CHAPTER 9

SUMMARY, CONCLUSIONS AND IMPLICATIONS

INTRODUCTION

An analysis of current teaching procedures and instructional materials in mainstream Australian primary schools suggests that there appears to be little importance formally placed on individual differences in cognitive abilities. The main aims of the present ATI research were to investigate the potential for educators to re-examine this current practice. Outcomes suggest that the Luria (1966a - 1982) model, which provided the theoretical underpinning, has characteristics that commend it as a pragmatic representation of an aggregation of conscious mental processes relevant to classroom learning. The model, neuro-physiologically based, can be characterised by two readily identifiable orthogonal dimensions describing process-of-learning differences rather than involving the complications of acquired knowledge. The model has been shown by a continuing body of research in the last twenty years or so to highlight distinctive and important pre-cursor differences in the manner in which normal students differ in their habitual or preferred modes of information processing for the acquisition of knowledge. Luria characterised the two major modes of information processing as simultaneous and successive.

Aptitude-treatment interaction (ATI) research between the early 1960s and mid 1970s did not realise its theoretical promise and a review of the literature revealed a preponderance of unsupported hypotheses and indecisive outcomes. There has been a minority of studies reporting significant disordinal interaction between cognitive abilities and instructional treatments, some of which subsequent research has been unable to replicate. It would appear that when the subjects engaged in activity to meet formal learning objectives, the complexity of the potential personological and environmental variables involved were not adequately accommodated by the models of cognition upon which this earlier research was based. As a consequence, the unproductive or indeterminate findings which frequently ensued led many psychometric researchers to contend that ATI studies were unlikely to realise their theoretical promise in classroom contexts. The perception was that models of intellectual function were inadequate representations of the learning process, and, further, that cognitive processes could not be studied in isolation from the attitudes, knowledge and beliefs of students.

However there have been a number of more recent studies based upon the Luria model that have resulted in definitive and positive findings, suggesting that its process dimensions are sufficiently robust and influential in relation to learning outcomes within normal school environments. For example, Green (1977) and Walton (1983) both explored aptitude-treatment interactions associated with simultaneous and successive processing and corresponding instructional treatments designed to optimise learning and reported significant interaction effects. These researchers concluded that the Luria model has potentially important practical implications for the design and administration of teaching materials to cater for individual differences.

In the present research, studies were conducted with Year 6 female students to investigate interactions between the differences in cognitive abilities described in the work of Luria and alternative instructional treatments designed to cater for these differences. In Study 1 (N=296) and the preliminary phase of Study 3 (N=251) aptitude tests, related to those originally used by Luria and subsequently developed and refined by numerous researchers for classroom use with normal subjects, were tailored for the senior primary subjects. Data were analysed using principal component analysed to determine the levels of aptitude of each subject for simultaneous and successive processing and the resultant aptitude profiles used in the aptitude-treatment experiments conducted in Study 2.

Study 2 (N=274) investigated whether individual learning could be improved by the administration of alternate treatments of instructional materials designed to match different cognitive profile groups. The teaching unit developed for the study covered topics that have been traditionally used to introduce students to elementary logic and reasoning, namely Set Theory concepts, Set manipulation, and syllogistic reasoning. The two alternate sets of self-administered instructional materials were labelled, for convenience, "spatial" and "verbal". The former was designed to assist individuals whose simultaneous aptitude was superior to their successive aptitude, and the latter for individuals whose successive aptitude was superior to their simultaneous aptitude. Each treatment contained the same tasks and exercises, except for differences that related specifically to the two disparate solution strategies provided for solving syllogisms - one a "spatial" strategy utilising Venn diagrams intended to facilitate syllogistic reasoning for subjects with higher simultaneous abilities, the other a "verbal" strategy involving step-wise procedures designed to benefit students with higher successive aptitudes. Learning performance was evaluated from data obtained from a Post Test administered immediately upon completion of the Reasoning unit, and a Delayed Test applied approximately one week later. Test items were grouped into three distinct categories of content, namely ‘understanding and knowledge' of Set Theory and syllogisms, 'Set manipulation' and 'syllogistic reasoning'.

Study 3 (N=49) initially involved the aptitude testing of a new group of Year 6 female subjects (N=251) from 5 independent girls' schools drawing their student population from the same socio-economic band as in Study 2. Five of the aptitude tests were those used in Study 2, but with a reduced number of items, and a sixth criterion test Sets was developed and administered. Subjects' component scores on each information processing dimension were divided into three ability levels "high", "medium" and "low", and the subjects selected for the major phase of Study 3 were those two groups of students partitioned as "high simultaneous - low successive" and "low simultaneous - high successive".

To clarify Study 2 findings, an important aim of Study 3 was to investigate in more depth interactions between the aptitude profiles and two specific treatments of the lesson content classified as 'understanding and knowledge' and 'Set manipulation'. One treatment presented instructional material using only words, numbers, letters and symbols (again for convenience only called the "verbal" treatment); the other treatment was composed by supplementing this textual treatment with diagrammatic and pictorial adjuncts (and called the "spatial" treatment). Each of the treatments was randomly assigned to the subjects within the two groups of interest such that approximately equal numbers were administered each treatment.

The main phase of the study involved a clinical interview with each subject and observation of cognitive processes and learning strategies as she proceeded through the self-administered instructional materials. The study design included a systematic application of structured probes, a Post Test and the collection of anecdotal evidence.

MAJOR FINDINGS

Study 1

Principal component analysis with varimax rotation was applied to the test data and two independent components clearly emerged, consistent with the two cognitive dimensions of simultaneous and successive processing in the Luria model. The hypothesis that Principal Component Analysis of data obtained from the tests administered would produce two independent and significant components was supported. These results (and also the aptitude testing of Study 3 summarised below) specifically commend the use of these tests to identify information processing abilities in children of senior primary school age, and provide further support to a line of research suggesting that relative strengths and weaknesses in these two information processing dimensions are readily measurable and reflect notable individual differences in cognitive abilities.

Study 2

Multivariate analyses of variance of data from both Post Test and Delayed Test items involving syllogistic reasoning confirmed a significant disordinal interaction between the verbal and spatial instructional treatments and the high simultaneous - low successive and low simultaneous - high successive ability groups. There was a non-significant disordinal interaction for this same category of tasks between the high simultaneous - medium successive and medium simultaneous - high successive ability groups and treatment, and for the interaction between treatment and the medium simultaneous - low successive and low simultaneous - medium successive ability groups. The hypotheses of significant disordinal interactions between aptitude and treatment were not supported for the other two categories of learning investigated within the Reasoning unit, namely 'understanding and knowledge' of Sets and syllogisms, and 'Set manipulation'.

It was concluded from an analysis of the interaction effects for the three distinct categories of learning within the Study 2 Reasoning unit that the nature of the task demands placed upon the learner by the *content* appears to be a primary consideration in the justification for the design and administration of alternative instructional treatments to capitalise on individual information processing aptitudes. A follow-up study was designed to investigate further, through a clinical interview and individual observation procedure, learner strategies and cognitive processes as individuals undertook tasks in the content areas of Study 2 that did not result in significant disordinal aptitude x treatment interaction.

Study 3

Principal component analysis of data from the administration of the criterion test Sets, newly developed for this study, loaded .80 on the simultaneous component and suggests that Set manipulation tasks predominantly call upon simultaneous abilities, consistent with comparable findings from Study 2.

