

# Research in Brief: Understanding Tabular Displays

Patricia Wright

Tabular displays can differ from each other both in the logic underlying their construction and in the way a particular principle of tabulation is displayed. Experimental studies have shown that people find some tabulation logics difficult to understand. If the user of a table is required to carry out operations other than *search* and *read*, the size of the population of competent users is markedly reduced. Tabulation schemes requiring synthetic or analytic operations on the part of the user seem to buy economy of space at the cost of comprehension. This appears to be true both of two dimensional matrices and tables involving simple arithmetic. Furthermore one of the necessary prerequisites for the successful use of matrix formats appears to be the user's familiarity with the relevant dimensions of the problem he is trying to solve, rather than his familiarity with the table itself. When information about the outcomes of complex conjunctive and disjunctive contingencies must be presented (e.g., in technical manuals) the use of a flow chart, or logical tree, is often more effective than other ways of presenting the same information.

Studies of alternative ways of displaying tabular list structures have shown that it is helpful to have:

- (a) Items arranged so that they are scanned vertically, rather than horizontally
- (b) Typographic distinction between different units in the table (rather than using conventional unit abbreviations after each item)
- (c) Appropriate spacing within and between columns (i.e., with related pairs closer than unrelated pairs)

351 *Wright : Understanding Tabular Displays*

- (d) Column headings much larger and bolder than the text for large, wall-size displays (such headings do not seem helpful for tables used at normal reading distance)
- (e) Appropriate print size, style of character, and contrast with background coloring.

Probably we have all at some time puzzled over railway timetables, or misread mileage charts; so we know how true it is that getting information out of some kinds of tables can be much more difficult than getting it out of others. But what is it that makes some tabulation formats difficult? What are the hallmarks of a good tabular display? Recent research has raised doubts about the wisdom of the commonly held opinion that the best table is the one with the fewest figures.

To illustrate this last point, consider the findings of a large-scale experiment using a modified market survey technique in which over two thousand people were tested [Wright and Fox, 1970]. In this experiment people were shown a small section of a conversion table—either section (a) or section (b) from Figure 1—and were asked how much two £sd amounts would be in the new currency, and also what two £p amounts were in the old currency.

Both tabular sections (a) and (b) contained the information needed to answer the questions, although section (b) required the user to carry out a simple addition (e.g., to add 40p and  $1\frac{1}{2}$ p to convert  $8\frac{1}{4}$ d). Averaging across the data from all four questions, the proportion of people able to give the correct answer varied from 85% to 40% depending upon whether the person had section (a) or (b), how old they were, and their socio-economic background.

Even providing written instructions on how to use section (b), setting out the conversion as a simple arithmetic sum, was not always beneficial. The elderly people taking part in the experiment had significantly fewer correct answers when given this extra information. Perhaps they were bewildered by yet more figures. The results of this experiment are given in Figure 2.

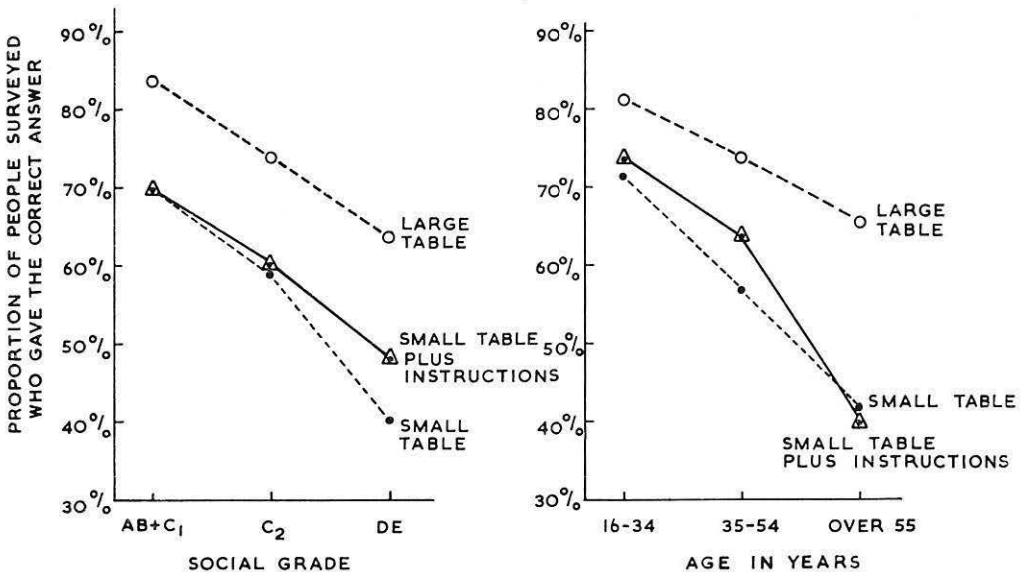
|     |               |               |               |
|-----|---------------|---------------|---------------|
| (a) | 7/4d ... 36½p | 8/4d ... 41½p | 9/4d ... 46½p |
|     | 7/5d ... 37 p | 8/5d ... 42p  | 9/5d ... 47p  |
|     | 7/6d ... 37½p | 8/6d ... 42½p | 9/6d ... 47½p |

