Time Tables: A User View

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Abstract:

Past research indicates that people have problems understanding and therefore using traditional public transport timetables As a consequence, the research argues, people limit their use of public transport The assumption behind this argument is that effective utilisation of a system depends on effective understanding of that system For example, if people cannot see interconnections on a route, they are unlikely to utilise them If people cannot identify a particular type of service they will not use it.

We hypothesised that by incorporating users' information needs and perspectives as well as appropriate design principles in a new timetable design, we could enhance users' effective understanding of the public transport system. Our initial investigation suggests that our hypothesis is viable Users' effective understanding of the system did improve Further work, we conclude could enhance system usage

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Introduction

This paper is the result of a project the Communication Research Institute of Australia undertook on behalf of Queensland Transport. Our brief was to research and develop a prototype timetable that could be used across all transport systems in Brisbane, both public and private, on rail, bus and ferry services.

Past research (Bartram 1980, 1984; Horne *et al* 1986) has indicated that public transport is not fully utilised, in part, because people have no clear understanding of the transport system that is available to them. Ellson and Tebbs' research (1978, 1981, cited in Bartram 1984), demonstrates that improving information can be a relatively cheap and highly cost-effective way of increasing patronage. Yet timetables are continually reproduced in a form that both research and anecdotal evidence suggest people cannot easily understand and use.

The basic problem we set ourselves was to answer the questions: How can timetabling data for complex services be arranged on paper so that people can utilise those services fully? Can understanding be improved, both at the macro level of route connections within the transport system as a whole, and at the micro level improving understanding of the frequency and pattern of services along an individual route?

In both research and design work, our approach is to focus primarily on the needs of the user, for if the user cannot understand the timetable, they cannot act on it. We integrated relevant findings from historical research and legibility research with our understandings of the current Brisbane Transport system. The result was two prototype timetable solutions, the Enhanced Numeric and the Timeline (Figs 5 & 6).

Both solutions represent cost-effective ways of presenting interconnection data as well as scheduling data. Both use a more graphic, visual approach to the display of timetabling information than current alphanumeric genres. The Timeline solution takes the concept of a visual timetable to completeness, transforming the traditional matrix of raw numerical data into a more dynamic and accessible visual display of 'timelines'.

We then tested our prototypes with users, to further increase our general understanding of the problems people have in using timetables, and how they might be solved. Testing also allowed us to see if the two new Communication Research Institute of Australia (CRIA) formats, the Enhanced Numeric and the Timeline, reduced the number of problems people have with the current timetables.

This paper documents our reasoning and methodology in the development of the prototypes, and our evaluation process. The testing reinforced our initial position that macro and micro levels of route understanding are both extremely important to the user and their use of the system. Our prototypes provide partial solutions, but the testing highlights potential avenues for further research and development.

Design objectives

Information design bridges the worlds of technology and art. It is a blend of communicative, aesthetic and technical objectives. In developing timetable prototypes for Brisbane Transport our concern was to balance the communication needs of the user—for clarity and effectiveness—with a concern for technical appropriateness (to the current production infrastructure) and visual quality.

Our communication objectives were to develop a timetable which:

- people can use with greater ease, so they can act on the information efficiently and effectively
- presents timetabling information in a clear and precise way, so aiding people to process and memorise the information
- integrates the varied approaches to timetabling of the numerous state, city, and private operators into a standardised information system with consistent visual presentation, coordinated colour coding and common graphic devices
- is a practical size for handling *en route*.

Our technical objective was to ensure that our design was consistent with current systems management of data at input, available printing technology at output, and economically viable.

Our aesthetic objectives were to make the timetable visually interesting and inviting, encouraging people to pick it up and use it. We also intended to use current developments in reproduction technology, namely economically viable multi-colour printing, to create graphic quality even in something as mundane as a timetable.

Our research based approach—what we did

Our approach to developing new timetable prototypes for Queensland Transport employed various strands of research which helped us to fully understand the problem and its context. Initially we conducted:

- A user and carrier survey—to fully understand passengers' information requirements within the overall context of public transport systems in Brisbane, the tasks users need to perform, how timetables are currently obtained and whether they are retained.
- Structural analyses of existing timetables—to determine what information is needed and what can be left out, what current aspects of data presentation are most helpful to the user, and where current timetable formats create problems in accessing the data.
- Historical research—to look at the way other information designers have dealt with the problems of presenting timetabling data. Our emphasis was on inter-

preting the historical solutions in relation to the Brisbane context to maximise any effective principles of presentation revealed by historical precedents.

- Legibility literature search—to provide general guidelines on the relative effectiveness of different timetable presentation options.
- Technological research—to identify the current systems of data storage and production, and to assess opportunities and constraints in the light of leading edge technological developments.

We used our research findings to provide the building blocks for the new prototypes.

The information context and legibility

Our structural analysis of existing timetables for bus and train carriers in the Brisbane area highlighted a number of problems, both at the macro level of the overall state transport system and in the micro details of timetable design.

A timetable, no matter how well designed and tested, is only part of the answer to a 'legible' transport system. By themselves timetables are inadequate. They need a whole range of contextual and supporting information, much of which is lacking or inconsistent at present in the many Brisbane Transport systems.

> A 'legible' system is one in which a passenger can get from one point to another easily and without any anxiety about getting lost. Furthermore, if the system is inherently 'legible' the passenger should be able to do this without having to ask other people for information or reassurance. (Bartram 1984:299)

System legibility

Bartram cites the London Underground as a particularly legible system. Passengers need to be able to determine their location and the pattern of actions necessary to take them to their destination. That is, they need to be able to relate the information on the timetable to the information on the ground. The visual information on the timetable and at depots, stations, bus stops, and on trains must be consistent and continually reinforce the data provided at each other point in the system. We can no longer be content to say that plenty of people habitually use the buses without any difficulty. Clearly, the person who catches the same bus to work every day no longer needs support information. But, as soon as they need to travel to another part of the city, or use another service, they are in the same position as a tourist or stranger.

Passengers require two major types of support information, in order to allay fears and prevent them from getting lost: (1) route planning information, such as regional public transport maps, and (2) in-transit information which allows passengers to make the correct choice at each decision point, ie. Is this the right bus stop? Is this the right bus? Is this where I get off? Do I need to have the exact fare? Is this where

I change for the train? In-transit information includes integrated signage at interchanges and individual stopping points, and on the outside and inside of all transport carriers.