Analysis of Post Test scores for 'understanding and knowledge' and 'manipulation of Sets', notwithstanding the endeavour to develop two treatments that would respectively present task demands to call predominantly upon each of the aptitudes under investigation, indicated that there was no disordinal interaction, although there was a trend towards an ATI effect with respect to time taken to complete the post test items. In general, the results of Study 3 were consistent with those from Study 2.

It appeared that the addition of diagrams and pictorial adjuncts to the textual instructional materials did not advantage students with high simultaneous - low successive processing aptitudes. This finding supports a general conclusion of a Hughes and Hall (1983) study that investigated the value of picture adjunct aids. The findings of lack of aptitude-treatment interaction in the present study, with Post Test achieved scores as the dependent variable, *appear* to contradict the conjoint retention hypothesis of Stader et al (1990) and also the findings of Kulhavy et al (1990) and Burton and Wildman (1978), but it is suggested that these studies are not comparable in that (i) they used younger subjects[1], and (ii), their focus was solely on recall.

It was argued that the subject matter in the category 'understanding and knowledge' was not amenable to a spatial treatment that placed distinctly different cognitive demands upon the learner from that of the verbal treatment. In particular, it appeared that the spatial treatments' presentation of tasks, in Study 2 and also Study 3, did not require the use of predominantly simultaneous processing abilities. The "spatial" treatment could perhaps be characterised as simply the verbal treatment supplemented with diagrammatic and pictorial adjuncts that were not critically germane to the learning process, did not require spatial reasoning, and thus did not differentially advantage those students with high simultaneous aptitudes. In these treatments, the learner was neither encouraged nor compelled to engage in simultaneous *reasoning* activity.

A further factor inhibiting significant disordinal aptitude x treatment interaction in learning performance in the 'understanding and knowledge' category of learning was that the spatial instructional treatment necessarily included the obligatory component of verbal material required by the simple associative learning tasks such as knowledge of the meaning of terms (such as "element", "empty set", "middle term", "premise" and "predicate") and symbols (such as $\subset$, $\cap$, $\cup$ and $\in$). All the test items in both Study 2 and Study 3 classified as 'understanding and

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1 *There was anecdotal evidence from some subjects in the present study suggesting that their perception of the value of pictorial aids may have been more favourable in earlier years.*

knowledge' required a knowledge of terms and symbols such as these. Consistent with the traditional exposition of much of the elementary curricula at primary school level, dependence on textual statements to teach equivalences and definitions in the form of verbal statements containing words, numbers, or symbols is perceived as inescapable.

An important implication of this research is considered to be the evident practicality of the criterion tests employed in both Study 1 and Study 3 for use by educators interested in a deeper understanding of individual learning differences within normal classrooms. In Study 3, which used a reduced number of items, less than one hour for total test administration was adequate for the identification of two definitive and powerful indicators of important differences in cognitive abilities.

SUGGESTIONS FOR FUTURE RESEARCH

1. Time as a factor in ATI

In Study 3, there was an interesting treatment x aptitude effect related to the time the subjects took to complete the Post Test. Each subject was timed as she completed each item in the test, permitting a multivariate analysis of variance using these times as the dependent variables and the two aptitude profiles and alternate treatments as the independent variables. Disordinal interaction between aptitude groups and treatments was evident, although not significant. It is suggested that this aspect of ATI may warrant further exploration by researchers. Results could potentially be of interest to instructional designers of primary resource materials interested in improving learning productivity.

2. Independent learning in Study 3

In Study 3, during which subjects were individually supervised during learning, the mean performance of the group with higher simultaneous aptitudes exceeded that of the group with higher successive aptitudes; whereas in Study 2, in which the subjects were supervised as a total class, the reverse applied. This contrast suggests that subjects with high simultaneous processing aptitudes relative to their successive aptitudes may not be as amenable or responsive to learning from self-administered instructional materials as their peers with higher successive processing aptitudes. Further research is recommended to investigate the proposition that higher simultaneous subjects may not be as self-disciplined in maintaining concentration when working relatively independently and supervised at a distance (as in Study 2) but may try harder when observed individually at close hand (as in Study 3), compared with high successive subjects who may be able to concentrate over extended periods without close supervision and monitoring. This comment is highly speculative, although it could be argued that working through a series of self-administered teaching materials is more of a successive task than a simultaneous one and would be more suited to students with higher successive aptitudes. Future research is needed to address this general issue in order to evaluate adequately ATI findings using self-administered instructional materials.

It may be advisable in future similar ATI studies to include as part of the investigation the effects of interaction between aptitude and this style of instructional delivery, such that any observed effect can be taken into account and its influence on the focal ATI results assessed. It is contended that this line of research could have important ramifications for the manner in which instruction is delivered to students, particularly if it is confirmed that students high in simultaneous processing are not as responsive to self-administered delivery systems. Support for this proposition was also provided by anecdotal evidence from one class teacher from Tara School who stated that she could have predicted the students who gained successive aptitude component scores in the top half of her class because they were the ones that could work independently for longer periods (and were also largely in the top half in her spelling order of merit). Osburn and Melton (1963) found subjects high in "verbal reasoning" derived most benefit from traditional instructional treatments with successions of rules and exercises, which could be likened more to the self-administered instructional materials used in these studies. On the other hand, Osburn and Melton (1963) concluded that subjects high in "spatial reasoning" capitalised more on a discovery treatment. These findings are not directly applicable to the group-supervision / individual-supervision of Study 2 / Study 3, but they do indicate that there may be differences that could warrant future investigation.

3. The design of ATI treatments

As outlined above, other researchers have also experienced difficulties in designing treatments involving the use of appropriate spatial reasoning skills to advantage students high in simultaneous abilities. For example, Cronbach and Snow (1977) criticised the original Behr (1967) study for utilising "figural symbolic" treatments that did not call upon "spatial" processing aptitudes. It is clear that diagrammatic and pictorial adjuncts within "spatial" treatments cannot be assumed to present automatically the subjects with spatial *reasoning* task demands. It is considered that a promising line of research pertinent to ATI studies involving information processing aptitudes is that which dissects "spatial abilities" into components for definition and elaboration. It is suggested that image coding, as would be required simply to glance or superficially view a pictorial or diagrammatic adjunct, is but one of a number of simultaneous analysis / synthesis component processes, possibly comprising, dependent upon the task, aptitudes for discernment of the appropriate characteristics of the image pertinent to the task, aptitudes for coding the image at the requisite quality, and aptitudes for subsequent processes such as comparing, editing and retrieval. For example, Skemp (1971) considers that learners obtain a "visual image or a pictorial representation" by leaving out properties and abstracting to a higher level as an "integrative and simultaneous" activity. Cooper (1980) found spatial processing to comprise differentiated sub-abilities, and Kosslyn (1985) lends support to the multiple-faceted view of spatial abilities, finding "imagery" to be not a single ability but a collection of distinct abilities. It is probable that models of individual differences will emerge that take into account aptitudes for each of these processes. It seems likely that future psychometric and clinical aptitude-treatment investigations involving cognitive abilities will be enhanced by neuro-physiological and neuro-chemical research augmenting the understanding of the collection of activities that aggregate to the simultaneous analysis / synthesis.

