Planning and design approaches for cycling infrastructure

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This chapter argues that approaches to design for cycle traffic have been undertaken based on inappropriate assumptions about the relationship between motor traffic and cycle traffic. The chapter provides provides the philosophy of science as a context, that is to say the nature of ways of understanding the world. This culminates with an understanding of different paradigms. Attention is then drawn to ten contentions in provision for cycle traffic: the sources of risk; language; priority; equivalence of provision; space; speed; network planning; control; separation and vehicle design. The chapter concludes by suggesting that progress will be made when mindsets are not constrained by old fashioned thinking, or, in the language of scientific discovery, when paradigms are shifted.

1 Introduction

This chapter summarises a lecture given on 26th May 2014 at the Technical University Vienna on planning and design approaches for cycling infrastructure. The lecture is set in the context of the nature of research and in particular the way that research is usually undertaken within a paradigm. The anaology is that design for cycling has been undertaken within a paradigm, but that paradigm needs to be augmented, or shifted, so that planning and design is on the assumption of mass cycling. A short history of cycling is presented in Section 2. This is then followed in Section 3 with a summary of the scientific method. The contentions which exist, and need to be developed or shifted, are then explored in Section 4. Section 5 provides a conclusion.

2 History of the bicycle

The bicycle's roots are usually traced no further back than Baron von Drais's running machine (McGurn, 1999). 1816 was known as 'the year without a Summer', and was caused by a variety of factors including volcanic eruptions in Indonesia in 1815 ending with the eruption of Mount Tambora. Some suggest the consequential oat famine, leading to a lack of horses for farm work and transport, helped spur the development of the machine, but this is perhaps quite a tendentious argument.

Cycling caught on particularly in France, and particularly amongst the aristocracy, but there were, even then, cultural differences across Europe. McGurn notes that while the Mayor of Haarlem in The Netherlands rode a version of the hobby-horse, the authorities in Milan banned the machines by civic order.

While the poor state of the roads assisted in the development of railways, they also militated against the extensive use of the bicycle. It was only Hausmann's relaying of Paris that allowed "Paris [to be] just now afflicted with a serious nuisance ...velocipedes, machines like the ghosts of departed spiders, on which horrible boys and detestable men career about the streets and boulevards". An extensive discussion of the nature of the development of infrastructure for cycling is provided by Reid (2014).

The other technological development of significance was the pneumatic bicycle tyre patented by John Dunlop in 1888. It is interesting to note that by 1905 the tyre had

become so widespread that Sir Arthur Conan Doyle describes Sherlock Holmes as being familiar with forty-two different impressions left by tyres (Conan Doyle, 1905).

The bicycle has continued to be an important means of transport in Northern Europe, particularly Denmark and The Netherlands. Ebert and Carstensen (2012) noted that cycling was presented as promoting Dutch virtues such as independence, self-confidence, self-control, balance and consistency. In Denmark, cycle touring played an important role in the development of a sense of national identity with the bicycle viewed as a way of educating and cultivating citizens in the varied landscapes of the country. The Danish 'bicycle girl' of the 1930s was also an important symbol and harked back to the emancipation afforded to women at the turn into the twentieth century based around the movement for 'rational dress' championed in the UK by Lady Harberton (Ritchie, 1975). Ebert and Carstensen demonstrate that the bicycle itself is associated with 'individuality', and 'independence' and hence is well aligned with female and working-class emancipation. If it was the electric light that allowed the working man and woman to study at home, it was the bicycle that carried them to their night-classes at the Mechanics Institute.

3 The nature of research and discovery

The origins of research may be traced to Francis Bacon (1561-1626) whose suggested scientific method was to collect a vast number of facts and, from them, through an inductive approach, develop theories. He advocated a step-by-step approach, and his analogy for the scientific method was that of a ruler which helps someone draw a straight line: the scientific method was a mechanical aid to discovery.

Scientific method was further developed by those associated with the Royal Society and Sprat's history of the society (1667) suggests the underlying philosophy (Gribbin, 2005):

> ‚To this I shall add, that they have never affirm'd any thing, concerning the cause, till the trial was past: whereas, to do it before, is a venomous thing in the making of Sciences: for whoever has fix'd on his Cause, before he has experimented; can hardly avoid fitting his Experiment, and his Observations, to his own Cause, which he had before imagin'd; rather than the Cause to the truth of the Experiment itself‘

Research is hence concerned with fitting hypotheses to the observed facts rather than twisting facts to fit mistaken ideas. The manner of the testing of such hypotheses is undertaken by review of competent peers, often through open discussion at conferences and through peer review of papers before they are published in journals. The origin of this approach may be traced to a conciliatory letter from Robert Hooke to Isaac Newton, part of a tense series of exchanges concerning light (with original spellings):

> ‚Your designes and myne I suppose aim both at the same thing wch is the Discovery of truth, and I suppose we can both endure to hear objections, so as they come not in a manner of open hostility, and have minds equally inclined to yield to the plainest deductions of reason from experiment.‘

Newton was a quarrelsome and secretive man and his response, however seemingly conciliatory, contained perhaps the most famous line in scientific history ‚If I have seen farther, it is by standing on the shoulders of Giants‘. Out of context, this is often

assumed as a comment on his development of his theory of gravity: in reality it was a put down to Hooke, suggesting that Hooke's work on light is of no value.

