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# DESIGN HISTORY OF THE CAR: AN EMPIRICAL OVERVIEW OF THE DEVELOPMENT OF LAYOUT AND FORM

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## Abstract

It was suspected that car design was paradigmatic in behaviour, with designers constrained within their thinking processes and by the market to a particular way of designing, at particular dates. Four hundred and fifty three cars dating from 1878 to the present have been analysed for nineteen layout and forty-seven form parameters. These parameters have been reduced using optimal scaling routines to two layout dimensions and three form dimensions.

Results for car layouts show that this paradigmatic behaviour certainly takes place, with a definitive layout being reached at around 1904, and with little development of this taking place until after 1934. Layouts then develop in a gradual fashion and do not exhibit a stepwise change that might have been expected. Car form develops in a more general manner, with distinctive changes occurring through time for two of the three dimensions.

The dimensions do not refer to any specific quantity, but a rotated arrangement of the layout dimensions could be called ‘car-ishness’ and ‘time development’: the three form dimensions could be termed ‘roundedness’, ‘proportion’ and ‘formality’.

*Keywords: Design History, Engineering History, Automotive Design*

## 1 Introduction

The UK Classic Car industry is reckoned to be as large as £1.6 billion per annum by Classic and Sports Car Magazine [1]. In the industry, the major characters are the cars themselves, without which the industry would cease to exist. A study of the way cars developed is not only of particular interest to those within the industry, but is also useful in terms of the way in which ways of designing the product can be seen to be developing and changing throughout the generic product’s life history from its start in the late nineteenth century through to today.

This work has developed not only from interests in design and automotive history, but also from work on design paradigms, which made reference to the car [2], and from work on perceptions and aesthetics in Japanese recreational vehicles [3-6].

## 2 A General Overview of Car History

In Britain, at least, car history is traditionally divided into a number of periods, each with its following and organisations. Traditionally, the start of car history is dated 1886, although this can be debated. From then until 1904 is the Veteran period. The Edwardian period lasts from 1905 until 1918, although it is split by the First World War, during which few cars were built. After the First World War comes the Vintage period, from 1919 to 1930. Following that there are a number of cars that are called Post Vintage Thoroughbreds, but date terminology runs cold, periods tending to be named after decades or the war rather than anything more specific. Terms such as Classic and Antique tend to have varying meanings: Classic is a generic term that encompasses the whole industry, while Antique is used in the US to mean a car from the earlier periods.

## 3 Objectives

The previous work on design paradigms was speculative, proposing that they should be verified [2]. One of this work's purposes is to investigate this and see whether the perception is justified. In particular, it was thought that a number of design paradigms for the car existed through its history, and that these occurred in the form of paradigm shifts in a similar way to those in the area of scientific discovery proposed by Kuhn [7].

## 4 Methods

The investigation took a pragmatic approach, analysing 453 examples of cars, collected into 25 five-year periods.

The reason for this was largely to answer the question of how representative examples should be chosen. An initial perception of the way car designs develop and influence each other is that car designers, who are in general also car enthusiasts, do not necessarily use cars that are commercially successful as their influences, but also enthuse over cars in small-scale production, one-off prototypes and so on. A representative sample is therefore to produce. An analogy with palaeontology seems to be apt. Perceiving old cars as being fossils suggests that all examples of cars provide useful information, and any theory develops from the examples that are collected: adding extra data only serves to revise, refine or refute the theory, which could be argued to be a classical scientific process.

Car fossils are not in short supply, and neither is information concerning them. There is an embarrassingly large number of cars from which to choose. The pragmatic approach was to base the initial survey on a colour slide collection of 453 examples dating from 1878 to 1998. The data is particularly messy and unrepresentative in that the photographs tended to have been taken at Classic Car events and also tended to show particular esoteric and slightly eccentric interests. They also focus more on engineering perceptions rather than aesthetic ones but these are likely to be accorded greater subconscious merit than might be appreciated [8].