Though discussion of these areas was outside the scope of our brief (and this paper), we stress that support information must be developed and implemented along with any improved timetabling presentation to ensure the legibility of the overall transport system.

The timetable within a legible system

When considering the transport system as a whole, the timetable can become an effective medium for both demonstrating and creating the integrated nature of the system as a whole. If the same graphic structure and format is used for the timetables of each separate carrier—bus, train, ferry—travellers will not need to learn to read many different timetable formats to complete one journey. The advantage of a standard timetable is that users can acquire a fluency across the entire transport system. Once travellers are familiar with the structure and graphic devices of one timetable, they have immediate access to the data in all other timetables. Constancy of design, together with consistent use of colour coding, icons and other graphic devices lessens the users' burden of decoding. Our task, then, was to develop a format that would be flexible enough to cater for the complexities and service differences between routes and carriers.

From the users' perspective this format needs to be eminently portable, preferably pocket-sized, and functional in any situation, whether the user is standing up in an overcrowded bus, or at a windswept bus stop.

From the production perspective this format needs to be reproduced economically and efficiently; to allow the addition of multiple schedules without the complex and impractical folding of the current timetables; and to allow the data to be drawn directly from the central IPTS (Integrated Public Transport System) data base, eliminating the current practices of laboriously re-keying, re-setting and re-proofing in order to print a revised or new edition.

Timetable legibility: numeric or linear presentation

The current genre for timetables presents the data numerically, with the sequence of location stops as the vertical dimension, and the times of journeys on the horizontal. Bartram's (1984) studies, which assessed people's ability to understand such timetables, revealed surprisingly poor performance—people do not understand timetables well, nor do they like using them (Bartram 1984, p. 313).

One of the major reasons for this poor performance is that people have great difficulty understanding information presented in tabular form, particularly when the table is presented as a two-dimensional matrix (Wright and Fox 1970). Secondly, as Bartram pointed out (1984, p. 315), the practice of running the route stops along the vertical dimension is contrary both to our reading pattern, which is left to right, and to the fact that people visualise motion in terms of left to right. Yet, throughout the world, timetabling information continues to be presented in this tabulated numerical form, even though every day experience confirms the research findings that such timetables are notoriously difficult for the average passenger to understand (Bartram 1985, Kinross 1991, p. 227).

Description of a transport system has to be two-dimensional because it requires both time and spatial orientation. How then can timetabling data be arranged on paper so that people can more readily make sense of them, and perhaps even enjoy using them? We are not the first to have asked this question! Historical research reveals there are alternatives to simply presenting timetabling data numerically.

William Playfair (1759–1823), the English political economist who is generally credited as the inventor of statistical graphs and linear charts, realised that anything which could be expressed in numbers could also be represented by lines. His insights led him away from the alphanumeric presentation of data in printed tables to the exploration of graphic formats that allow the 'mind of the eye' to make sense of the data.

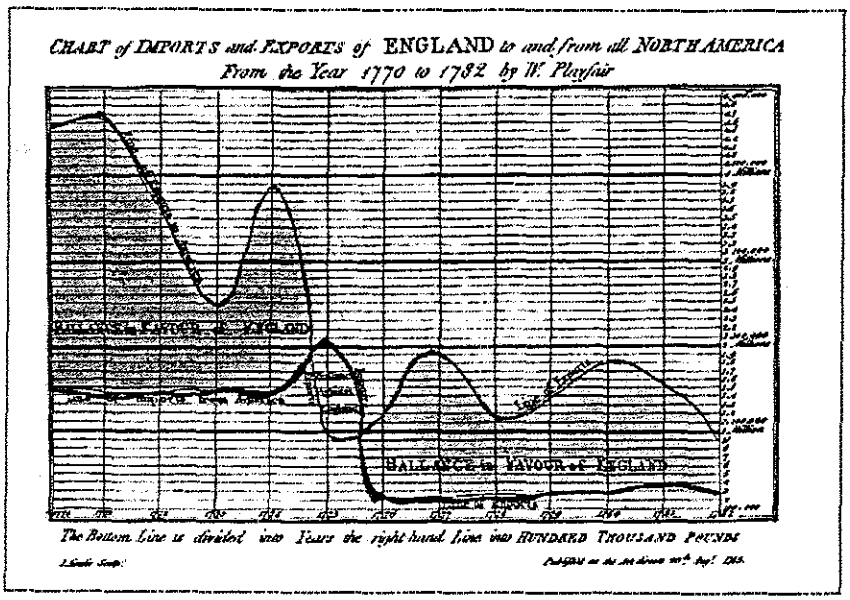

Figure 1. **Playfair's Chart of Imports and Exports, *Commercial and Political Atlas*, 1786.**

Playfair used a time grid to plot the data as lines. This device revealed the visual shape of the data, inviting comparison and improving memory retention of the facts.

> .. as much information may be obtained in five minutes as would require whole days to imprint on the memory... by a table of figures (Playfair, 1801, p. xi–xii, cited in Biderman, 1990)

In our developmental work on the timetable prototypes we followed Playfair's example of simplifying the presentation of complicated data for its quick and ready grasp by the busy ordinary person, by using visual and relational means to present data. Our Timeline prototype adopts his grid and line technique to describe and summarise a set of numbers.

We have also borrowed from other information designers working with this linear form to solve timetabling problems. Charles Ibry, a Paris engineer, patented a graphic schedule for transport systems in 1846. Ibry increased the explanatory power of Playfair's time-series graphs by showing data moving over space as well as through time. His ideas were used by Marey in 1888 to schedule French railway services (see Figure 2), but Ibry's hope that his visual schedule would be used by the general public was never fully realised.