Descartes was a deductive rationalist who confined himself more to mathematics which lends itself to deductive logic (Descartes, 1641). Classical science, however, has been based on empiricism, which is the development of scientific knowledge based on experience through observation and induction. John Stuart Mill in his System of Logic (Mill, 1843) noted two ways forward for research: the method of agreement and the method of difference. This was essentially an observational and inductive approach and allowed for conclusions to be drawn from observations which were essentially all 'relative'. He also noted the need for theory to guide experimentation.

Karl Popper, an Austrian and British philosopher (1902-1994) proposed what he called 'critical rationalism', and argued that scientific theories are abstract (Popper, 1934). He suggested that the only way to prove a theory is through falsifiability: a single negative outcome will be logically decisive and show a theory to be false, but a whole string of positive outcomes cannot prove a theory to be true. See the box for an explanation.

A scientist is considering the colour of birds. He has a theory that all swans are white. He sets up a test hypothesis, H_0: there is no difference between swans in terms of colour. He walks along the river bank and sees:

	Reject H_0	Do Not Reject H_0
Swan No 1	White	X
Swan No 2	White	X
Swan No 3	White	X
Swan No 4	Black	X

If he had 'accepted' the hypothesis that all swans were white before he reached the fourth swan, he would have looked foolish. By 'not rejecting' we are simply saying that, based on the evidence we have to date, we cannot reject the idea that all swans could be the same in terms of colour.

Popper was 'anti-inductivist', that is he demanded the need for falsifiability in order to make an observation 'deductivist'. The problem with Popper's approach is that new theories are hard to come by, but you cannot reject a theory without a replacement. Also, if something is falsified you may not know whether it was falsified because of bad data, other non-considered factors confounding the outcome, or whether the theory was wrong. To remind ourselves of the distinction and power of deductive logic as compared with inductive logic consider Table 1:

Deductive	Inductive
1) All buses are public transport	1) Hundreds of types of buses have been observed to have diesel engines
2) All public transport is transport	2) So, all buses have diesel engines
3) So, all buses are transport	

Tabel 1: Deductive versus inductive logic

The deductive logic is incontrovertible, whereas it would only take a single counter-observation to destroy the inductive logic.

While Popper's philosophy now essentially lies at the heart of modern research methods, subsequent philosophers have challenged the rigidity suggested by the implicit relentless, perhaps linear, development of science implicit in this approach. Thomas Kuhn (who gave us the phrase 'paradigm shift', Kuhn, 1970) noted that scientific truth cannot be established at any point in time from a scientific consensus

and that observations are theory laden. As an illustration of this, see Figure 1, is it a duck or is it a rabbit? The conclusion comes from the theory (or more precisley in this case, perhaps the angle of the observers head) brought to the observation by the observer.

Figure1: The duck-rabbit: your point of view affects what you ‚see'.

4 Current contetions in provision for cycling

This section is proposes ten central contentions that are of most relevance so far as the philosophy of design for cycle traffic is concerned.

4.1 Source of risk

If you ask a typical traffic engineer for a list of ‚safety problems' on the public road system, I am sure one amongst the list of will be cyclists, others are likely to be pedestrians and possibly children, for example. The interesting point is that these road users are not the source of the risk, which is the fast moving high-mass motor vehicle. The point is, in our current transport system, we are so familiar with motor traffic that we often do not see its contribution as the source of risk for other road users. Davis (1992) eloquently provides a comprehensive treatment of this subject and points out that the profession of road safety engineering does not pursue as frequently as it should do the matter of ‚road danger reduction' at source.

4.2 Language

The term ‚vulnerable road user' is often used to describe those legitimate road users such as cycle users and pedestrians. Interestingly, the antonym of ‚vulnerable' is ‚invincible': it would be odd to think of any road user as invincible and there are connotations of significant power imbalances as well as implications about ‚blaming the victim'. Similarly, it is often the case that motor traffic is discussed in the same breath as ‚cyclists'. This is also unusual because the equivalent of the ‚cyclist' is the driver. More balance in language is needed, and whenever traffic is discussed, the adjectival nouns ‚motor' and ‚cycle' would usefully be added so that the nature of the traffic being discussed is clear.

