high surface finish” (Bailou, et al., 2016, p. 1061). This also reduces the amount of unused material; “there's much less scrap produced using Fiberforge since the tailored blank process puts material only where it is needed in the part” (Cramer, 2004, p. 1). Referring back to the example of Koenigsegg’s Aircore™ carbon wheels, the wheels are so light that they can be picked up with only one finger as they only weigh 5.9 kilos for a front 19-inch wheel. They are also much more resistant to cracks and scratches than common alloy wheels because carbon fiber has a harder surface and is a more rigid material compared to the alloy counterparts (“Making 280mph Capable,” 2014).

As these innovations in the Hypercar industry become proven to work, other companies use the knowledge that the Hypercar manufacturers learned and implement it into their own cars. The 2016 Ford GT350R is one of the first companies to use a wheel based off of Koenigsegg’s Aircore™ carbon wheels. “The single-piece, painted wheel is made by infusing a dry carbon fiber preform with a proprietary resin system via the resin transfer molding (RTM) process”

(Malnati, 2016, p. 25). This drastically reduces the overall weight of the car and thereby increases performance. This is one example of how the million dollar Hypercar industry is making a difference in the common cars normally seen on the road.

Innovations in 3D Printing in the Automobile Industry

Another innovation that Koenigsegg has recently made has to do with 3D printing in their production cars. Although no other car manufacturer has attempted this method before, after Koenigsegg has, it can be expected that some production cars will include 3D printed parts like this in the future. Since Koenigsegg's turbo has not one but two chambers in it, to allow for low rpm and high rpm boost, it would have been very complicated to make the part using a casting method. Instead they turned to the 3D printing method where they created the turbo out of stainless steel. This was very efficient for them because they were printing the turbos in such low volume; in result making the turbos also fairly cost efficient using this method ("The 3D Printed Variable Turbo," 2014).

3D printing is becoming an interest to manufacturing companies in many industries. According to consulting firm IDC, "[...] global spending on 3D printers, both desktop and industrial, hit about \$11 billion in 2015 and is forecast to reach \$27 billion by 2019" (Ramsey, et al., 2016, p. 30). More research was done by a research company named "MarketsandMarkets;" their research showed that "[...] 3D printing will experience 30% compound annual growth and reach \$30 billion by 2022" (Ramsey, et al., 2016, p. 30).

Some of the auto industry is already seeing this movement towards the 3D printing method besides Koenigsegg. BMW is not yet using 3D printing on their cars, but is using the technology for their assembly line workers. The company saw many of its technicians experiencing strain with their fingers due to pushing so many rubber plugs into holes during

production. BMW's solution was to create them a finger brace using 3D printing technology. Each worker's finger is scanned and built a custom finger brace to relieve stress while working (Lecklider, 2016). Audi is another automobile manufacturer that has started to implement the use of 3D. They are currently using 3D printers to manufacture their proprietary tools and for certain spare parts. They like using the technology of 3D printing because they have no waste at the end of manufacturing and therefore it is faster and cost effective. Audi also believes that there will be some major innovations to 3D printing within the next few years (Hall, 2016; "*Innovation Forum*," 2015).

Innovations in Braking

The Porsche 918, along with other Hybrid Hypercars, has what is called regenerative braking. This allows for the electric batteries to recharge when the driver uses the brakes. However, this system feels a bit different from traditional braking systems. One concern automobile manufacturers had with implementing this system into everyday cars was safety; this system may be very good on a racetrack but that does not mean it will be up to par with the safety regulations in some countries (Cocron, et al., 2013). This exact situation occurred when regenerative braking was brought to the attention of the Economic Commission for Europe (ECE); there was then a study to prove that this new braking system could in fact meet the regulation requirements of the ECE. After a study was done that proved that "[...] the composite braking was controlled just within the requirements of ECE regulations" (Liu, et al., 2013). This example demonstrates how the Hypercar industry and their innovations has a "trickling down" effect to other car companies.

The Next Innovation by the Hypercar Industry

Koenigsegg also has a sister company named FreeValve. This company has been experimenting with a new innovation that may change the way the combustion engine works. The current combustion engine uses what is called a camshaft to operate its valves. This locks the camshaft into a specific pattern to be used throughout the engine's entire running process. However, with the new addition of FreeValve, the manufacturers and engine programmers can change almost every aspect of each valve separately for both the intake and exhaust. “[...]

FreeValve allows independent control over every valve's precise opening/closing position and timing throughout the whole combustion cycle. The result is a disruptive technology that allows an unprecedented degree of control [...]” (“Koenigsegg – FreeValve Technology,” 2016). The ability to control each valve independently allows for not only a higher rpm limit, but (in the test engine that FreeValve was working on) will also increase power by 45% and torque by 47% (Improved Performance, n.d.). The FreeValve system was also able to increase fuel economy by 15% in FreeValve's test engine (Fuel Consumption Reduction, n.d.). By removing unneeded parts and components from the traditional combustion engine, the engine will in turn become smaller and also weigh less. In FreeValve's test engine, they were able to lose 20kg from the weight of the engine (Compactness, n.d.). Although this is not implemented into any production car currently, FreeValve is continuing to refine their new technology in hopes that it will be a standard feature in all combustion engines in the future.

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