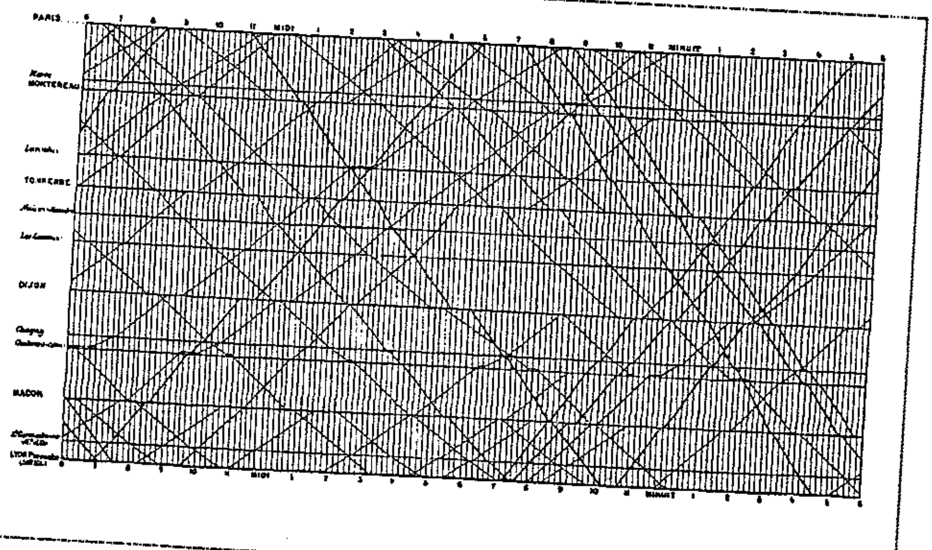

Figure 2. **Marey's schedule for Train services, Paris to Lyons, 1888 (from Tufte, 1983, p. 115)**

The contemporary information designer, Edward Tufte, is the first to have exploited the combination of Ybry's graphic schedule with current technology to solve the problem of timetabling design.

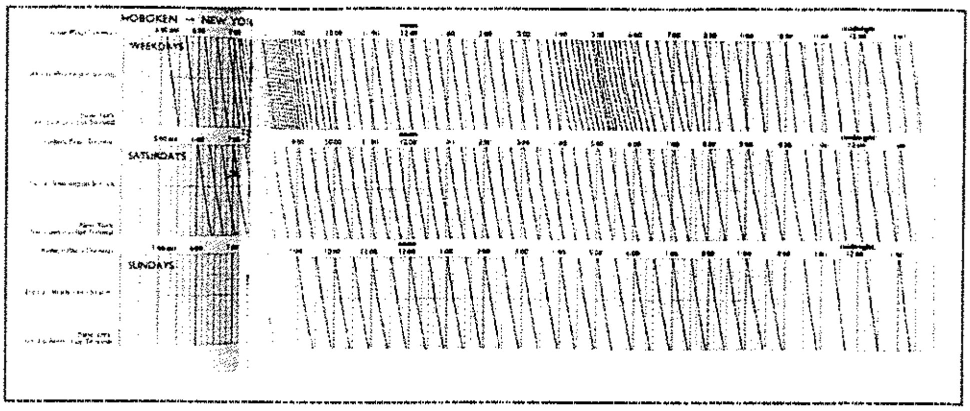

Figure 3. Tufte's 'string timetable' for the New York Transit Department (Tufte, 1990, p. 108–9)

Discussing his 'string timetables' in his recent book, *Envisioning Information*, Tufte comments:

> Hourly, daily and weekly rhythms of the buses are clearly revealed, as well as details of each journey During rush hours, lines densely crowd into spaghetti—but then service is so frequent that the jumble of lines informs the rider simply to show up, for there will be virtually no wait for whatever bus it is that arrives The grey grid is set at ten-minute intervals in order to ease the visual interpolation of the times of arrival (Tufte, 1990, p 108)

From our historical research we concluded that the tradition of the linear timetable inspired by Playfair, Ibry and Marey, and developed by Tufte, had potential. It could be used to present timetabling information in a clear, visual way, allowing travellers immediate and detailed access to an additional level of route information, the frequency and pattern of services along a paricular route over a particular time period. But Tufte's 'string timetables' still follow the established genre, with the times running along the horizontal axis and the route locations along the vertical axis. In our redevelopment of the linear timetable we adopted Bartram's (1984) 'reflected timetable format', with the route travelling left to right horizontally and the times indicated vertically. This rotated format capitalises on left to right reading gravity. In fact, Bartram's research showed the rotated format improves both scanning time and accuracy.

A second improvement is that we added a stick map along the horizontal axis which names *all* stops along a particular route in chronological sequence. Tufte, in his 'string timetables', eliminates much valuable route information, presenting merely departure and arrival times with one midway timing point. To overcome the lack of route information on the timetable he provides the traveller with a large accompanying route map, overlaid in colour on a detailed aerial photograph. Tufte argues this is 'so much richer than the typical schematic diagram of bus routes'

(1990, p. 108). His solution, however, has been severely criticised in terms of the economic viability of reproducing up-to-date aerial maps of a whole transport region, and the ergonomic problems of passengers handling such cumbersome timetables (Kinross, 1991, p. 25).

In contrast to Tufte's somewhat extravagant, though very elegant solution, the horizontal stick map we added allows us to include *all* necessary route information within a pocket-sized format, without incurring the additional expense of detailed maps. The stick map also allows us to introduce additional micro level locational information, such as Park and Ride facilities. Furthermore, the stick route map allows us to bring in macro level interconnection information, in the form of visual icons, allowing the user to see where some of the other services within the overall transport system interconnect with the local service.

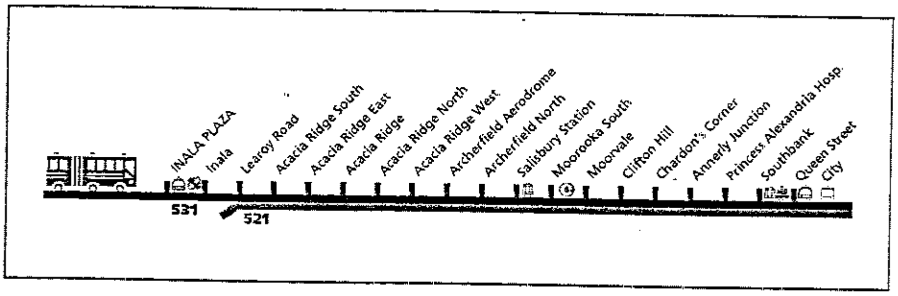

Figure 4. A black and white detail of our prototypes, showing the horizontal stick route map with additional micro and macro level route information.