4.3 Priority

Roads and streets provide for movement and, in complex and congested circumstances, that movement needs to be managed with decisions about priority being made at virtually every junction and every crossing. The left hand picture in Figure 2 illustrates the end of a typical cycle lane in the UK, which shows a quasi 'give way' line, by contrast the figure also illustrates, on the right hand side, the rather different, and diametrically opposite approach promulgated in American guidance (NACTO, 2012) which requires motor traffic to give way to cycle traffic when entering the mixing zone on the approach to a traffic signal controlled junction. The messages of different levels of priority for different types of traffic provide powerful indications of the overarching paradigm for traffic management.
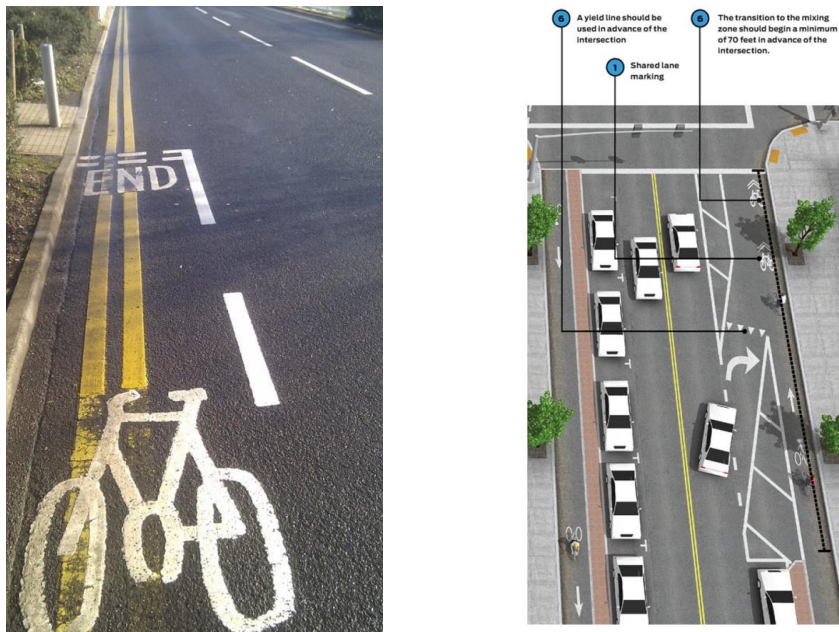

Figure 2: Different approaches to providing priority, UK and NACTO (2012)

4.4 Equivalence of provision

Infrastructure for movement on the highway comprises of not only the lane for movement, but also a whole panoply of associated equipment including road direction signing and, for example, loops cut into the road surface to detect vehicles to call or extend phases at traffic signal controlled junctions. Again, historically at least, there has been less attention paid to these 'equipment provision needs' for cycle traffic. Interestingly, however, in Copenhagen, there have been moves to provide special and additional equipment for cycle users to make their life that little bit easier, such as footrests at signal controlled junctions, as shown in Figure 3. The overall point is that there needs to be an equivalence in provision for different types of user. Thinking of personal equipment, rather than infrastrcuture: a sports car driver will need a hood in rainy weather, a pedestrian will need an umbrella.

Figure 3: Equipment specifically for cycle traffic: footrests in Copenhagen

4.5 Space

UK advocacy groups currently have an extensive camapign around the banner headline ‚Space for Cycling‘, and this is to tackle directly the absence of provision of appropriate space for cycling within the public realm that has increasingly occurred over the last few decades or so. This campaign is about space within the carriageway, through provision of wider cycle lanes, on routes specifically for cycle traffic and also within junctions. A rather ‚paradgim shifting‘ approach would be to upend the philosophy of cycling being at the ‚margin‘ of the carriageway, with provision being made much more clearly and in a pronounced way. Approaches which have reversed current thinking include, for example ‚Fahrradstrasse‘, or bicycle streets, which offer movment predominantly to cycle traffic, but allow other traffic for access purposes only.

4.6 Speed

Our thinking on speed can be rather confused. A reduction in mean speed at a specific location (a recuction in time mean speed, or the arithmetic mean of the speeds at a specific location), is not the same as a reduction in the mean speed across a network (the space mean speed, or the mean speed estimated from the arithmetic means of the times to make journeys). The two means are related via the variance of the speed and arguably our attention should have always been focussed much more on reducing the variance in speed: doing so would assist in reducing differential speeds and hence enhancing safety. In more recent times, this is what we have effectively been doing with area wide 30 kph (20 mph) speed limits. It would seem as though the public perception can still be some way distant from the reality, however, that lower speed limits have little effect on overall journey times, but do have impacts on safety. It is an interesting and open question as to how we might influence thinking on this, amongst traffic engineers as well as the public.