IMPLICATIONS FOR TEACHING AND LEARNING

1. Individual differences in classroom learning

The concept of aptitude-treatment interaction is theoretically appealing and presents as a promising rationale for re-examining traditional classroom teaching. There is a recurrent theme in (populist) educational journals that school instruction is "left-brain oriented" and places undue emphasis on the use of successive processing. Criticism is levelled at primary school teachers and instructional designers of primary texts for paying little regard to the nurture of simultaneous abilities and for not providing "spatial" materials and delivery modes that encourage application of these abilities, so as to cater for the "right-brain" segment of the population. More generally, there has been condemnation expressed regarding a lack of attention to individual differences in cognitive abilities, with claims suggesting the success rate of many students would be substantially increased if teaching resources and instructional strategies were to cater for these differences. The results of the present research suggest that such broad claims need to be viewed with caution, and that instructional designers and teachers need to be selective in their choice of content before the benefits of catering for individual differences in cognitive abilities can be realised.

2. Pictorial and diagrammatic adjuncts in learning materials

The pictorial and/or diagrammatic supplementation of textual treatments, relatively common in primary school resource materials, may be perceived by numerous students as simply providing either decoration or, at best, amplification. From the results of Study 2 and 3, it was concluded that "spatial" presentations are not necessarily created by the mere addition of diagrammatic and pictorial adjuncts. Spatial treatments of simple associative learning tasks may contain pictorial and diagrammatic adjuncts that are not indispensable with regard to the learning process, and may frequently be viewed by learners as peripheral to, a dispensable ancillary to, the main lesson procedure. Bracht (1970), Gagné and Gropper (1965), Gustafsson (1982) in his ATI study, King Roberts and Kropp (1969) and Cronbach and Snow (1977) in their analysis of ATI studies, also found that the mere addition of diagrams did not transform verbal presentations into treatments to advantage subjects with higher "spatial" abilities. Very young students, and perhaps also less academically able students, are more likely to process pictures as conscious *activity* whereas older students may tend only to glance at, then ignore, the picture as an unconscious *operation* (after Leont'ev, 1981) - a habit developed over time from finding numerous similar illustrative adjuncts as not critical to learning. It seems likely that numerous subjects in this research disregarded such adjuncts in a *habitual* "skipping" procedure. A range of pictures and diagrams in primary school texts have, subsequent to these findings, been evaluated by the researcher and much of the material could be considered little more than decorative in the sense of aesthetically improving the routine dullness of textual presentation. The message provided by the children used in this study is that picture and diagrammatic adjuncts to textual instructional materials are only warranted if they are perceived to facilitate learning or enhance learning productivity. It would appear that this level of discernment has not generally been applied by instructional designers of primary texts. There appears to be a need to consider the relevance and productive value of such adjuncts more than perhaps is the case in much of the primary materials currently in use in Australian schools.

A related issue concerns the cueing of pictorial and diagrammatic adjuncts. Anecdotal evidence from Study 3 confirmed suggestions in the literature that it cannot always be assumed that learners encode spatial adjuncts to textual presentations. Directed questioning during the course of Study 3 interviews asked the children to either comment upon or explain a diagram from a section of a lesson they had recently completed. A frequent response could be summarised "I didn't pay too much attention to that" or "I skipped it". Numbers of the Year 6 subjects, inculcated with their schools' academic focus, "did not waste time" encoding images that they perceived as being superfluous or peripheral to learning because they already had "the message" from the text alone. There does appear to be a need to cue pictures and diagrams that the instructional designer sees as contributing to, or by themselves forming, essential steps in the learning sequence being presented. Beck (1991) and Hughes and Hall (1983) also recommend that instructional designers devote more attention to cueing illustrative materials.

3. Dominant abilities and ATI effects

It would seem that the predominantly simultaneous processing demands placed upon the learner by the Set manipulation tasks in this research inhibited an aptitude x treatment interaction. In the learning category 'manipulation of Sets', an analysis of responses to items in the Post and Delayed Tests of Study 2 and the Post Test of Study 3 indicated that such tasks appear predominantly to require the application of simultaneous processing aptitudes. For these tests on the manipulation of Sets there were significant correlations between performance and simultaneous processing scores. It was found that for these tasks, containing more than one structure (such as two Sets), subjects appear to be drawn habitually to apply simultaneous analysis / synthesis to derive the problem solution regardless of individual differences in relative strengths and weaknesses in the two information processing modes under study and regardless of treatment. This is but one example of specific tasks in primary school learning that would predominantly require either one or the other of the aptitudes under study. For example, it is suggested that the demands of tasks such as rote learning (spelling lists, number facts, etc.) and paired associate learning (foreign language vocabulary, meaning of technical terms and symbols, etc.) would largely require successive processing; and that problem solving in a number of mathematics and science curricula areas would substantially require simultaneous processing. It may be concluded that in circumstances in which either one or the other of the abilities used in the ATI study is a particularly dominant variable affecting learning performance, to the extent that the design of the "alternate" treatment is unable markedly to overcome this influence, an aptitude x treatment interaction effect is unlikely.

LIMITATION OF THE STUDY

The Year 6 population of students from eight independent girls' schools located in the northern suburbs of Sydney provided a subject population that could be characterised as being relatively homogenous in terms of academic bias and discipline. The girls' class teachers, encouraged by the school Principals, engendered a general spirit of active and positive interaction with the research project. This favourable disposition was predicated by teacher perception that the area of investigation included the measurement of important individual differences in cognitive abilities which they could potentially use in the classroom, and also the view that the potential enhancement of reasoning skills through the Reasoning unit was a worthwhile objective. It has also been suggested that girls of the age used in this study are ideal as subjects for educational research. Whilst the agreeable focus of the subjects is considered to have restricted the influence of extraneous variables in less disciplined educational environments that tend to produce scattered "noise" and obscure findings, the atypical nature of the sample is seen as a limitation in terms of the lack of general applicability of findings to other different school populations. It may be expected that the patterns of relationships between cognitive abilities and performance would be different for subject samples that did not display this homogeneity and focus.

CONCLUDING THOUGHTS

It is suggested that this research contributes further insight into the interaction between the two information processing dimensions of the Luria model and the treatment of instructional materials designed to optimise learning by catering for individual differences in cognitive abilities.

More generally, the findings suggest that the *content* of planned instruction be initially examined to determine if alternate treatments can be designed that are respectively sympathetic to individual differences in information processing profiles. This should be the first consideration in determining if the attention to individual differences is likely to lead to a successful, practical and cost-effective educational strategy in the context of the model being considered. This general focus is supported by Becker (1970), Cooper (1980) and Tobias (1976) who concluded that an effective instructional technique for one learning objective might be inappropriate for another and that the content of learning is a determinant. Das (1979, 1988) and his colleagues have also consistently indicated the importance of the "demands of the task" in determining the proportion of the two modes of information processing that Luria (1966b) suggested "act in concert". Similarly, Crawford (1986, p. 268) found that "the pattern of relationships between cognitive variables and achievement varied according to the characteristics of the assessment tasks". Although it is intuitively appealing for designers and teachers to assume that some students will perform better under one set of instructional conditions while others require a different set for optimal performance, the examination of the content to be treated will, within primary curricula, restrict wide application of ATI theory.

When content *is* suitable for two contrasting treatments matched to the abilities of the subjects, the interaction with the aptitudes of the kind suggested by the Luria model can be significant and lead to increases in learning productivity. The suggested preliminary focus on content should not be construed as changing the emphasis from ATI to CTI (content-treatment interaction), after Jonassen (1982). CTI is seen as essentially providing an acronym for good instructional design, proposing as it does that learner characteristics can be matched by progressively modifying materials to make them uniformly more effective. Driscoll (1987), although promoting CTI as a "heuristic for researchers and designers" that is more practical than ATI, concedes that it is "not as attentive to differences in learner aptitudes".