The prototypes

The features of our prototypes are as follows:

- Route number, destination and arrival points are boldly and clearly displayed within an area of clear space at the top of the timetable.
- A horizontal stick map showing all route stops, with an icon of the carrier, gives users direct visual orientation to both route and direction.
- Times are shown down the vertical dimension of the rotated format.
- Times are presented using the 12-hour clock to avoid common confusions with the 24-hour clock, and the words 'morning', 'afternoon' and 'evening' are used instead of the frequently misunderstood Latin abbreviations, am and pm.
- Timetabling schedules are presented one per page in a contiguous unbroken set.
- Each scheduling period, ie. Weekdays, Weekends, Public Holidays has a banner heading for easy recognition.

- Consistent icons, representing interconnection points and other useful passenger information (such as parking facilities at rail stations, local centres etc), are inserted on the stick map, building up a more useful 3-D image of the route and the overall transport system.
- All routes and interconnection information are consistently colour coded.

With the Timelines (see Figure 5 below), the numerical timing data is replaced with a dataline, colour coded for the particular service it represents. The dataline overprints on a muted background grid that displays timing points in quarterly hour divisions.

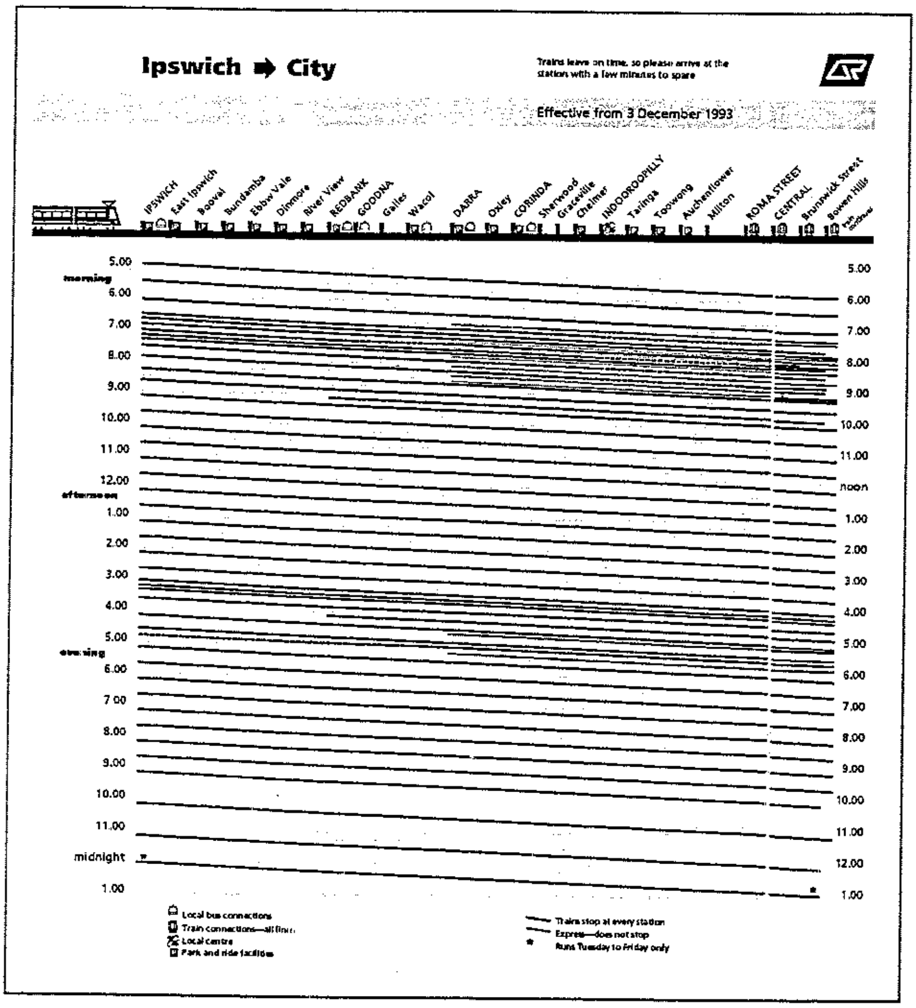

Figure 5. The Timeline

Ipswich ➡ City

All trains leave on time, so please arrive at the station with a few minutes to spare.