Cars were described using 19 layout parameters and 47 form ones, and by date. The parameters were initially descriptive text categories, and were chosen simply on pragmatic grounds. Figure 1

shows a photograph of a 1901 de Dion Bouton vis à vis – a relatively common car from the Veteran period – with eighteen of the nineteen parameters labelled. The nineteenth describes cylinder orientation, with options of 'in line', 'vee', 'horizontally opposed', 'W' and 'square'. As the de Dion has a single cylinder engine, no orientation is possible. A number of parameters have values that relate to the majority of cars in the survey. These can conveniently be referred to as default values. In general, these were set relatively early on in the history of the car, and have not been challenged significantly since.

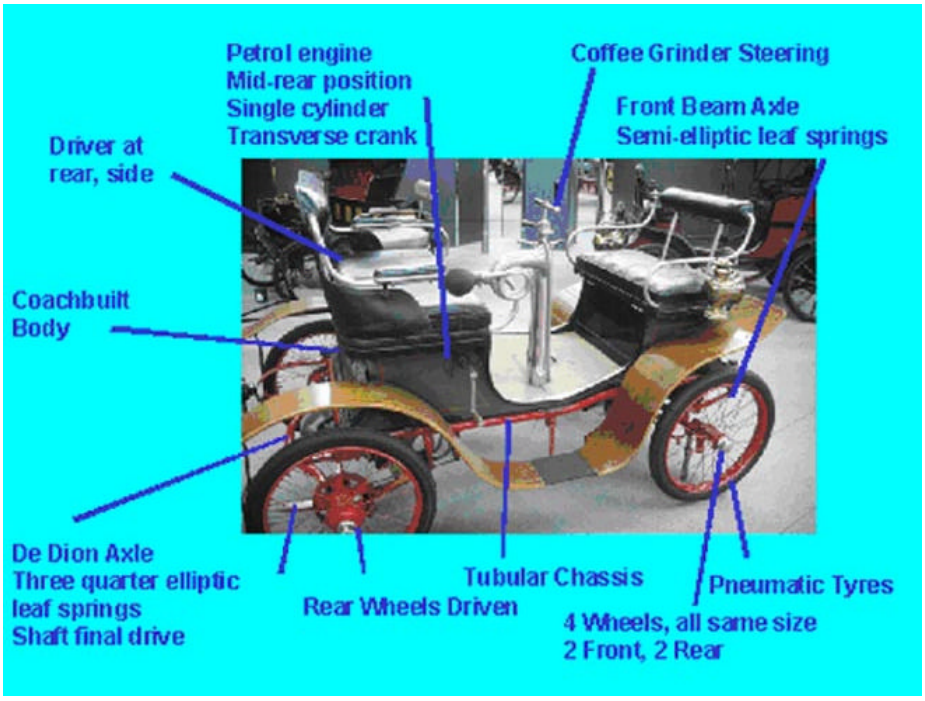


Figure 1: 1901 de Dion vis à vis showing layout parameters

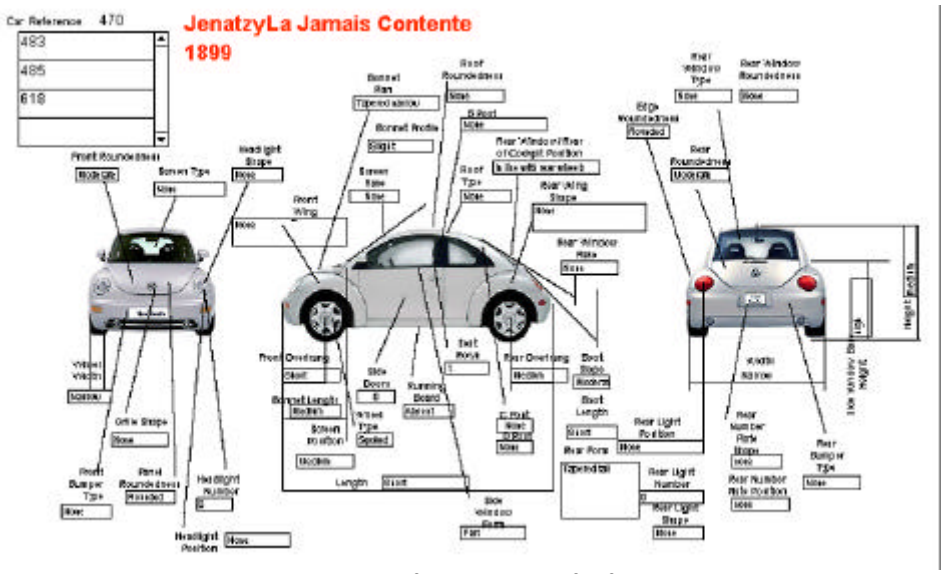


Figure 2: An example of the input data for form parameters

Figure 2 shows the input format that was used for the form parameters. The picture does not relate to the car described, but was simply used as an input example.

After changes and developments in individual parameters and in a number of combined parameters were investigated, the parameters were changed from string variables to nominal integer ones. They were then reduced using the routine CatPCA, which is a Principal Components Analysis for categorical data, using