4.7 Network planning

Any system for transport is inevitably formed into a network: the first motorways have become part of a countrywide motorway network, and in urban areas the highway network is managed on an area wide basis through area wide traffic management schemes. Historically, for cycle traffic, the transport issues have been regarded as related more to risk than to the need to travel from an origin to a destination and the idea of a comprehensive network of routes for cycle traffic has for some reason been

of marginal interest to the transport planning profession. There are very good examples of where comprehensive network planning across a range of modes has been considered and this is particularly the case in The Netherlands. In Houten, for example, it is possible to penetrate across the central town area by bicycle, but access by motor car is limited to routes approaching the centre, from an outer ring road. Such ‚filtered permeability' (Melia, 2012) provides a differentiated network on which it is more attractive to cycle and walk. An historical approach of network planning where ‚one size fits all', even where that network is managed in such a way as to facilitate easy movement of only motor traffic, is an anachronism that steadily needs to be designed out of modern towns and cities.

4.8 Control

The railway network is a system with complete speed and priority control: train drivers obey signals and drive at prescribed line speeds to maximise the capacity of the network. Traffic engineering borrowed the concepts of signalling from railway engineering to control movement of traffic through junctions. The increasing prevalence of control on motorways through signalling on each individual lane to show speed and availability is a natural progression for large and complex transport systems, where the need is to allow for passage of as many vehicles as possible. A different direction of travel is occuring in some branches of traffic engineering for urban areas, however. Some urban realm designs are removing the direct ‚signalling' aspects of design and the control provided by signs and markings. Designs are evolving which are more sophisticated and subtle, with clues being provided through careful and high quality design about appropriate speed and road positioning. These approaches are dubbed ‚shared space' schemes. Some have been succesful, and the mark of succesful schemes seems to be linked with the way the environmemnt encourages progression ‚together' and at low speed: stop start traffic is replaced by a slow speed choreography of communal movement. It would appear that traffic management on inter-urban roads is going a rather different way than traffic management on urban roads. This is fine, and is arguably a natural bifurcation that needs to be encouraged further.

4.9 Separation

There has been a long, and sometimes accrimonious, debate between those who would see cycle traffic always mixed with motor traffic, the so-called ‚vehicular cycling' approach (Forester, 1994) and those who would assume that cyclists always want to be separated from motor traffic. The separationists seem to assume the reason is linked with perceptions around risk, while it is demonstrably the case that there are a large proportion of cycle collisions that are single vehicle (see for example, Franklin, 1999). Notwithstanding, it is farily clear that it would be much more comfortable and attrative to be remote from the noise and close physical proximity of large volumes of fast moving traffic. The corollary to the collisions data is that any route for cycle traffic still needs to be designed to high standards of geometry. Interestingly, there is a developing notion, at least in the UK around what has been termed ‚light segregation', where the advantages of some level of separation are provided, but the difficulties of providing full separation are avoided. There would appear to be a good deal of further movement needed in design thinking to determine what the most appropriate level of separation is for comfort reasons without compromising on risk.

4.10 Vehicle design

The motor car was born of the bicycle: many of the components developed for the bicycle such as the bearings, pneumatic tyre, tensioned spokes and so on, were

borrowed by the first motor vehicle designers. After a centruy of divergence, it is arguable that there is some sort of ‚coming together' again of design of vehicles, at least for urban use. Motor vehicles are becoming smaller, and the power train is being greened. The bicycle is getting larger with the more prevalent use of cargo bicycles and bicycles that can carry children. Electric bicycles are increasingly popular. It is interesting to consider how this convergence might continue and what the consequences may be for infrastructure design for vehicles in urban areas.

5 What of the future?

The influential UK politician, Tony Benn, who died in 2014, held various ministerial posts in technology, industry and energy in the 1960s and 1970s. Famously he said:

> ‚It's the same each time with progress. First they ignore you, then they say you're mad, then dangerous, then there's a pause and then you can't find anyone who disagrees with you.'

Somewhat more scientifically, Geels (2005) provides a model for the progress of innovation in technology, but importantly he notes that there is a strong moderating influence of what he calls the ‚socio-technical regime' that exists. Niche innovations may have an influence on this regime, but so too does the overarching landscape of exogenous factors. Despite such modelling, it remains difficult to determine the extent of impact of innovation until it has happened.

Whatever the politics and whatever the modelling, it has been my contention in this chapter to point out that resistance to change is imposed by a variety of ‚ways of thinking', or paradigms, which are prevalent in traffic engineering and prevent as rapid a development as might otherwise be the case in provision for cycle traffic. While we have always been good as traffic engineers at technical design, we need to become a lot better at planning for the future. But such planning for the future requires that our ‚mindsets' are not constrained by old fashioned thinking.

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