When one takes into account the testing time, the design of matching treatments, the administration of these treatments, and the comparative evaluation of results, a teacher cannot be expected consistently to cope with catering for other than broad-band, robust aptitudes matched with treatment. In this respect the cause of ATI will be advanced over time by the fuller use of computers, whether in the classroom or remotely located, being accessible by teachers and students, with expert heuristic systems assisting with each stage of aptitude testing, treatment preparation and delivery of appropriately matched strategies as learning content changes.

REFERENCES

Abkemeier, M.K. and Bell, F.H. Relationships between variables in learning and modes of presenting mathematics concepts. International Journal of Mathematics Education in Sciences and Technology, 1976, **7**, 257-270.

Adler, N. and Guttman, R. The radex structure of intelligence: A replication. Educational and Psychological Measurement, 1982, **42**, 739-748.

Anastasi, A. Psychological Testing (6th Edition). New York: Macmillan, 1988.

Anderson, J.R. An examination of Children's learning through audio-visual media in relation to a model of simultaneous and successive information processing. Unpublished doctoral dissertation, University of New England, 1980.

Anderson, J.R. and Bower, G.H. Human Associative Memory. Washington, D.C.: Winston, 1973.

Angell, R.B. Reasoning and Logic. New York: Appleton-Century-Crofts, 1964.

Angus, J.W. Examination of children's learning through audio-visual media in relation to a model of simultaneous and successive processing. Unpublished doctoral dissertation, University of New England, 1984.

Ashman, A.F. The role of planning and decision-making in the training of retarded persons. Human Learning, 1984, **3**, 19-32.

Ashman, A.F. and Das, J.P. Relations between planning and simultaneous-successive processing. Perceptual and Motor Skills, 1980, **51**, 371-382.

Austin, J.D. An experimental investigation of the effect of three instructional methods in basic probability and statistics on cognitive and affective variables. Unpublished doctoral dissertation, Purdue University, 1972.

Beck, Charles R. Strategies for cueing visual information: Research findings and instructional design implications. Educational Technology, 1991, **31**, 16-20.

Becker, J.P. An attempt to design instructional techniques in mathematics to accommodate different patterns of mental ability. Unpublished doctoral dissertation, Stanford University, 1967.

Becker, J.P. Research in mathematics education: The role of theory and aptitude-treatment-interaction. Journal for Research in Mathematics Education, 1970, **1**, 19-28.

Begg, I. and Denny, J.P. Empirical reconsideration of atmosphere and conversion interpretations of syllogistic reasoning errors. Journal of Experimental Psychology, 1969, **81**, 351-354.

Behr, M.J. A study of interactions between "Structure-of-Intellect" factors and two methods of presenting concepts of modulus seven arithmetic. Unpublished doctoral dissertation, Florida State University, 1967.

Behr, M.J. Interactions between "Structure-of-Intellect" factors and two methods of presenting concepts of modular arithmetic - A summary paper. Journal for Research in Mathematics Education, 1970, **1**, 29-42.

Behr, M.J. and Eastman, P.M. Interactions between structure-of-intellect factors and two methods of presenting concepts of modulus seven arithmetic - A follow-up and refinement study. Journal for Research in Mathematics Education, 1975, **5**, 150-157.

Berliner, D.C. Developing conceptions of classroom environments: Some light on the T in classroom studies of ATI. Educational Psychologist, 1982, **18**, 1-13.

Berliner, D.C. and Cahen, L.S. Trait-treatment interaction and learning. In, F.N. Kerlinger (Ed.), Review of Research in Education. Itasca, Illinois: Peacock, 1973(a).

Binet, A. and Henri, V. La psychologie individuelle. Annee Psychology, 1896, **2**, 411-465.

Bishop, A.J. Space and Geometry. In, A.J. Bishop (Ed.), Acquisition of Mathematical Concepts and Processes. New York: Academic Press, 1983.

Bloom, A. The Linguistic Shaping of Thought: A Study in the Impact of Language on Thinking in China and the West. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1981

Bloom, B.S. (Ed.) Developing Talent in Young People. New York: Ballentine Books, 1985.

Bohm, D. Wholeness and the Implicate Order. London: Ark, 1983.

Boring, E.G. Intelligence as the tests test it. New Republic, 1923, **34**, 35-37.

Bracht, G.H. Experimental factors related to aptitude-treatment interactions. Review of Educational Research, 1970, **40**, 627-645.

Bracht, G.H. and Glass, G.V. The external validity of experiments. American Educational Research Journal, 1968, **5**, 437-474.

Brainerd, C.J. The Origins of Number Concept. New York: Praeger, 1979.

Brainerd, C.J. Working-memory systems and cognitive development. In, C.J. Brainerd, (Ed.) Recent advances in cognitive-development theory: Progress in cognitive development research. New York: Springer-Verlag, 1983. (pp. 167-236)

Bruner, J.S. The course of cognitive growth. American Psychologist, 1964, **19**, 1-15.

Burt, C. Alternative models of factor analysis and their relations to Pearson's method of 'Principal Axes'. British Journal of Psychological Statistics, 1949, **2**, 98-121.

Burt, C. The evidence for the concept of intelligence. British Journal of Educational Psychology, 1955, **25**, 158-177

Burt, C. The genetics of intelligence. In, W.B. Dockrell (Ed.), On Intelligence. London: Methuen, 1970.

Burt, C. Inheritance and general intelligence. American Psychologist, 1972, **27**, 175-190.

Burton, John K. and Wildman, Terry M. Dual Coding in Children. ERIC Document Reproduction Service No. ED178208. 1978.

Carey, S. Conceptual Change in Childhood. Cambridge, Massachusetts: MIT Press, 1985.

Carry, L.R. Interaction of visualisation and general reasoning abilities in curriculum treatment in algebra. Unpublished doctoral dissertation, Stanford University, 1967.

Case, R. Intellectual Development: Birth to Adulthood. New York: Academic Press, 1985.

Cattell, R.B. Theory of fluid and crystallised intelligence: A critical experiment. Journal of Educational Psychology, 1963, **54**, 1-22.

Cattell, R.B. The meaning and strategic use of factor analysis. In, R.B. Cattell, (Ed.), Handbook of Multivariate Experimental Psychology. Chicago: Rand McNally, 1966. (pp. 174-243)

Cattell, R.B. Abilities: Their Structure, Growth and Action. Boston: Houghton Mifflin, 1971.

Ceraso, J. and Provitera, A. Sources of error in syllogistic reasoning. Cognitive Psychology, 1971, **2**, 400-410.

Chapman, L.J. and Chapman, J.P. Atmosphere effect re-examined. Journal of Experimental Psychology, 1959, **58**, 220-226.

Clark, H.H. Linguistic processes in deductive reasoning. Psychological Review, 1969(a), **4**, 387-404.

Clark, H.H. Influence of language on solving three-term series problems. Journal of Experimental Psychology, 1969(b), **82**, 205-215.

Clark, R.E. Adapting aptitude-treatment interaction methodology to instructional media research. AV Communication Review, 1975, **23**, 133-137.

Clark, R.E. Antagonism between achievement and enjoyment in ATI studies. Educational Psychologist, 1982, **17**, 92-101.

Cohen, G. Hemispheric differences in serial versus parallel processing. Journal of Experimental Psychology, 1973, **97**, 349-356.

Cole, M. and Scribner, S. The Psychology of Literacy. Cambridge, MAS: Harvard University Press, 1981.