|     |              |            |
|-----|--------------|------------|
| (b) | 7/-d ... 35p | 4d ... 1½p |
|     | 8/-d ... 40p | 5d ... 2p  |
|     | 9/-d ... 45p | 6d ... 2½p |

Figure 1. Sections of the two tabulation formats used in the market survey experiment. (a) A section from a large, fully explicit table that requires the user simply to search for the correct answer. (b) A section from a smaller table where much of the information is implicit, and requires additional operations on the part of the user.

Figure 2. The results of the market survey experiment, showing the proportions of correct conversions made by different sections of the general public. The groupings along the horizontal axis correspond approximately to thirds of the adult population.

### PROPORTIONS OF THE GENERAL PUBLIC ABLE TO USE VARIOUS CONVERSION TABLES



From the data shown in Figure 2, it would seem necessary to adopt the fully explicit tabulation scheme of section (a) if the conversion table was to be used by the general public. More recent studies have suggested that this remains true even when the information tabulated is non-numerical [Wright and Fox, 1972]. Tabulation schemes that involve people in doing more than simply searching for the correct answer may save space at the cost of ease of comprehension.

One tabular arrangement which on the face of it only involves a search by the user, is a matrix format. Here a double-entry table is arranged so that the user locates a particular cell within the table by reference to both row and column headings. Numerical matrices have been known to present problems for some users [Wright, 1968]. Nevertheless, there is evidence that such formats can be very efficient ways of expressing the outcome of complex conjunctive and disjunctive contingencies (the "if this . . . then, if not . . . the other" type information). Research suggests that whenever a problem is clearly structured, so that people are confident about which rows and columns they want to look up, then consulting a matrix is both speedy and relatively error free [Wright, 1971].

When the problem is less well structured—for example, when buried in irrelevant details—then an algorithm or flow chart is much less error prone than the matrix. For information that has to be used from memory neither the matrix nor flow chart seem to be optimal formats. Perhaps because of the use made by many people of verbal coding procedures when remembering material, it was found that presenting the information in the form of a list of short sentences gave better retention than non-sentential formats [Wright and Reid, 1973].

The generality of the findings from laboratory studies of tabulation formats is always a serious issue. The results just mentioned show that there is often no universally optimal way of presenting information. Characteristics of the working situation and the user population all combine to determine the most effective format. Nevertheless there is one general point that must be made. A more realistic working environment appears to enhance the superiority of whichever table is found to be better in the laboratory. This has been illustrated with reference to the comparison of the explicit and implicit tables of Figure 1. A pencil and paper test suggested that there was a difference between the tables of one

second per conversion, with the explicit Table (a) being the faster table to use. In a shopping situation, which involved handling merchandise and various other distractions, the difference between the two tabulation formats became six seconds per conversion. The lesson to be drawn is that as the working conditions become poorer so there is an increasing advantage for the easier table. Similar potentiation is found when a comparison is made between people of differing intellectual and/or numerical abilities. Small differences found between tabulation formats used by very bright people tend to become large differences when the tables are used by people of lesser ability. This point cannot be made too forcefully because when discussing alternative tabulation displays it is all too easy for intelligent people, looking at a particular table in conditions of comparative calm, to feel that variations in display have only marginal effects; but in the working environment there can be substantial benefits from using the easier of two typographic formats.

So far we have discussed tables which are based on different underlying logical principles. The choice of a particular principle determines to a large extent who will be able to understand the information being presented. There is very little that can be done typographically to rescue a tabulation scheme which is making too severe demands upon the intellectual capacity of the user. However, the converse is not true. A tabulation scheme which is in principle easily comprehended by the target population, may result in performance that is far from optimal on account of typographic and related display characteristics.