Mondays to Fridays — Effective from 3 December 1993

	IPSWICH	East Ipswich	Booval	Bundamba	Ebbw Vale	Dinmore	River View	REDBANK	GOODNA	Gailes	Wacol	DARRA	Oxley	CORINDA	Sherwood	Graceville	Chelmer	INDOOROOPILLY	Taringa	Toowong	Auchenflower	Milton	ROMA STREET	CENTRAL arrive	depart	Brunswick Street	Bowen Hills	continues to
morning	458	502	504	506	508	510	512	516	518	520	524	527	529	531	532	532	533	535	537	539	541	543	546	548	550	552	554	Cb
	529	531	533	535	537	539	541	543	547	549	551	555	558	600	602	603	604	606	608	610	612	614	617	619	621	623	625	Cb
	603	605	607	609	611	613	615	617	621	623	625	629	632	634	636	637	638	640	642	644	646	648	652	654	656	658	700	P
												647	650	652	654	655	657	659	701	703	705	707	711	713	715	717	719	FG
	634	636	638	640	642	644	646	648	652	654	656	700	703	705	707	708	709	711	➡	➡	➡	➡	719	721	723	725	727	M
	642	644	646	648	650	652	654	656	700	702	704	708	711	714	716	717	718	720	722	724	726	728	732	734	736	738	740	–
	649	651	653	655	657	659	701	703	707	709	711	715	718	720	722	723	724	726	728	730	732	734	738	740	743	745	747	Nb
												721	724	726	728	729	730	733	735	737	739	741	744	746	748	750	752	S
	702	704	706	708	710	712	714	716	720	➡	➡	727	730	733	➡	➡	➡	➡	➡	➡	➡	➡	753	755	756	758	800	E
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	712	714	716	718	720	722	724	726	730	732	734	738	741	743	745	746	747	749	➡	➡	➡	➡	758	800	802	804	806	Cb
	717	719	721	723	725	727	729	731	735	737	739	743	746	748	750	751	752	754	756	759	800	802	806	808	809	811	803	–
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	733	735	737	739	741	743	745	747	751	753	755	759	802	804	806	807	808	810	➡	➡	➡	➡	819	821	823	825	827	–
												807	810	812	814	815	816	818	820	822	824	826	830	833	835	837	839	FG
	753	754	756	758	800	802	804	806	810	812	815	819	822	825	827	828	829	831	➡	➡	➡	➡	839	841	842	844	846	–
												824	827	829	831	832	833	835	837	839	841	843	847	850	851	853	855	–
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	818	820	822	824	826	828	830	832	836	838	840	844	847	849	851	852	853	855	857	859	901	903	906	908	910	912	914	Db
	839	841	843	845	847	849	851	853	857	859	901	905	908	910	912	913	914	916	918	920	922	924	927	929	931	933	935	Cb
								911	915	917	919	923	926	928	930	931	932	934	936	938	940	942	946	948	949	951	953	–
	909	911	913	915	917	919	921	923	927	929	931	935	938	940	942	943	944	946	948	950	952	954	957	959	1001	1003	1005	Cb
afternoon	Trains then run regularly, every half hour, departing Ipswich at 9 and 39 minutes past each hour until																											Cb
	239	241	243	245	247	249	251	253	257	259	301	305	308	310	312	313	314	316	318	320	322	324	327	329	331	333	335	Cb
	303	305	307	309	311	313	315	317	321	323	325	329	332	336	338	340	342	344	346	348	350	352	357	359	401	403	405	S
	313	315	317	319	321	323	325	327	331	333	316	340	343	346	348	349	351	353	355	357	359	401	405	407	409	411	413	P
	320	322	324	326	328	330	332	334	338	340	342	346	349	352	354	356	358	400	402	404	406	408	412	414	416	418	420	S
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	433	435	437	439	441	443	445	447	451	453	455	459	502	504	506	507	508	510	512	514	516	518	521	523	525	527	529	S
	447	➡	➡	➡	➡	➡	➡	➡	➡	➡	➡	506	509	511	513	514	515	517	519	521	523	525	528	530	532	534	536	Cb
												517	520	522	524	525	526	528	530	532	534	536	539	541	543	545	547	Cb
	509	511	513	515	517	519	521	523	527	529	531	535	538	540	542	543	544	546	548	550	552	554	557	559	601	603	605	Cb
evening	Trains then run regularly, every half hour, departing Ipswich at 9 and 39 minutes past each hour until																											Cb
	909	911	913	915	917	919	921	923	927	929	931	935	938	940	942	943	944	946	948	950	952	954	957	959	1001	1003	1005	–
	1009	1011	1013	1015	1017	1019	1021	1023	1027	1029	1031	1035	1038	1040	1042	1043	1044	1046	1048	1050	1052	1054	1057	1059	1101	1103	1105	Cb
	1109	1111	1113	1115	1117	1119	1121	1123	1127	1129	1131	1135	1138	1140	1142	1143	1144	1146	1148	1150	1152	1154	1157	1159	1201	1203	1205	–
*	1201	1202	1204	1206	1208	1210	1212	1214	1218	1220	1222	1226	1229	1231	1233	1234	1235	1237	1239	1241	1243	1245	1248	1250	1251	1253	1255	Cb

* Does not run on Monday evenings
➡ Express, train does not stop
Local bus connections
Local centre
Park and ride facilities

Cb—Caboolture; Db—Doomben; EF—Eagle Farm; FG—Ferny Grove; M—Mitchelton; Nb Nambour; P—Petrie; Pb—Pinkenba; S—Shorncliffe

Figure 6. The Enhanced Numeric

With the Enhanced Numeric, we improved legibility of the figures without taking up more space, by removing the colon generally used between the hours and minutes figures and increasing the size of the hour figure in relation to the minute figure. We also introduced more white space between the horizontal lines of figures so that people could track efficiently, following standards developed during our research into the presentation of statistical tabular information (MacKenzie 1992).

In looking at both prototypes, we believed the advantage of the Timeline to be that it shows at a glance, in a way alphanumeric tables never can, the overall picture of services on a particular route. Instead of an endless repetition of numbers we have a visual display of route, (its length and direction), interconnection points for other services, and the number of buses/trains that pass a particular stop throughout the day. One can readily contrast the frequency of regular daytime or evening services with rush hour peaks, irregularities become evident, and the frequency of the service becomes a clear and memorable 15 minute, half-hourly or hourly interval.

While the introduction of the graphic stick map to introduce macro level interconnection information about the transport system as a whole, the Timeline, is an attempt to show both macro and micro information in a systemic fashion.

However, the prototypes remained to be validated through user testing.

Diagnostic testing

Research based evaluation is a critical and integral part of the iterative design process we use. Over the past ten years, the Institute has developed a proficient testing method to predict the likely performance of public documents in use. The method is diagnostic and consists of asking a diverse range of users to undertake tasks they would normally undertake when using the document; observing their actions in performing these tasks; and noting their descriptions of the tasks, their speed and accuracy in performing the tasks and their comments about the document.

As its name suggests, the emphasis of the method is diagnostic. It takes the observed behaviours of people using a document as symptoms of the document's pathological condition or good health. The power of this method derives from its use in a cyclic process of testing and modification as follows. During the test, we observe symptoms of document pathology, in the form of inappropriate behaviour. We then modify the document to eliminate the pathological condition. We then retest the document to see if the symptoms, in the form of inappropriate behaviours, persist, and keep an eye open for unforeseen side-effects.

We assume that the problem with the document has been eliminated when the behavioural symptoms associated with that problem disappear in subsequent tests. Repeated experience has shown us that conclusions from such testing are robust in practice, and the cost of diagnostic testing is very much cheaper than more traditional methods such as surveys or focus groups.

In this case we were commissioned for a single round of testing only. We expected the testing to confirm pathological conditions of existing timetables (which we had diagnosed through our research) and to indicate where these conditions have been successfully dealt with by the modifications we made to the standard genre, as represented in the Enhanced Numeric and Timeline timetables. We also expected the testing to show where there is still room for improvement, and to highlight any unacceptable side-effects.