optimal scaling within the SPSS computer package [9]. This recognises the ordinal nature of the categories. In this way the nineteen layout parameters were reduced to two dimensions and the forty-seven form categories to three dimensions. Following inspection of the data, it seemed sensible to carry out a rotation and translation process.

# 5 Results

## 5.1 Layout parameters

The most important layout parameters could be taken to be those describing the engine position, its orientation, and the choice of driven wheels. Figure 3 is a cumulative bar chart that shows the way in which these change over time.

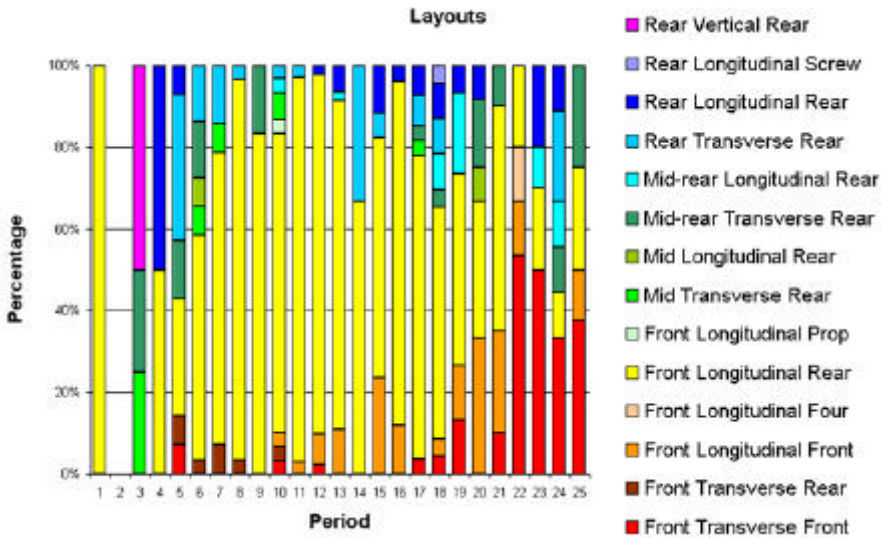


Figure 3: Engine position, orientation and drive for periods.

The large yellow area in the centre of the chart represents cars that have a front longitudinal engine driving the rear wheels. Below that the areas represent cars that have front engines mounted longitudinally or transversely. Above that, most of the graph refers to cars with mid, mid-rear and rear engines. These may be mounted longitudinally or transversely, (or in a couple of cases vertically) and drive the rear wheels. Essentially, we see that the layout with front longitudinal engine driving the rear wheels was established around period 6, that is between 1900 and 1904. This arrangement holds sway until about period 19, the late 1960s, when we find that

front wheel drive starts to become important, increasingly so after the late 1970s (period 21).