Cooper, L.A. Spatial information processing: Strategies for research. In, R.E. Snow, P.A. Frederico, P.A. and W.E. Montague (Eds), Aptitude, Learning, and Instruction. Vol.1 Cognitive Process Analyses and Aptitudes. Hillsdale: Lawrence Erlbaum Associates, 1980. (pp. 149-176)

Copi, I.M. Symbolic Logic. New York: Macmillan, 1965.

Copi, I.M. Introduction to Modern Logic (5th Edition). New York: Macmillan, 1978.

Cowart, C.A. and McCallum, R.S. Multi-trait--multi-method investigation of the Simultaneous-Successive-Planning model. Journal of Psychoeducational Assessment, 1988, **6**, 55-66.

Crawford, K.P. Simultaneous and successive processing, executive control and social experience: Individual differences in educational achievement and problem solving in mathematics. Unpublished doctoral dissertation, University of New England, 1986.

Cronbach, L.J. The two disciplines of scientific psychology. The American Psychologist, 1957, **12**, 671-684.

Cronbach, L.J. How can instruction be adapted to individual differences? In, R.M. Gagné (Ed.), Learning and Individual Differences. Columbus, Ohio: Merrill Books, 1967.

Cronbach, L.J. Beyond the two disciplines of scientific psychology. American Psychologist, 1975, **30**, 116-127.

Cronbach, L.J. and Snow, R.E. Individual differences in learning ability as a function of instructional variables (Final report). Stanford, Cal.: School of Education, Stanford University, 1969.

Cronbach, L.J. and Snow, R.E. Aptitudes and Instructional Methods. New York: Irvington, 1977.

Crouch-Shinn, J. and Shaughnessy, M.F. Brain Research: Implications for Education. ERIC Document Reproduction Service No. ED271707. 1984.

Das, J.P. Structure of cognitive abilities: Evidence for simultaneous and successive processing. Journal of Educational Psychology, 1973(a), **65**, 103-108.

Das, J.P. The uses of attention. Alberta Journal of Educational Research, 1973(b), **19**, 99-108.

Das, J.P. Intelligence and information integration. In, J. Kirby (Ed.), Cognitive Strategies and Educational Performance (Chapter 2). New York: Academic Press, 1984(a).

Das, J.P. Successive and simultaneous processing in children with learning difficulties. Topics in Language Disorders, 1984(b), **4**, 34-47.

Das, J.P. Aspects of planning. In, J.R. Kirby (Ed.), Cognitive Strategies and Educational Performance. New York: Academic Press, 1984(c). (pp. 13-31)

Das, J.P. Simultaneous and successive processes and K-ABC. The Journal of Special Education, 1984(d), **18**, 229-238.

Das, J.P. On definition of intelligence. In, R.J. Sternberg and D.K. Detterman (Eds), What is Intelligence? Norwood, New Jersey: Ablex, 1986. (pp. 55-56)

Das, J.P. and Dash, U.N. Hierarchical factor solution of coding and planning processes: Any new insights? Intelligence, 1983, **7**, 27-37.

Das, J.P. and Heemsbergen, D.B. Planning as a factor in the assessment of cognitive processes. Journal of Psychoeducational Assessment, 1983, **1**, 1-16.

Das, J.P. and Kirby, J.R. The Case of the Wrong Exemplar. Journal of Educational Psychology, 1970, **70**, 877-879.

Das, J.P. and Molloy, G.N. Varieties of simultaneous and successive processing in children. Journal of Educational Psychology, 1975, **67**, 213-220.

Das, J.P., Kirby, J.R. and Jarman, R.F. Simultaneous and successive synthesis: An alternate model for cognitive abilities. Psychological Bulletin, 1975, **82**, 87-103.

Das, J.P., Kirby, J.R. and Jarman, R.F. Simultaneous and Successive Cognitive Processes. New York: Academic Press, 1979.

Dash, U.N. and Mahapatra, S. Development and differentiation of simultaneous, successive and planning processes. Psychological Studies, 1989, **34**, 75-83.

de Bono, E. Teaching Thinking. London: Temple Smith, 1976.

de Bono, E. The CoRT thinking program. In, J.W. Segal, S.F. Chipman, and R. Glaser (Eds), Thinking and Learning Skills: Vol. I. Relating Instruction to Research. Hillsdale, N.J.: Erlbaum, 1985. (pp. 363-388)

Degn, H., Holden, A.V. and Olsen, L.F. Chaos in Biological Systems. New York: Pelum Press, 1987.

DeSoto, C.B., London, M. and Handel, S. Social reasoning and spatial paralogic. Journal of Personality and Social Psychology, 1965, **2**, 513-521.

Detterman, D.K. Qualitative integration: The last word? In, R.J. Sternberg and D.K. Detterman, What is Intelligence? Norwood, New Jersey: Ablex, 1986. (pp. 163-66)

Di Vesta, F.J. Trait-treatment interactions, cognitive processes, and research on communication media. AV Communication Review, 1975, **23**, 185-196.

Donaldson, M. Children's Minds. New York: Norton, 1979.

Driscoll, M.P. Aptitude-treatment interaction research revisited. Paper presented at the Annual Convention of the Association For Educational Communications and Technology, Atlanta, 1987.

Dunn, B.R. Electrophysical and prose recall determinants of cognitive style: New directions for prose research. In, B.R. Dunn (Chair), Prose research and analysis: A 10 year retrospective. Symposium conducted at the annual meeting of the American Psychological Association, Anaheim, California, 1983.

Dunn, B.R. Brain organisation and cognitive style: Facts, fancies and possibilities. Invited paper presented at the 11th Western Symposium on Learning, Cognition, and Instruction. Western Washington University, 1985.

Eastman, P.M. The interaction of spatial visualisation and general reasoning abilities with instructional treatment in quadratic inequalities. Unpublished doctoral dissertation, University of Texas, 1972.

Eastman, P.M. and Carry, L.R. Interaction of spatial visualisation and general reasoning abilities with instructional treatment in quadratic inequalities: A follow-up study. Journal for Research in Mathematics Education, 1975, **6**, 132-141.

Eastman, P.M. and Salhab, M. The interaction of spatial visualisation and general reasoning abilities with instructional treatments on absolute value equations. Journal for Research in Mathematics Education, 1978, **9**, 152-154.

Ekstrom, R.B., French, J.W., Harman, H.H. and Dermen, D. Kit of factor-referenced cognitive tests. Princeton: Educational Testing Service, 1976.

El Koussy, A.H. The visual perception of space. British Journal of Psychology, 1936, **7**, 20.

Elliott, A.S. The social-cognitive complexity of young children's play in selected computer-based learning environments: An exploratory study. Unpublished doctoral dissertation, University of New England, 1990.

Ennis, R.H. Children's ability to handle Piaget's propositional logic: A conceptual critique. Review of Educational Research, 1975, **45**, 1-41.

Epstein, S. and O'Brien, E.J. The person-situation debate in historical and current perspective. Psychological Bulletin, 1985, **98**, 513-537.

Erickson, J.R. A set analysis theory of behaviour in formal syllogistic reasoning tasks. In, R.J. Solso (Ed.), Theories in Cognitive Psychology: The Loyola Symposium. Potomac: John Wiley, 1974. (pp. 305-329)

Ericsson, K.A. and Simon, H.A. Protocol Analysis: Verbal Reports as Data. Cambridge, MA: MIT Press, 1984.

Evans, J. On the problems of interpreting reasoning data: Logical and psychological approaches. Cognition, 1973, **1**, 373-384.

Eysenck, H.J. The Structure and Measurement of Intelligence. Berlin: Springer-Verlag, 1979.