This point has been illustrated by studies of currency conversion tables, all of which were based on the principle shown in Figure 1a. It was found that such conversion tables were used more speedily if successive pairs were arranged vertically down the page (as in Figure 3b) rather than horizontally (see Figure 3a).

It was also found that differentiating the £p and £sd amounts typographically resulted in faster performance, which was then impaired if the abbreviations "p" and "d" were introduced into the table after each item. Such abbreviations were clearly unnecessary, and may have hampered the scanning process when people were locating a particular item within the table.

|                               |                  |                   |                  |                  |                   |                  |                   |                  |                   |                  |                   |                    |
|-------------------------------|------------------|-------------------|------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|--------------------|
| OLD s. d.<br><b>NEW PENCE</b> |                  | 1                 | 2                | 3                | 4                 | 5                | 6                 | 7                | 8                 | 9                | 10                | 11                 |
|                               |                  | $\frac{1}{2}$     | 1                | 1                | $1\frac{1}{2}$    | 2                | $2\frac{1}{2}$    | 3                | $3\frac{1}{2}$    | 4                | 4                 | $4\frac{1}{2}$     |
| OLD s. d.<br><b>NEW PENCE</b> | 1/-<br><b>5</b>  | 1/1<br><b>5½</b>  | 1/2<br><b>6</b>  | 1/3<br><b>6</b>  | 1/4<br><b>6½</b>  | 1/5<br><b>7</b>  | 1/6<br><b>7½</b>  | 1/7<br><b>8</b>  | 1/8<br><b>8½</b>  | 1/9<br><b>9</b>  | 1/10<br><b>9</b>  | 1/11<br><b>9½</b>  |
| OLD s. d.<br><b>NEW PENCE</b> | 2/-<br><b>10</b> | 2/1<br><b>10½</b> | 2/2<br><b>11</b> | 2/3<br><b>11</b> | 2/4<br><b>11½</b> | 2/5<br><b>12</b> | 2/6<br><b>12½</b> | 2/7<br><b>13</b> | 2/8<br><b>13½</b> | 2/9<br><b>14</b> | 2/10<br><b>14</b> | 2/11<br><b>14½</b> |
| OLD s. d.<br><b>NEW PENCE</b> | 3/-<br><b>15</b> | 3/1<br><b>15½</b> | 3/2<br><b>16</b> | 3/3<br><b>16</b> | 3/4<br><b>16½</b> | 3/5<br><b>17</b> | 3/6<br><b>17½</b> | 3/7<br><b>18</b> | 3/8<br><b>18½</b> | 3/9<br><b>19</b> | 3/10<br><b>19</b> | 3/11<br><b>19½</b> |
| OLD s. d.<br><b>NEW PENCE</b> | 4/-<br><b>20</b> | 4/1<br><b>20½</b> | 4/2<br><b>21</b> | 4/3<br><b>21</b> | 4/4<br><b>21½</b> | 4/5<br><b>22</b> | 4/6<br><b>22½</b> | 4/7<br><b>23</b> | 4/8<br><b>23½</b> | 4/9<br><b>24</b> | 4/10<br><b>24</b> | 4/11<br><b>24½</b> |
| OLD s. d.<br><b>NEW PENCE</b> | 5/-<br><b>25</b> | 5/1<br><b>25½</b> | 5/2<br><b>26</b> | 5/3<br><b>26</b> | 5/4<br><b>26½</b> | 5/5<br><b>27</b> | 5/6<br><b>27½</b> | 5/7<br><b>28</b> | 5/8<br><b>28½</b> | 5/9<br><b>29</b> | 5/10<br><b>29</b> | 5/11<br><b>29½</b> |
| OLD s. d.<br><b>NEW PENCE</b> | 6/-<br><b>30</b> | 6/1<br><b>30½</b> | 6/2<br><b>31</b> | 6/3<br><b>31</b> | 6/4<br><b>31½</b> | 6/5<br><b>32</b> | 6/6<br><b>32½</b> | 6/7<br><b>33</b> | 6/8<br><b>33½</b> | 6/9<br><b>34</b> | 6/10<br><b>34</b> | 6/11<br><b>34½</b> |
| OLD s. d.<br><b>NEW PENCE</b> | 7/-<br><b>35</b> | 7/1<br><b>35½</b> | 7/2<br><b>36</b> | 7/3<br><b>36</b> | 7/4<br><b>36½</b> | 7/5<br><b>37</b> | 7/6<br><b>37½</b> | 7/7<br><b>38</b> | 7/8<br><b>38½</b> | 7/9<br><b>39</b> | 7/10<br><b>39</b> | 7/11<br><b>39½</b> |
| OLD s. d.<br><b>NEW PENCE</b> | 8/-<br><b>40</b> | 8/1<br><b>40½</b> | 8/2<br><b>41</b> | 8/3<br><b>41</b> | 8/4<br><b>41½</b> | 8/5<br><b>42</b> | 8/6<br><b>42½</b> | 8/7<br><b>43</b> | 8/8<br><b>43½</b> | 8/9<br><b>44</b> | 8/10<br><b>44</b> | 8/11<br><b>44½</b> |
| OLD s. d.<br><b>NEW PENCE</b> | 9/-<br><b>45</b> | 9/1<br><b>45½</b> | 9/2<br><b>46</b> | 9/3<br><b>46</b> | 9/4<br><b>46½</b> | 9/5<br><b>47</b> | 9/6<br><b>47½</b> | 9/7<br><b>48</b> | 9/8<br><b>48½</b> | 9/9<br><b>49</b> | 9/10<br><b>49</b> | 9/11<br><b>49½</b> |