The existence of default values for some of the parameters suggests that, after a period of indecision, car designers did not seek to challenge these basic design features, and we might expect to see early variation, followed by a settling down of the layout design. For instance, the most spectacular change in the car layout occurs when tyre types are considered. The earliest car in the survey to have pneumatic tyres is a Peugeot dating from 1895. By 1900 virtually every car is fitted with them. There are only three exceptions after that date.

When we look at the overall results obtained from the rotated and translated Principal Components analysis, we obtain a set of points on a two dimensional plane, shown in Figure 4. In this diagram the colour of the data points changes with the period. The earliest car is in red, and then with successive periods the colours change in a rainbow sequence through orange, yellow, green, blue: to magenta and red-magenta for the latest cars.

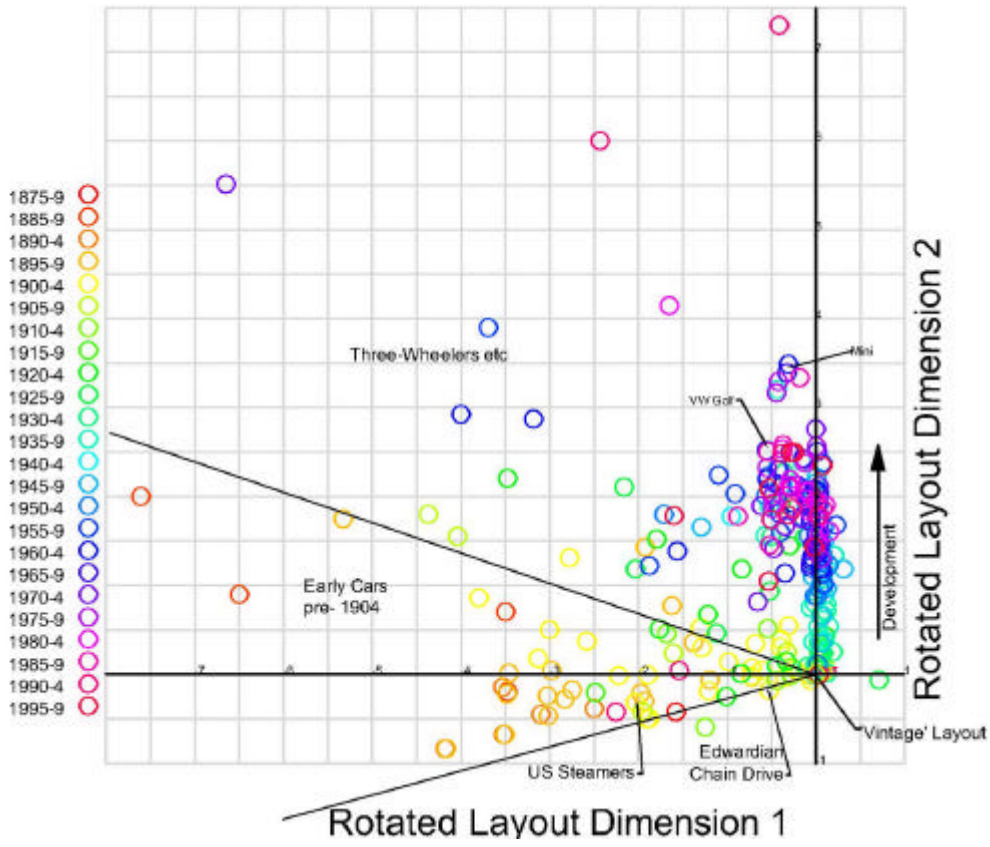


Figure 4: Results of two-dimensional analysis of layout parameters

The plot shows a two dimensional field spread over the area x = -7 to +1, and from y = -1 to +7, but in stating this one should remember that the scale of the numbers is solely relative, and that the factual meaning is difficult to ascertain. The early cars, to about 1904, are largely spread over a triangular area, narrowing down to what is an extremely small area, deliberately centred on the origin after the translation process. In reaching this point, there are a number of small clusters of cars, including the one labelled as US Steamers, which have a steam engine underneath the seat,