With this form of diagnostic testing it is not necessary to use large numbers of respondents. The intent is to identify major problems and to resolve them; not to prove that all the population can understand the document.

How the testing was conducted

With the assistance of a Department of Transport representative, we tested 52 people over a period of two days at two inner city locations. Our participants were from many ethnic backgrounds: Australian, European, Asian, Aboriginal and Pacific Islanders, and comprised regular users of public transport (65%), casual users (33%) and non-users (2%). Of the respondents, 67% were adults, 12% were youths and 21% were senior citizens. Use of English was problematic for 13%, and 11% of respondents were tourists with no local knowledge.

Unlike some studies which use homogeneous sampling techniques to obtain representative information about the average person, we designed our sampling procedure to diagnose the range of problems a heterogeneous sample of people has in using timetables. We compared three approaches to the presentation of timetable data:

Standard

The existing alphanumeric Queensland Rail timetable for the Ipswich line, ref-erred to throughout this paper as the Standard. It provided a baseline for comparative assessment.

Enhanced Numeric

Our alphanumeric prototype timetable for the Ipswich Rail line. It incorporates the rotated format, the horizontal route map, the addition of graphic devices for interchange information and our formatting recommendations for the presentation of numbers in tabular form. It was included in this study to enable us to assess the performance of our many graphic changes in isolation from the linear presentation of timing data on the Timeline (see below).

Timeline

Our linear graphic timetable prototype for the Ipswich Rail line. It has the same rotated format as the Enhanced Numeric, and the same graphic devices to clarify route and interchange information. The numeric timing points, however, are replaced with linear representation—hence the reference, Timeline.

Each respondent was briefly shown the three alternative forms of timetable. They were then handed one particular version, and asked to familiarise themselves with it. We then asked respondents to perform a number of tasks (without help or instruction from the testers).

In setting the tasks we made assumptions, based on our research, about the everyday tasks people use a timetable for. The tasks were designed to test respondents' ability to identify key elements on the timetable:

- route stops
- departures and arrival times
- express trains
- morning, afternoon, evening and after-midnight trains
- information about park and ride facilities
- information about interconnection facilities
- in the event of an enquiry, what number to ring.

We designed other tasks to allow our observation of the ease/difficulty with which respondents could locate correct times; distinguish between the different scheduling periods; and recognise frequency patterns.

We rated respondents' performance in two ways: accuracy of interpretation (correct or incorrect answer), and ease of access (timed in number of seconds until correct answer given). They also documented respondents' comments and behaviour. Out of a total of 52 respondents: 12 were tested on the Standard, 17 were tested on the Enhanced Numeric, and 23 were tested on the Timelines.

Larger numbers of participants were randomly assigned to the Enhanced Numeric and Timeline because we wished to test the viability of these prototype versions for addressing the already identified shortcomings of the Standard.

Results and analysis

Analytical procedures

The major part of each task protocol was devoted to finding out whether respondents could perform basic tasks. We noted all instances when they became confused, or gave up because something was incomprehensible.

We established a 30% failure rate as the determining indication of an unacceptable level of performance. That is to say, where 30% or more of the heterogeneous sample failed to respond correctly to a particular task, the results indicate that the timetable has a major problem in need of repair.

Establishing cut-off points, like the 30% failure rate used here, is our normal way of handling *diagnostic* quantitative data. However, at the preliminary presentation of results in Brisbane, we were asked to use our data to draw comparisons between the three types of timetables. As we had not structured the testing process to meet this requirement, we had not insured homogeneity of sample.

Consistent with our view that we are mainly interested in large differences in performance, conservative Chi-Square (χ^2) analyses were used to calculate the statistical reliability (or significance) of the differences in the proportion of participants who correctly versus incorrectly performed a given task across the three different timetables. These test results should be interpreted with caution: our diverse samples mitigated against finding small differences.

As it only makes sense to consider the length of time to complete a task when it has been performed correctly, the substantial number of incorrect responses resulted in insufficient sample sizes for using inferential statistics. However, in each case, the pattern of results reinforce the pattern found in the Chi-Square (χ^2) analyses of the relative frequencies of correct versus incorrect responses. Timetable elements that facilitated correct answers were also responded to more quickly.

Diagnostic results

The percentage frequency of incorrect responses is shown in Table 1.

Table 1. Percentage of incorrect responses on the Standard timetable

Task	Problem	% incorrect responses
1	Locating route stops, arrival and departure times	34%
2	Finding an express service	42%
3	Locating arrival and departure times on Public Holidays	42%
4	Locating a specific Park and ride facility	100%
5	Understand regular frequency of services throughout the day	25%
7	Understanding changes in frequency of service	50%
8	Identifying that an express train does not stop at a station	17%
9	Identifying an after midnight service	100%
10	Understanding where trains continue on to	42%
11	Specifying how long the train waits at Central	9%
14	Locating an enquiries number for information	100%

Table 1 indicates that the current genre of timetable causes people considerable problems in accessing and acting on timetabling information. Applying the 30% failure rate as the criteria of unacceptable performance, the results in the table indicate the Standard or current genre of timetable does not perform adequately for eight of the eleven performance based tasks.

The qualitative data provides some insight into respondents' problems with the Standard timetable. Negative comments were made by 92% of the respondents assigned to that timetable. Respondents found the Standard timetable 'too confusing', 'needs simplifying', with 'too many numbers' that are 'too small to see'.

'You can't see at a glance, you have to sit down and study them, it takes a lot of concentration'

33% of respondents commented on the difficulty distinguishing scheduling periods.

'all the trains for one day should continue across the page without a break'

'I don t like the way weekdays continues lower down. I thought it would continue over the page'.

When questioned about their need for more information, respondents said they wanted more network and interconnection information. The Standard timetable does not meet these needs: it simply does not provide any overview of the transport system.

Statistical analysis

Table 2 presents the results of our statistical analyses.