Figure 3. Some alternative ways of displaying a large, fully explicit conversion table (Clockwise from above). (a) Items arranged so that they can be scanned horizontally. (b) Items arranged so that they can be scanned vertically. (c) Some items made larger and bolder than the body of the table to serve as landmarks when scanning.

In differentiating the two currencies, color cues were found no more effective than the contrast of bold and light typefaces. Clearly this may cease to be the case when there are more than two items to be related in a table. Nevertheless one danger in the use of color did become apparent in these studies. There is always the risk of impairing legibility if the color of the typeface and the background do not present a sufficient contrast, thereby slowing down the user and increasing the risk of simple reading errors.

Introducing landmarks or sub-headings into a table (see Figure 3c) is not inevitably beneficial. Many people seem to ignore such headings, and may even report that the information given in the heading (for example the conversion of 2/-) is not included in the table (i.e., they say that they cannot find it). However, it is possible that the size of the landmarks relative to the body of the text may be fairly critical, since this phenomenon of apparent invisibility was

| OLD<br>s. d. | NEW<br>PENCE | OLD<br>s. d. | NEW<br>PENCE | OLD<br>s. d. | NEW<br>PENCE | OLD<br>s. d. | NEW<br>PENCE | OLD<br>s. d. | NEW<br>PENCE |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|              |              | 2/-          | 10p          | 4/-          | 20p          | 6/-          | 30p          | 8/-          | 40p          |
| 1d           | ½p           | 2/1d         | 10½p         | 4/1d         | 20½p         | 6/1d         | 30½p         | 8/1d         | 40½p         |
| 2d           | 1p           | 2/2d         | 11p          | 4/2d         | 21p          | 6/2d         | 31p          | 8/2d         | 41p          |
| 3d           | 1½p          | 2/3d         | 11½p         | 4/3d         | 21½p         | 6/3d         | 31½p         | 8/3d         | 41½p         |
| 4d           | 2p           | 2/4d         | 12p          | 4/4d         | 22p          | 6/4d         | 32p          | 8/4d         | 42p          |
| 5d           | 2½p          | 2/5d         | 12½p         | 4/5d         | 22½p         | 6/5d         | 32½p         | 8/5d         | 42½p         |
| 6d           | 3p           | 2/6d         | 13p          | 4/6d         | 23p          | 6/6d         | 33p          | 8/6d         | 43p          |
| 7d           | 3½p          | 2/7d         | 13½p         | 4/7d         | 23½p         | 6/7d         | 33½p         | 8/7d         | 43½p         |
| 8d           | 4p           | 2/8d         | 14p          | 4/8d         | 24p          | 6/8d         | 34p          | 8/8d         | 44p          |
| 9d           | 4½p          | 2/9d         | 14½p         | 4/9d         | 24½p         | 6/9d         | 34½p         | 8/9d         | 44½p         |
| 10d          | 5p           | 2/10d        | 15p          | 4/10d        | 25p          | 6/10d        | 35p          | 8/10d        | 45p          |
| 11d          | 5½p          | 2/11d        | 15½p         | 4/11d        | 25½p         | 6/11d        | 35½p         | 8/11d        | 45½p         |
| 1/-          | 5p           | 3/-          | 15p          | 5/-          | 25p          | 7/-          | 35p          | 9/-          | 45p          |
| 1/1d         | 5½p          | 3/1d         | 15½p         | 5/1d         | 25½p         | 7/1d         | 35½p         | 9/1d         | 45½p         |
| 1/2d         | 6p           | 3/2d         | 16p          | 5/2d         | 26p          | 7/2d         | 36p          | 9/2d         | 46p          |
| 1/3d         | 6½p          | 3/3d         | 16½p         | 5/3d         | 26½p         | 7/3d         | 36½p         | 9/3d         | 46½p         |
| 1/4d         | 7p           | 3/4d         | 17p          | 5/4d         | 27p          | 7/4d         | 37p          | 9/4d         | 47p          |
| 1/5d         | 7½p          | 3/5d         | 17½p         | 5/5d         | 27½p         | 7/5d         | 37½p         | 9/5d         | 47½p         |
| 1/6d         | 8p           | 3/6d         | 18p          | 5/6d         | 28p          | 7/6d         | 38p          | 9/6d         | 48p          |
| 1/7d         | 8½p          | 3/7d         | 18½p         | 5/7d         | 28½p         | 7/7d         | 38½p         | 9/7d         | 48½p         |
| 1/8d         | 9p           | 3/8d         | 19p          | 5/8d         | 29p          | 7/8d         | 39p          | 9/8d         | 49p          |
| 1/9d         | 9½p          | 3/9d         | 19½p         | 5/9d         | 29½p         | 7/9d         | 39½p         | 9/9d         | 49½p         |
| 1/10d        | 10p          | 3/10d        | 20p          | 5/10d        | 30p          | 7/10d        | 40p          | 9/10d        | 50p          |
| 1/11d        | 10½p         | 3/11d        | 20½p         | 5/11d        | 30½p         | 7/11d        | 40½p         | 9/11d        | 50½p         |