Federico, P.A. Hemispheric Asymmetries and Cognitive Attributes. Paper presented at the Annual Meeting of the American Educational Research Association (68th), New Orleans, 1984.

Feldman, D.H. Nature's Gamble: Child Prodigies and the Development of Human Potential. New York: Basic Books, 1986.

Feuerstein, R. Instrumental Enrichment: An Intervention Program for Cognitive Modifiability. Baltimore: University Park Press, 1980.

Fischer, K.W. A theory of cognitive development: The control and construction of hierarchies of skills. Psychological Review, 1980, **86**, 477-531.

Fischer, K.W., Hand, H.H. and Russell, S. The development of abstractions in adolescence and adulthood. In, M.L. Commons, F.A. Richards and C. Armon (Eds), Beyond Formal Operations: Late Adolescence and Adult Cognitive Development. New York: Praeger, 1984. (pp. 43-73)

Fitzgerald, D. Behavioural Research in Education. Armidale, NSW: Centre for Behavioural Studies, University of New England, 1973.

Fitzgerald, D. A Model of Simultaneous and Successive Processing as a Basis for Developing Individualised Instruction. Education Research and Development Committee, University of New England, Armidale, NSW, 1978.

Fitzgerald, D. Computer Based Assessment and Cognitive Modelling. Interim report to Digital Equipment. Centre for Research on Information Technology in Education, University of New England, Armidale, NSW, 1990.

Fleishman, E.A. and Bartlett, C.J. Human abilities. Annual Review of Psychology, 1969, 349-380.

Frederiksen, N. Toward a broader conception of human intelligence. American Psychologist, 1986, **41**, 445-452.

Gagné, R.M. (Ed.) Learning and Individual Differences. Columbus, Ohio: Charles E. Merrill Books, 1967(a).

Gagné, R.M. Instruction and the conditions of learning. In, L. Siegel (Ed.), Instruction: Some Contemporary Viewpoints. San Francisco: Chandler Publishing Co., 1967(b).

Gagné, R.M. The Conditions of Learning (4th edition) New York: Holt, Rinehart, and Winston, 1985.

Gagné, R.M. and Gropper, G.L. Individual differences in learning from visual and verbal presentations. Unpublished report, American Institutes for Research, Pittsburgh, 1965.

Galton, F. Hereditary Genius: An Inquiry into its Laws and Consequences. London: Watts, 1869.

Gardner, H. Frames of Mind. New York: Basic Books, 1983.

Gardner, H. The Mind's New Science. New York: Basic Books, 1985.

Gavurin, E.I. Anagram solving and spatial ability. Journal of Psychology, 1967, **65**, 65-68.

Gazzaniga, M.S. Organisation of the human brain. Science, 1989, **245** (4921), 947-52.

Gelman, R. and Gallistel, C.R. The Child's Understanding of Number. Cambridge, Mas.: Harvard University Press, 1978.

Glaser, E. An Experiment in the Development of Critical Thinking. Teachers College, Columbia University, 1941.

Glaser, R. Some implications of previous work on learning and individual differences. In, R.M. Gagné (Ed.), Learning and Individual Differences. Columbus, Ohio: Merrill Books, 1967.

Glaser, R. Individuals and learning: The new aptitudes. Educational Researcher, 1972, **1**, 5-13.

Glaser, R. Adaptive education: Individual Diversity and Learning. New York: Holt, Rinehart, and Winston, 1977.

Glass, G. Discussion. In, M.C. Wittrock and D.C. Wiley (Eds), The Evaluation of Instruction. New York: Holt, Rinehart and Winston, 1970.

Gleick, J. Making a new Science. New York: Viking Penguin, 1987.

Gratch, H. (Ed.) Twenty Five Years of Social Research in Israel. Jerusalem: Academic Press, 1973.

Green, K.N. An examination of a model of individual differences in sequential and simultaneous processing for the study of aptitude-treatment interaction. Unpublished doctoral dissertation, University of New England, 1977.

Grinder, R.E. The gifted in our midst: By their divine deeds, neuroses, and mental test scores we have known them. In, F.D. Horowitz and M. O'Brien (Eds), The Gifted and Talented: Developmental perspectives. Washington, D.C.: American Psychological Association, 1985. (pp. 5-36)

Guilford, J.P. The structure of intellect. Psychological Bulletin, 1956, **53**, 267-293.

Guilford, J.P. The Nature of Human Intelligence. New York: McGraw-Hill, 1967.

Guilford, J.P. Cognitive styles: What Are they? Educational and Psychological Measurement, 1980, **40**, 715-35.

Guilford, J.P. Higher-Order structure-of-intellect abilities. Multivariate Behavioural Research, 1981, **16**, 411-35.

Guilford, J.P. Cognitive psychology's ambiguities: Some suggested remedies. Psychological Review, 1982, **89**, 48-59.

Guilford, J.P. Some changes in the structure-of-intellect model. Educational and Psychological Measurement, 1988, **48**, 1-4.

Gustafsson, J.E. Verbal and Figural Aptitudes in Relation to Instructional Methods. Studies in Aptitude-Treatment Interactions. Goteborg: Acta Universitatis Gothoburgensis, 1976.

Gustafsson, J.E. New models of the structure of intellectual abilities: Implications for testing and teaching practice. Paper presented at the International Congress of Applied Psychology (20th, Edinburgh), 1982.

Gustafsson, J.E. and Lindstrom, B. Analysing ATI data by structural analysis of covariance matrices. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, 1979.

Guttman, L. The structure of interrelations among intelligence tests. In, Proceedings of the 1964 Invitational Convention on Testing Problems. Princeton, N.J.: Educational Testing Service, 1965(a).

Guttman, L. A factored definition of intelligence. In, R.R. Eiferman, (Ed.), Scripta Hierosolymitana, Vol. 14. Jerusalem: Magnes Press, 1965(b).

Guttman, L. Integration of test design and analysis. In, Proceedings of the 1969 Invitational Convention on Testing Problems. Princeton, N.J.: Educational Testing Service, 1969.

Guttman, L. and Levy, S. Two structural laws for intelligence. Megamot, 1980, 25, 421-438.

Haars, V. Children's Understanding of Class Inclusion and Their Ability to Reason with Implication. Paper presented at the 65th Annual Meeting of the American Educational Research Association, Los Angeles. ERIC Document Reproduction Service No. ED208021. 1981.

Hadar, N.B. Children's conditional reasoning: An investigation of fifth graders' ability to learn to distinguish between valid and fallacious inferences. Unpublished doctoral dissertation, Stanford University. ERIC Document Reproduction Service No. ED118359. 1975.

Halberstadt, W.H. An introduction to Modern Logic. New York: Harper and Row, 1960.

Hancock, R.R. Cognitive factors and their interaction with instructional mode. Journal for Research in Mathematics Education, 1975, 5, 37-50.

Handel, S., DeSoto, C. and London, M. Reasoning and spatial representation. Journal of Verbal Learning and Verbal Behaviour, 1968, 7, 351-357.

Hartman-Haas, H.J. Improving Cognitive Skills: Procedures, Problems and Prospects. Paper presented at the 3rd Annual Symposium on Developmental/Remedial Education Rochester, NY. ERIC Document Reproduction Service No. ED188129. 1980.

Hawkins, J., Pea, R.D., Glick, J. and Scribner, S. "Merds That Laugh Don't Like Mushrooms": Evidence for Deductive Reasoning by Preschoolers. Developmental Psychology, 1984, 20, 584-594.

Henle, W. On the relationship between logic and thinking. Psychological Research, 1962, 69, 366-378.