Table 2. Percentage of incorrect responses to the three timetables

Task	Problem	Standard	Enhanced	Timeline	p
1	Locating route stops, arrival and departure times	34%	17%	26%	ns
2	Finding an express service	42%[a]	19%[b]	19%[b]	<.01
3	Locating arrival and departure times on Public Holidays	42%	23%	26%	ns
4	Locating a specific Park and ride facility	100%[b]	0%[a]	19%[a]	<.01
5	Understand frequency of services throughout the day	25%	12%	13%	ns
7	Understanding changes in frequency of service	50%[b]	53%[b]	32%[a]	<.02
8	Identifying that an express train does not stop	17%[b]	6%[b]	0%[a]	<.01
9	Identifying an after midnight service	100%[a]	43%[b]	38%[b]	<.01
10	Understanding where trains continue on to	42%	14%	33%	ns
11	Specifying how long the train waits at Central	9%[a]	6%[a]	71%[b]	<.01
13	Identify bus interconnection	(100%)	0%	0%	na
	Identify local centre	(100%)	0%	91%	na
	Identifying train connections	(100%)	35%	45%	na
14	Locating an enquiries number for information	(100%)	19%	13%	na

a b Percentages with the same letter are not significantly different from one another

Table 2 indicates that the Enhanced Numeric and the Timeline performed significantly better than the Standard timetable. However, when precision was required to solve the task (Task 11) users were significantly more likely to perform better using the Enhanced Numeric and/or the Standard.

Interpretation of statistical and diagnostic results

We believe a number of components of presentation contributed to the significant differences in performance among the three timetable formats.

Temporal and spatial issues—the concept of am and pm

A distinguishing feature of the Enhanced Numeric and Timeline is that both replace the Standard use of am/pm with the words morning/afternoon/ evening, and both use the 12-hour rather than the 24-hour clock. We believe that these two components contributed to the significant improvement in performance in the case of Task 9—to identify an after-midnight service

All respondents assigned to the Standard went to the wrong place on the timetable when asked to find the after-midnight information. We infer that they did not expect to find information about an after-midnight train listed prior to information about morning trains.

> 'Why do trains stop after midnight?'
>
> 'Can't tell whether they run after midnight'

In contrast, respondents using both the enhanced Numeric and Timeline had little difficulty in locating the after-midnight trains. The over 30% failure rate for the Enhanced Numeric and Timeline is attributable to the way the task was framed. Participants were asked to identify whether a train ran after midnight on *Monday*. The respondents who 'failed' did identify the after-midnight service. However, they did not see the associated symbol which indicates that the service does not, in fact run on Monday evenings. They, therefore, 'failed' the task.

The behaviour pattern of respondents helps to explain the results of the statistical analysis. Participants were significantly more likely to identify the after-midnight services using either the Timeline or the Enhanced Numeric. We infer that the morning/afternoon/evening solution, with the use of the 12-hour clock, allows a significant improvement, over the am/pm/24-hour clock of the Standard which has implications for usage. People cannot use an after-midnight service if they are not aware that it exists.

Temporal and spatial issues—Ease of access

Tasks 1, 3 and 10 were designed to test the ease with which people could access information about what time to travel in order to arrive at a set destination by a particular time.

Although the results are not significantly different, the diagnostic results indicate a trend. Respondents assigned to the Enhanced Numeric and the Timeline performed better. At minimum, 74% of respondents could perform these tasks successfully.

In our opinion, the improved performance of the Enhanced Numeric and the Timeline relate to the use of the rotated format, in which the route runs horizontally, left to right, rather than vertically up and down. It is thus congruent with the established convention of reading, with peoples' reading pattern, and with reading gravity. Furthermore, the position of the 'continuing on' information, at the far right of the route, appears to match respondents' expectations regarding where one might expect to find such information. This suggests that the rotated format has great potential for making timetables easier for the traveller to use.

Secondly, we believe our practice of separating each scheduling period with a prominent banner heading enables users to easily differentiate between services running on weekdays and those running on weekends or public holidays.

Our research into the legibility of tables (MacKenzie 1992) allows us to infer that, on the Enhanced Numeric, other design components are also coming into play to improve ease of access. These are the increased type size, the differentiation in size of the hour and minutes figures, the muted vertical grid lines and the replacement of horizontal grid lines with increased line spacing. The combined effect or Gestalt of these design components is also playing a part in the improved performance of the Enhanced Numeric over the Standard.

We would also suggest that respondent's inability to solve arrival and departure problems relates in part to the 'thence every half hour' wording on the Standard:

> 'The most frustrating thing is trying to calculate the half hours.'

If people cannot interpret the train/bus times, then they cannot see when to catch it. Naturally this has usage implications.

Graphic versus alphabetic

Three of the tasks where the Enhanced Numeric *and* the Timeline performed significantly better than the Standard relate, we believe, to the introduction of graphic presentation techniques. The results for Tasks 2 and 8 (concerned specifically with the way express data is presented), for Task 4 (locating a Park and ride facility) and for Task 7 (understanding changes in the frequency of services throughout the day) allow us to infer that people more readily comprehend the graphic solutions presented in the Enhanced Numeric and the Timeline than the alphabetic solutions used in the Standard.

For example, respondents using the Standard timetable were initially unaware that express trains were indicated:

'It doesn't tell you which are expresses'

Even after the express device had been highlighted in Task 2, 17% of respondents still failed to grasp the alphabetic coding of the Standard when answering Task 8. So, although the diagnostic results seem to suggest the Standard timetable adequately indicates an express train, the acceptable failure rate on the Standard for Task 8 must be interpreted in the context of the ordering of the test tasks; that is, respondents had already been made aware of the 'Exp' abbreviation in Task 2. By comparison, the graphic Timeline solution allowed a 100% correct performance in Task 8.

The significant difference in performance and the high scores of accuracy achieved by the Enhanced Numeric and Timeline suggests that visual solutions in providing a graphic symbol for express trains is working extremely well.

Similarly, the performance of visual icons to present ancillary interconnection information on the Enhanced Numeric and Timeline clearly shows the effectiveness of graphic solutions. The icons are positioned along the horizontal route map adjacent to the relevant station, creating a logical visual relationship which we conclude helps respondents find the information they are seeking. The graphic presentation and interconnection of symbol with station is only possible on the Enhanced Numeric and Timeline because of the rotated format. This again leads us to conclude that the rotated format provides users with extra timetabling information at both the micro and macro levels. The implication of this for transport managers and operators is that if users are provided with, and made aware of, connecting services and the integrated nature of the transport system as a whole, it is likely that usage of these public transport services will increase.