| OLD<br>s. d. | NEW<br>PENCE | OLD<br>s. d. | NEW<br>PENCE | OLD<br>s. d. | NEW<br>PENCE | OLD<br>s. d. | NEW<br>PENCE |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|

|     |     |            |           |            |            |            |            |            |            |
|-----|-----|------------|-----------|------------|------------|------------|------------|------------|------------|
|     |     | <b>1/-</b> | <b>5p</b> | <b>2/-</b> | <b>10p</b> | <b>3/-</b> | <b>15p</b> | <b>4/-</b> | <b>20p</b> |
| 1d  | ½p  | 1/1d       | 5½p       | 2/1d       | 10½p       | 3/1d       | 15½p       | 4/1d       | 20½p       |
| 2d  | 1p  | 1/2d       | 6p        | 2/2d       | 11p        | 3/2d       | 16p        | 4/2d       | 21p        |
| 3d  | 1½p | 1/3d       | 6½p       | 2/3d       | 11½p       | 3/3d       | 16½p       | 4/3d       | 21½p       |
| 4d  | 2p  | 1/4d       | 7p        | 2/4d       | 12p        | 3/4d       | 17p        | 4/4d       | 22p        |
| 5d  | 2½p | 1/5d       | 7½p       | 2/5d       | 12½p       | 3/5d       | 17½p       | 4/5d       | 22½p       |
| 6d  | 3p  | 1/6d       | 8p        | 2/6d       | 13p        | 3/6d       | 18p        | 4/6d       | 23p        |
| 7d  | 3½p | 1/7d       | 8½p       | 2/7d       | 13½p       | 3/7d       | 18½p       | 4/7d       | 23½p       |
| 8d  | 4p  | 1/8d       | 9p        | 2/8d       | 14p        | 3/8d       | 19p        | 4/8d       | 24p        |
| 9d  | 4½p | 1/9d       | 9½p       | 2/9d       | 14½p       | 3/9d       | 19½p       | 4/9d       | 24½p       |
| 10d | 5p  | 1/10d      | 10p       | 2/10d      | 15p        | 3/10d      | 20p        | 4/10d      | 25p        |
| 11d | 5½p | 1/11d      | 10½p      | 2/11d      | 15½p       | 3/11d      | 20½p       | 4/11d      | 25½p       |