chain final drive, pram frame suspension with full elliptic springs, and tiller steering. The major car cluster from 1904 onwards is at the origin and is shown on the Figure as the 'Vintage' Layout, although strictly speaking the Vintage period is only from 1919 to 1930. Essentially, car layouts remain almost locked in this position for about thirty years and it is only after 1934 that they move significantly, although the eclectic nature of the data means there are a number of cars that may be pioneers, left-overs and eccentricities that do not fit the pattern. After 1934, layouts seem to develop, moving in the vertical direction in the Figure (labelled 'Development'). This movement seems to start with a change in front suspension design from the rigid beam axle. By the end of the Second World War the beam front axle is virtually dead. Leaf spring front suspension follows it a little later, to be replaced by coil springs. Also starting in the late 1930s, there is a move towards unitary body construction and away from coachbuilt bodies using panelling on wooden frames. This also takes place in stages, with the all-steel non-structural body being accepted before the body becomes the main structural unit. This development during the late 1930s was not expected before doing the analysis.

Figure 5 shows a selection of cars with the 'Vintage' layout, from 1904 to as late as 1947.


Figure 5: Examples of the 'Vintage' layout: (clockwise from left) 1925 Morris Cowley (Bullnose), 1947 HRG, 1904Peerless, 1909 American Underslung.

It could be argued strongly that this 'Vintage' layout, comprising a very tightly-knit selection of parameters, constitutes the way that cars were 'supposed' to be designed between 1904 and 1934, and could clearly be described as a design paradigm for the car.

Later cars also show degrees of clustering, but although the general layout moves significantly the later layouts do not show the extent of the clustering that is shown in the early layout. At the present time few cars have rear engines, but some manufacturers hold that the 'correct' place for the drive is at the rear, whilst the majority now have front wheel drive and transverse engines. The time lapse between the first BMC Mini and when front-wheel drive with transverse engines became the norm was significantly greater than the time lapse before the 'Vintage' layout was adopted, being of the order fifteen years rather than taking place during a period of five.

The data has been produced over a two-dimensional area. However, it is very difficult to describe the x and y axes by a coherent description. The axes have been rotated such that the 'general development' direction becomes vertical, and it could be argued that this axis represents general

development and the horizontal direction could describe something like ‘car-ishness’. Vehicles, significantly removed from the vertical axis are able to be termed ‘marginal’ and have been known by various sub-car names such as cyclecars, bubble cars, cabin scooters and so on – perhaps to emphasise their general lack of acceptability within the car market.

## 5.2 Form parameters

The forty seven form parameters were reduced using the CatPCA analysis [9] to three dimensions. The reason for the three dimensions rather than any other number was pragmatic: with forty seven parameters a larger number of dimensions should be used, although that could clearly be debated.

Figure 6 shows a plot of the first two dimensions plotted against each other.