Hickson, M.L. and Stacks, D.W. NVC: Nonverbal communication studies and applications (2nd edition). Dubuque, IA: William C. Brown, 1989.

Horn, J.L. Organisation of abilities and the development of intelligence. Psychological Review, 1968, 75, 242-259.

Horn, J.L. On the subjective character of the empirical base of Guilford's structure of intellect model. Psychological Bulletin, 1973, 58, 120-136.

Hudson, T. Correspondences and Numerical Differences between Disjoint Sets. Child Development, 1983, 54, 84-90.

Hughes, G.E. and Cresswell, M.J. An Introduction to Modal Logic. London: Methuen, 1968.

Hughes, Jan N. and Hall, Donald M. Individual differences in children's ability to profit from picture adjunct aids. Paper presented at the Annual Meeting of the American Educational, 1983.

Humphreys, L.G. Critique of Cattell's "Theory of fluid and crystallised intelligence: A critical experiment". Journal of Educational Psychology, 1967, **58**, 120-136.

Humphreys, L.G. A conceptualisation of human giftedness. In, F.D. Horowitz and M. O'Brien (Eds), The Gifted and Talented: Developmental perspectives. Washington, D.C.: American Psychological Association, 1985. (pp. 331-360)

Hunt, D. and Randhawa, B.S. Cognitive processes and achievement. Alberta Journal of Educational Research, 1983, **29**, 206-15.

Hunter, I.M.L. The solving of three term series problems. British Journal of Psychology, 1957, **48**, 286-298.

Huttenlocher, J. Constructing spatial images: A strategy in reasoning. Psychological Review, 1968, **75**, 550-560.

Inhelder, B. and Piaget, J. The Growth of Logical Thinking from Childhood to Adolescence. New York: Basic Books, 1958.

Jarman, R.F. Cognitive processes and syntactic structure: Analyses of syntagmatic and paradigmatic associations. Psychological Research, 1980, **41**, 153-169.

Jensen, A.R. Varieties of individual differences in learning. In, R.M. Gagné (Ed.), Learning and Individual Differences. Columbus, Ohio: Merrill Books, 1967.

Jensen, A.R. Social class, race, genetics: Implications for education. American Education and Research Journal, 1968, **5**, 1-42.

Jensen, A.R. Hierarchical theories of mental ability. In, W.B. Dockrell (Ed.), On Intelligence. Toronto: Methuen, 1970.

Jensen, A.R. Educational Differences. London: Methuen, 1973(a).

Jensen, A.R. Educability and Group Differences. London: Methuen, 1973(b).

Jensen, A.R. Bias in Mental Testing.New York: The Free Press (A Division of Macmillan), 1980.

Jensen, A.R. The chronometry of intelligence. In, R.J. Sternberg (Ed.), Advances in the Psychology of Human Intelligence, Vol. 1. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1982. (pp. 255-310)

Johnson, K.M., Erickson, E., Bilby, R. and McEvoy, A. The Nature of Human Ability: An Historical Perspective on Intelligence. Paper presented at the 68th Annual Meeting of the American Educational Research Association. New Orleans, LA, April, 1984.

Johnson, T.W. Philosophy for Children: An approach to Critical Thinking. Phi Delta Kappa Educational Foundation, Bloomington, Ind. ERIC Document Reproduction Service No. ED242629. 1984.

Johnson-Laird, P.N. Models of deduction. In, R.J. Falmagne (Ed.), Reasoning: Representation and Process in Children and Adults. Hillsdale, N.J.: Erlbaum, 1975.

Jonassen, D.H. Aptitude- versus content- treatment interactions: Implications for instructional design. Journal of Instructional Development, 1982, 5, 15-27.

Karnes, F.A. and McCallum, R.S. Evidence for the Luria-Das model of information processing for gifted students: A preliminary investigation. Educational and Psychological Research, 1983, 3, 133-137.

Kaufman, G. Visual Imagery and its Relation to Problem Solving. New York: Columbia University Press, 1979.

Keating, D.P. Advances in the psychology of human intelligence. In, R.J. Sternberg, R.J. Advances in the Psychology of Human Intelligence, Vol. 2. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1982. (pp. 1-45)

Keefe, J.W. Learning Style Theory and Practice. National Association of Secondary School Principals, Reston, Va. 1987.

Kelley, T.L. Crossroads in the Mind of Man: A Study of Differentiable Mental Abilities. Stanford, California: Stanford, 1928.

Kenny, O. Simultaneous and successive information processing: Their relationship with the mathematics achievement of junior high school students. Unpublished masters dissertation, University of New England, 1979.

Kerlinger, F.N. Foundations of Behavioural Research (2nd Edition). New York, NY: Hold, Rinehart & Winston, 1973.

King, F.J., Roberts, D. and Kropp, R.P. Relationship between ability measures and achievement under four methods of teaching elementary set concepts. Journal of Educational Psychology, 1969, **60**, 244-247.

Kirby, J.R. Cognitive Strategies and Educational Performance. Orlando: Academic Press, 1984.

Kirby, J.R. and Biggs, J.B. Cognition, Development, and Instruction. New York: Academic Press, 1980.

Kirby, J.R. and Das, J.P. Reading achievement, IQ and simultaneous-successive processing. Journal of Verbal Learning and Verbal Behaviour, 1977, **69**, 564-570.

Kirby, J.R. and Das, J.P. Information processing and human abilities. Journal of Educational Psychology, 1978, **70**, 58-66.

Kleinfeld, J.S. and Nelson, P. Adapting instruction to Native Americans' "Learning Styles": An iconoclastic view. ERIC Document Reproduction Service No. ED321952. 1988.

Klich, Z. and Davidson, G. Memory skills in cross-cultural cognitive research. Paper presented at the Fifteenth Annual Conference of the Australian Psychological Society, Toowoomba, Queensland, 1980.

Kneller, G.G. Logic and Language of Education. New York: John Wiley, 1966.

Koopmans, M. The Difference between Task Understanding and Reasoning Skills in Children's Syllogistic Performance. Paper presented at the Annual Meeting of the American Educational Research Association, Washington, DC. ERIC Document Reproduction Service No. ED286373. 1987.

Kosslyn, S.M. Ghosts in the Mind's Machine: Creating and Using Images in the Brain. New York: W.W. Norton, 1983.

Kosslyn, S.M. Mental representation. In, Anderson, R.A. and Kosslyn, S.M., Tutorials in Learning and Memory. San Francisco: W.H. Freeman & Company, 1984. (pp. 91-117)

Kosslyn, S.M. Mental imagery ability. In, R.J. Sternberg (Ed.), Human Abilities: An Information Processing Approach. New York: W.H. Freeman and Company, 1985. (pp. 151-172)

Kosslyn, S.M. Aspects of cognitive neuroscience of mental imagery. Science, 1988, **240** (4859), 1627-31.

Kosslyn, S.M. and Pomerantz, J.R. Imagery, propositions, and the form of internal representations. Cognitive Psychology, 1977, **9**, 52-76.

Kruse, J. and Presseisen, B.Z. A Catalog of Programs for Teaching Thinking. Research for Better Schools, Inc., Philadelphia, Pa. ERIC Document Reproduction Service No. ED290125. 1987.

Krutetskii, V.A. The Psychology of Mathematical Abilities in School Children. Chicago: University of Chicago Press, 1976.

Kulhavy, R.W., Caterino, L.C. and Melchiori, F. Spatially cued retrieval sentences. Journal of General Psychology, 1990, **116**, 297-304.