Recognising the changing frequency of service

Tasks 5 and 7 were designed to test whether people could use the arrival and departure time information to identify a pattern of the regularity and frequency of train services throughout the day. It became apparent during testing that respondents had not thought about extracting this kind of information from timetables before,

'A regular pattern? I had no idea the trains were like this'

When the changing pattern of frequency becomes more complex and irregular (as in peak hours during weekdays), the Timeline performs significantly better (Task 7). The Standard and Enhanced Numeric both failed to give a clear picture of when regularity patterns change.

Respondents reacted to their discovery of the changing frequency of service throughout the day with enthusiasm. Commuters commented on the value of this level of understanding, for timing their travel to coincide with a range of peak hour services, noting a possible range of times for working late before they would need to bring the car.

Our research thus indicates that an ability on behalf of users to conceptualise and memorise changing patterns of service frequency may be important to actual usage of public transport. It is because travellers cannot see frequency and regularity that they decide not to risk the inconvenience of public transport. The implication is that if travellers can see the spatial and temporal context of a route, they can readily assess whether or not to use public transport in a particular context.

We infer that the Timeline format has the potential to increase user familiarity with their service, allowing them to make decisions and take an action they had not considered before. The Timeline format opens up new opportunities for users by providing a new capacity, and the benefits—a potential increase in public transport usage—needs to be explored further.

Graphic versus numeric—the issue of precision

The above results indicate the power of graphic presentation over alphabetic presentation. However, where graphic presentation completely replaces numeric presentation, we see a trend towards ease of access, but at the cost of precision.

Task 11, to specify how long trains wait at Central Station, diagnosed a serious side-effect in the Timeline. 72% of respondents could not accurately specify the wait time with a greater accuracy than five minutes, indicating that, for the majority of respondents, the Timeline has a precision range of five minutes. This lack of minute-by-minute precision, proved inadequate, for 56% of users.

> 'I don't like it at all. It's not accurate enough.... I'd have to check on the phone'

Yet almost half the respondents, 44%, were unconcerned about the lack of precision:

> 'This is a significant improvement Speaking as an old man it would be a tremendous help to old people You can see things at a glance—you're not disadvantaged by failing eyesight, and I always get there a bit early anyway'
>
> 'It's less jumbled. Doesn't need all the times on it because that just gets confusing with all the different columns of times of trains'

The important point here is that the purely graphic Timeline approach is appropriate for nearly 50% of respondents, just as the Enhanced Numeric approach addresses the needs of just over 50%.

Our conclusion is that information needs to be presented in different ways to different people, because different people have different needs.

In summary, timetables are read for very specific purposes by specific readers with specific problems. In our research on document structure and design we have repeatedly found that different readers have different needs, different access strategies and different search strategies. There is no one strategy for searching or accessing that suits all. Instead it is necessary to have different means for different people. Our research indicates that there is thus a place for both numeric and graphic timetabling information.

When reading a timetable we rarely need to go from beginning to end. Instead, we enter at a specific point and leave when we have found the information we need. The Standard timetable provides very little in the way of access features. On the Enhanced Numeric and Timeline we have introduced graphic features to help the traveller enter the timetable at the relevant place. For example, we have emphasised the route and direction of travel, with the train/bus icon on the left, and the arrangement of the stops running from left to right. The route travels with reading gravity, left to right, helping the traveller to access their particular departure and arrival points. It is a better match with peoples' expected reading pattern than the current genre of timetable which has the stops running vertically.
On the Enhanced Numeric and Timeline we have located additional ancilliary information about particular stations, such as the details of facilities at each station, and interconnection data, near the relevant station name along the route. This allows the information to be readily accessed. Testing suggests that to increase the effectiveness of symbols explaining irregularities, they too need to be placed repeatedly with every station that is affected along the route at the appropriate time.

The testing shows the graphic approach to the presentation of information is extremely effective. People could readily access both micro route information and macro interconnection information that they were not aware of with the Standard timetable. People cannot use an after-midnight service if they are not aware it exists. They cannot decide to take the train to speed up their journey to the city if they are unaware of interconnection with local bus routes. The way time-tabling information is presented can have a direct influence on public transport usage.

Conclusion

Our research has been encouraging, showing that the changes in format we introduced on the Enhanced Numeric and Timeline do address particular problems and 'pathological conditions' of the Standard genre of timetable. By introducing wording and structures (the rotated format) that are closer to peoples normal everyday way of doing things, we are able to improve performance across the range of tasks tested. By comparison, the existing timetable genre works against reading gravity and uses unfamiliar abbreviations.

Our changes and improvements address two issues in particular which the Standard, or current timetable does not. Our more visual, graphic prototypes provided people with a broader understanding of individual routes, and opened up an understanding of the overarching system of route and service connections.

However, neither the Enhanced Numeric nor the Timeline are fault free. These prototypes are only suggestive of what could be done in providing information at the micro and macro level: they have only gone through one round of testing. The next step would be iterative development and refinement of a new style timetable that incorporates the successful components of information presentation from both the Enhanced Numeric and the Timeline. That is, a new timetable that combines the precision of numeric presentation with the improved and broadened performance engendered by the introduction of graphic features. The potential of picturing frequency at the micro level and interconnectedness at the macro level could be developed and further explored.

Our research has highlighted that users have a much broader view of the transport system as a whole than perhaps managers and operators of transport systems do. Users think about timetables and their purpose in a much broader way than perhaps those of you who are running transport systems do. Issues of interconnectedness are extremely important to users, as are issues of frequency and service irregularity. Timetables need to be designed to reflect these user needs.

We suggest that the way in which frequency of service and interconnections are represented on the timetable can have a radical effect on the usage of those services. A timetable can be purposively used by joint operators to focus public attention on the interconnectedness and regularity of their services. As Ellson and Tebbs (1978, 1981) have demonstrated, providing information to the public about the availability of services in their area is a highly cost-effective way of increasing patronage. The timetable can be an ideal medium to explore these cost-effectiveness issues further.

In summary, transport services exist to serve users. Typically, as patronage declines, financial and political support for public transport also declines. Our work suggests that by incorporating users' perspectives and information needs into timetable design, user support for and use of public transport could be encouraged.

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