METHODS & DESIGNS

Performing item- and subject-based analyses using ALICE

EDWARD C. T. WALKER

Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

By using the program ALICE, we are able to perform subject- and item-based analyses of randomly ordered sets of data without the usual computational effort. The program allows us to transform data and combine, partition, or systematically manipulate them by simple, readily interpretable instructions. Of equal importance to us is the ease with which students and staff learn to use the program independently.

It has become fashionable to perform both subject- and item-based analyses in order to evaluate the results of language experiments (Clark, 1973; Clark, Cohen, Smith, & Keppel, 1976; Forster & Dickinson, 1976). For some time prior to the inception of the fad, this has been the practice in our laboratory, and we have developed considerable facility in overcoming the kinds of computational difficulties that such multiple analyses entail. In our experiments the analyses cause computational difficulties because items and subjects must be confounded in order to prevent testing any one subject more than once with any given stimulus item. In microcosm, the design of many of our experiments (Walker, Note 1) is that shown in Figure 1. While it is conceptually simple to rearrange the design in Figure 1 to show the replication across items more clearly (Figure 2), actually performing this rearrangement when the design more realistically includes many subjects and items, as well as several conditions, is tedious and error prone at best. The common practice of randomizing the occurrence of conditions in the sequence of trials only adds to the difficulties of rearrangement.

By using the computer program ALICE (Walker, Bauer, & Grubin, 1976), we are able to select from the experimental order of trials any subset or order suitable for analysis. But, more importantly, the program provides us with the capability to rearrange cells of the experimental design and thus compose a set of data for item-based analysis and another set of data for a subject-based analysis. Once the experimental trials have been selected, we can rearrange the matrix of Figure 1 to that

	Condition A	Condition B
Item 1	Subject 1	Subject 2
Item 2	Subject 2	Subject 1

Figure 2. Figure 1 rearranged to show replication across items.

of Figure 2 with ALICE by merely "forgetting" (temporarily) that the design is in fact 2 by 2, reordering the four cells, and imposing a new 2 by 2 matrix design (in which the cells are reordered appropriately).

Although these rearrangements are typically awkward or arduous to do with other programs (and certainly by hand), ALICE performs them easily with three instructions: forget dimension boundaries, select cells in a new order, reinstate matrix. Even in experiments which do not receive subject- and item-based analyses, this kind of matrix rearrangement is often a convenient way for "undoing" systematic counterbalancing, etc.

Matrix rearrangement, however, is a minor aspect of the analysis to which we typically submit data. Because item and subject sources of variance must be confounded in our designs, we usually seek to minimize the contribution of one confounded source by applying some correction (e.g., mean, z score, etc.) for that source prior to performing an analysis based on the other source. Of course, making such corrections is extremely difficult without the kinds of matrix rearrangement discussed earlier; we therefore require the use of ALICE again, both for the rearrangement and the correction itself. For example, suppose that our minimal example

	Condition A	Condition B
Subject 1	Item 1	Item 2
Subject 2	Item 2	Item 1

Figure 1. Simple experimental design confounding items and subjects.

	A	B	A-B
Subject 1	100 ₁	200 ₂	-100
Subject 2	300 ₂	400 ₁	-100

Figure 3. Artificial results for the simple experiment arranged by subject (subscripts refer to items).

	A	B	A-B
Item 1	100 ₁	400 ₂	-300
Item 2	300 ₂	200 ₁	+100

Figure 4. Artificial results for the simple experiment arranged by item (subscripts refer to subjects.).

describes a reaction time experiment and yields the results of Figure 3 (subscripts refer to item numbers). Rearranging these results for an item analysis without adjusting for absolute reaction times of subjects would yield the results shown in Figure 4 (subscripts refer to subject numbers). However, if we perform a simple mean correction by subjects prior to rearranging the cells of the matrix for an item analysis, then the result is that in Figure 5. The corresponding correction by items prior to subject-based analyses is shown in Figure 6. In this simple example, the effect of the rearrangement and correction is exaggerated. In practice, it merely decreases the noise of uncontrolled variance across experimental conditions.

Manipulations, corrections, and analyses of these types are almost always vexed by the occasional missing data produced by a subject's errors or equipment malfunctioning. Typically, we deal with correct responses only, and the ALICE routines are easily adaptable either to this method or to "replacing" empty cells by some constant or calculated measure. By the same token, ALICE provides simple procedures for adopting some method of "throwing away" abnormal reaction times, whether based on derived or absolute measures.

This brief description of our procedures should make clear the degree to which we depend on ALICE for what we require from computational routines. Prior to developing the program, we were compelled either to design experiments to fit the special-purpose computational routines we had available or to make a sub-

	A	B	A-B
Item 1	-50	+50	-100
Item 2	-50	+50	-100

Figure 5. Subject-mean corrected results for the simple experiment.

	A	B	A-B
Subject 1	-100	-50	-50
Subject 2	+50	+100	-50

Figure 6. Item-mean corrected results for the simple experiment.

stantial commitment of time and resources to overcome the daunting amount of computation for each analysis. Fortunately, both our students and research staff have been able to learn to use ALICE with only minimal instruction and, thus, can proceed rapidly to the more interesting and productive business of interpreting results. In fact, several users have learned to use the program without instruction.

From many points of view—the capabilities of the program, its general-purpose system organization, and its easy learnability—we feel that ALICE is virtually ideal for our needs, which we in turn feel are the needs of many experimenters, regardless of their field of interest.

REFERENCE NOTE

1. Walker, E. *Considerations in designing, conducting, and analyzing the data from reaction time experiments*. Paper presented at the Symposium on Reaction Time Data from Sentence Processing Experiments, International Congress of Psychology, Paris, July 1976.

REFERENCES

- CLARK, H. H. The language-as-fixed-effect fallacy. *Journal of Verbal Learning and Verbal Behavior*, 1973, 12, 335-359.
- CLARK, H. H., COHEN, J. SMITH, J. E. K., & KEPPEL, G. Discussion of Wike and Church's comments. *Journal of Verbal Learning and Verbal Behavior*, 1976, 15, 257-266.
- FORSTER, K. I., & DICKINSON, R. G. More on the language-as-fixed-effect fallacy. *Journal of Verbal Learning and Verbal Behavior*, 1976, 15, 135-142.
- WALKER, E., BAUER, J. A., JR., & GRUBIN, M. L. ALICE: A system for manipulating and analyzing multidimensional data. *Behavior Research Methods & Instrumentation*, 1976, 8, 347-351.
- WIKE, E. L., & CHURCH, J. D. Comments on Clark's "The language-as-fixed-effect fallacy." *Journal of Verbal Learning and Verbal Behavior*, 1976, 15, 249-255.

(Received for publication September 14, 1976;
accepted October 20, 1976.)