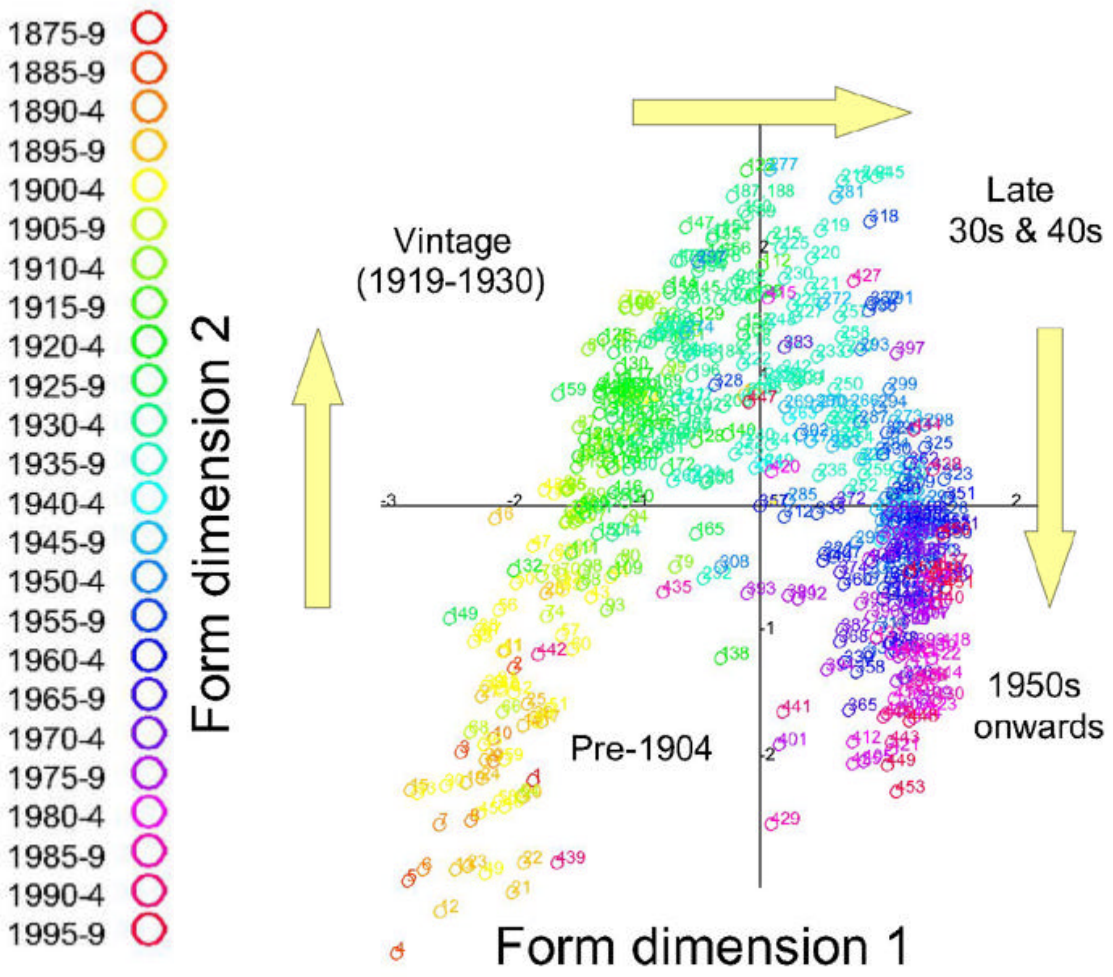


Figure 6: Form dimensions 1 & 2

In this Figure, the cars are numbered in order of periods: those from earlier periods having lower numbers. The colour of the data points changes with the period, as in figure 4. The results show that early cars, up to 1904, have a low value for both dimension 1 and 2. After that, cars became

lower, with longer bonnets, and dimension 2 increases, with only a slight increase in dimension 1. During the 1930s and 1940s they become rounder and more integrated and dimension 1 increases, whilst dimension 2 remains relatively static. After the Second World War the movement is towards shorter bonnets as the engine moves forward between the front wheels. Adoption of the transverse front-wheel-drive layout, following the BMC Mini's example, augments this process, with yet shorter bonnets taking up a smaller proportion of the vehicle's overall length. The process moves further with the popular adoption of the people carrier and one-box designs such as the Renault Twingo. Figure 7 illustrates Figure 6 with a car from each quadrant.