|            |            |            |            |            |            |            |            |            |            |
|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| <b>5/-</b> | <b>25p</b> | <b>6/-</b> | <b>30p</b> | <b>7/-</b> | <b>35p</b> | <b>8/-</b> | <b>40p</b> | <b>9/-</b> | <b>45p</b> |
| 5/1d       | 25½p       | 6/1d       | 30½p       | 7/1d       | 35½p       | 8/1d       | 40½p       | 9/1d       | 45½p       |
| 5/2d       | 26p        | 6/2d       | 31p        | 7/2d       | 36p        | 8/2d       | 41p        | 9/2d       | 46p        |
| 5/3d       | 26½p       | 6/3d       | 31½p       | 7/3d       | 36½p       | 8/3d       | 41½p       | 9/3d       | 46½p       |
| 5/4d       | 27p        | 6/4d       | 32p        | 7/4d       | 37p        | 8/4d       | 42p        | 9/4d       | 47p        |
| 5/5d       | 27½p       | 6/5d       | 32½p       | 7/5d       | 37½p       | 8/5d       | 42½p       | 9/5d       | 47½p       |
| 5/6d       | 28p        | 6/6d       | 33p        | 7/6d       | 38p        | 8/6d       | 43p        | 9/6d       | 48p        |
| 5/7d       | 28½p       | 6/7d       | 33½p       | 7/7d       | 38½p       | 8/7d       | 43½p       | 9/7d       | 48½p       |
| 5/8d       | 29p        | 6/8d       | 34p        | 7/8d       | 39p        | 8/8d       | 44p        | 9/8d       | 49p        |
| 5/9d       | 29½p       | 6/9d       | 34½p       | 7/9d       | 39½p       | 8/9d       | 44½p       | 9/9d       | 49½p       |
| 5/10d      | 30p        | 6/10d      | 35p        | 7/10d      | 40p        | 8/10d      | 45p        | 9/10d      | 50p        |
| 5/11d      | 30½p       | 6/11d      | 35½p       | 7/11d      | 40½p       | 8/11d      | 45½p       | 9/11d      | 50½p       |

much less commonly found with wall charts than with desk-size conversion tables. The detailed parameters of its occurrence are not yet known.

People who are accustomed to reading English are accustomed to taking in information in a left to right direction, and it might be expected that well established reading habits would affect the way people use tables. It has been found that for a table such as that shown in Figure 3b, people make conversions from £p to £sd more quickly if the £p amounts are on the left; similarly conversions from £sd are faster if £sd amounts are on the left. However, this finding may not generalize to situations in which people are always making conversions in a particular direction. In the present studies people were usually given a random series of £p and £sd amounts to convert. There is some evidence from related studies which suggests that when working with only one of the currencies, people quickly learn to "look up and then read off to the left," or whatever the appropriate routine is, and the apparent bias in favor of reading off amounts to the right disappears [Wright, 1968].

Finally, all the standard typographic caveats appertaining to print size, grouping, and spacing of items are of course relevant to tabular displays. Many people cannot easily read print smaller than 6-point x-height [Poulton, 1969] and some people read more slowly when the print is larger than 12-point [Spencer, 1968]. Grouping within columns in fives is more helpful than having larger blocks of ten items [Tinker, 1960]. And it would seem to be only common sense that the spacing between adjacent items that are related should be less than that between unrelated items.

In conclusion, although there remains a great deal that is not understood about why some tabular displays present the problems that they do, nevertheless many users of tabulated information would have fewer problems if those principles which have been established were more widely applied.

## REFERENCES

- Poulton, E. C. (1969). Skimming lists of food ingredients printed in different sizes. *Journal of applied psychology*, 53, 55-58.
- Spencer, H. (1968). *The visible word*, London: Times Drawing Office Ltd.
- Tinker, M. A. (1960). Legibility of mathematical tables. *Journal of applied psychology*, 44, 83-7.
- Wright, P. (1968). Using tabulated information. *Ergonomics*, 11, 331-343.
- Wright, P. and Fox, K. (1970). Presenting information in tables. *Applied ergonomics*, 1, 234-242.
- Wright, P. (1971). Writing to be understood: why use sentences? *Applied ergonomics*, 2, 207-209.
- Wright, P. and Fox, K. (1972). Explicit and implicit tabulation formats. *Ergonomics*, 15, 175-187.
- Wright, P. and Reid, F. (1973). Some alternatives to prose for expressing the outcomes of complex contingencies. *Journal of applied psychology*, 57, 160-166.

Reprinted with kind permission from "The Visual Presentation of Technical Data," a publication arising from the joint meeting of the Ergonomics Research Society and the Society of Industrial Artists and Designers at Nash House, London, November 1972. Copies are available from the Typography Unit, University of Reading, 2 Earley Gate, Whiteknights, Reading RG6 2AU, England. Price: £1 plus postage (USA \$3.25 by surface mail, \$4.50 by air mail).