Figure 7: Cars in Form dimension 1 & 2 Quadrants: Clockwise from lower left: 1903 Curved Dash Oldsmobile; 1930 Bugatti Type 40; 1953 OSCA MT4: 1996 Renault Twingo

When looking at the third form dimension, however, things become a little more complex. In this instance it is considerably harder to discern exactly what the dimension signifies, and harder still to see any movement through time. Figure 7 shows a plot of dimension 3 against dimension 2, with the same colour coding. Progression through time is clear on the horizontal axis, dimension 2, (the greens and blues on the right) but is much less clear on the vertical one, dimension 3.

It would seem as if cars that are more formal have a higher value for dimension 3. Formality seems to be indicated by numbers of doors, rows of seats, closed roofs and so on. Figure 8 gives examples from each of the four quadrants. Note that formality increases in the upward direction, and longer-bonneted proportions to the right.

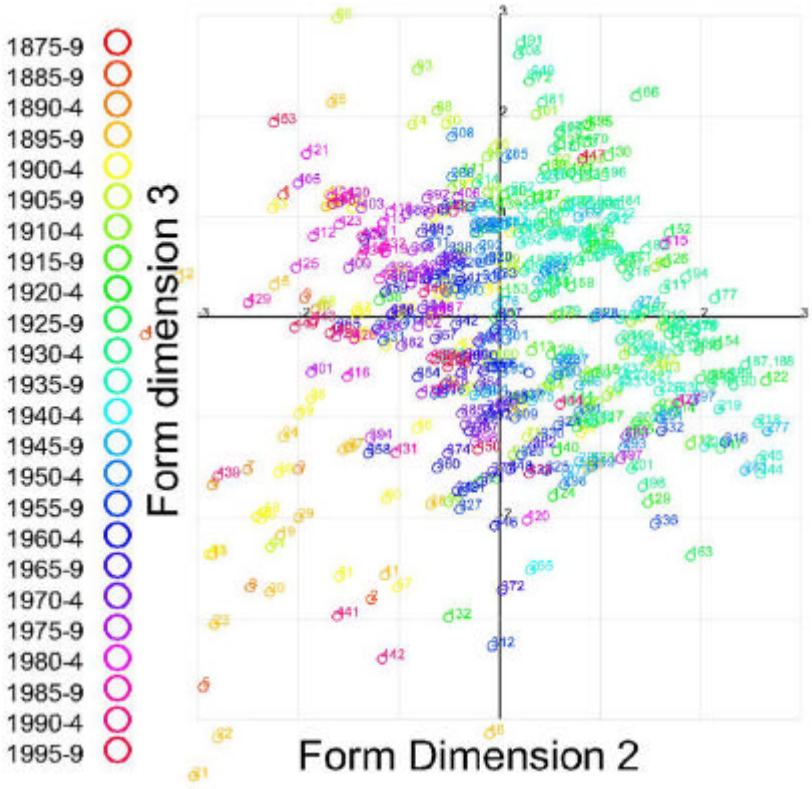


Figure 8: Form dimensions 2 & 3


Figure 9: Cars from Form dimension 2 & 3 quadrants. Clockwise from lower left: 1899 Star, 1998 Renault Espace, 1930 Bugatti Royale, 1947 Nardi-Alfa-Romeo

# 6 Conclusions

Existence of a paradigm is demonstrated in the case of car layouts. The time development has produced interesting results, tending to show that cars developed by evolutionary rather than the radical processes of paradigm shifts, following Kuhn [7]. The main paradigm is in place by 1904, and this changes gradually after about 1934, along an approximately linear direction. Form development is again time dependent, with roundedness and proportion having time-related values.

A number of areas that need more investigation. The database is currently small and more examples are needed. It is also clear that some developments take place that are not recorded within the chosen parameters, specifically in the form factors. Some areas of car development may have been missed because of the eclectic nature of the data.

It would be interesting to investigate if the traditional date categories have other than arbitrary meaning. In the case of the 1904 cut-off date for Veterans, this might be so, especially as in 2002 there was a significant outcry when the organisers of the London to Brighton run announced that they would change the eligibility rules from pre-1905 to pre-1907 – and then were forced, by popular opinion, to change them back [10].

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