Lamos, J.P. Programmed instruction to computer-based instruction: The evolution of an instructional technology. In, Instructional Development: The State of the Art, II; IR 013 273. ERIC Document Reproduction Service No. ED298902. 1984.

Languis, M.L. and Kraft, R.H. The neuroscience and educational practice: Asking better questions. In, V. Rentel, S. Corson, and B.R. Dunn (Eds), Psychophysical Aspects of Reading and Learning. New York: Gordon and Breach Science Publishers, 1985.

Leasak, J., Hunt, D. and Randhawa B. Cognitive processing, intervention and achievement. Alberta Journal of Educational Research, 1982, **28**, 257-266.

Leeb-Lundberg, K. Mathematics Is More Than Counting. Association for Childhood Education International, Wheaton, MD. Report No: ISBN-0-87173-110-X. ERIC Document Reproduction Service No. ED255305. 1985.

Leont'ev, A.N. The problem of activity in psychology. In, J. Wertsch (Ed.), The Concept of Activity in Soviet Psychology. Armonk, N.Y.: M.E. Sharpe, c. 1981.

Levy, J. Cerebral asymmetry and the psychology of man. In, M. Wittrock (Ed.), The Brain and Psychology. New York: Academic Press, 1980.

Lipman, M. The Cultivation of Reasoning through Philosophy. Educational Leadership, 1983, **42**, 51-56.

Lipman, M. and Sharp, A. Teaching Children Critical Philosophical Thinking. The Institute for the Advancement of Philosophy of Children, Montclair State College, 1975.

Lipman, M., Sharp, A.M. and Oscanyan, F.S. Philosophy in the Classroom (2nd edition). Philadelphia: Temple University Press, 1980.

Lubin, A. The interpretation of scientific interaction. Educational and Psychological Measurement, 1961, **21**, 807-817.

Luria, A.R. Human Brain and Psychological Processes. New York: Harper & Row, 1966(a).

Luria, A.R. Higher Cortical Functions in Man. New York: Basic Books, 1966(b).

Luria, A.R. On the pathology of computational operations. In, Kilpatrick and Wirsup (Eds), Soviet Studies in the Psychology of Learning and Teaching Mathematics. SMSG Stanford, 1969.

Luria, A.R. The Working Brain - An Introduction to Neuropsychology, London: Penguin, 1973(a).

Luria, A.R. The frontal lobes and the regulation of behaviour. In, K.H. Pribram and A.R. Luria (Eds), The Psychophysiology of the Frontal Lobes. New York: Academic Press, 1973(b).

Luria, A.R. The Man with a Shattered World. Hammondsworth, England: Penguin, 1975(a).

Luria, A.R. Basic problems of language in the light of psychology and neurolinguistics. In, E.H. Lenneberg and E. Lenneberg (Eds), Foundations of Language Development: A Multidisciplinary Approach. New York: Academic Press, 1975(b).

Luria, A.R. The Neuropsychology of Memory. New York: Winston & Sons, 1976(a).

Luria, A.R. Cognitive Development: It's Cultural and Social Foundations. Cambridge, MA: Harvard University Press, 1976(b).

Luria, A.R. Cultural differences in thinking. In, M. Cole and S. Cole (Eds), Making of the Mind. Cambridge: Harvard University Press, 1979.

Luria, A.R. Language and Cognition. J.V. Wertsch (Ed.). New York: Wiley, 1982.

Markovits, H. Schleifer, M. and Fortier, L. Development of Elementary Deductive Reasoning in Young Children. Developmental Psychology, 1989, **25**, 787-793.

Mason, E.J. The Development of Logical Thinking in Children. Report to the Netherlands Ministry for Pure Science Research (ZWO). ERIC Document Reproduction Service No. ED259893. 1980.

McCallum, R.S. and Merritt, F.M. Simultaneous-successive processing among college students. Journal of Psychoeducational Research, 1983, **1**, 85-93.

McCallum, R.S., Merritt, F.M., Dickson, A.L., Oehler-Stinnett, J. and Spencer, T.R. Planning ability across ranges of intellectual ability: An examination of the Luria-Das information-processing model. Journal of School Psychology, 1988, **26**, 405-411.

Meirovitz, M. and Jacobs, P.I. Muscles of the Mind: An International Program to Improve Thinking. Paper presented at the Harvard International Conference on Thinking, Cambridge, MA. ERIC Document Reproduction Service No. ED260973. 1984.

Merrill, M.D. Learner control: Beyond aptitude-treatment interactions, AV Communication Review, 1975, **23**, 217-226.

Merrill, M.D. Component display theory. In, C.M. Reigeluth (Ed.), Instructional design models and theories. New Jersey: Lawrence Erlbaum, 1983.

Merritt, F.M. and McCallum, R.S. Sex-related differences in simultaneous-successive information processing? Clinical Neuropsychology, 1983, **5**, 117-119.

Metzler, J. and Shepherd, R.N. Transformational studies of internal representation of three dimensional objects. In, R.J. Solso (Ed.), Theories of Cognitive Psychology: The Lovola Symposium. Potomac MD: Erlbaum, 1974.

Michalos, A.C. Improving Your Reasoning. Englewood Cliffs, N.J.: Prentice-Hall, 1970.

Miles, T.R. Contributions to intelligence testing and the theory of intelligence. I. On defining intelligence. British Journal of Educational Psychology, 1957, **68**, 474-481.

Molloy, G.N. and Das, J.P. Intellectual abilities and processes: An exploratory study with implications for person-teaching method interactions. Australian Journal of Education, 1979, **23**, 83-92.

Morgan, W. and Morgan, A.B. Logical reasoning: With and without training. Journal of Applied Psychology, 1953, **37**, 399-401.

Moshman, D. and Franks, B.A. Development of the concept of inferential validity. Child Development, 1986, **57**, 153-165.

Naglieri, J. and Das, J.P. Planning-Arousal-Simultaneous-Successive (PASS): A model for assessment. Journal of School Psychology, 1988, **26**, 35-48.

Nebes, R.D. Hemispheric specialisation in commissurotomized man. Psychological Bulletin, 1974, **81**, 1-14.

Neisser, U. Cognition and Reality. San Francisco: W.H. Freeman & Co., 1976.

Nickerson, R.S. Reflections on Reasoning. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1986.

Nickerson, R.S., Perkins, D. and Smith, E.E. The Teaching of Thinking. Hillsdale, N.J.: Erlbaum, 1985.

Orasanu, J. and Scribner, S. The development of verbal reasoning: Pragmatic, schematic, and operational aspects. In, W. Frawley (Ed.), Linguistics and Literacy. New York: Plenum, 1982.

Osburn, H.G. and Melton, R.S. Predictions of proficiency in a modern and traditional course in beginning algebra. Educational and Psychological Measurement, 1963, **23**, 277-288.

Osherton, D. Logical Abilities in Children: Vol. 2. Logical Inference: Underlying Operations. Hillsdale, NJ: Erlbaum, 1974.

Paivio, A. A factor-analytic study of word attributes and verbal attributes. Journal of Verbal Learning and Verbal Behaviour, 1968, **7**, 41-49.

Paivio, A. Imagery and Verbal Processes. New York: Holt, Rinehart and Winston, 1971.

Paivio, A. Imagery and synchronic thinking. Canadian Psychological Review, 1975, **16**, 147- 163.

Paivio, A. Concerning dual coding and simultaneous successive processing. Canadian Psychological Review, 1976, **17**, 69-71.

Papert, S. Mindstorms. New York: Basic Books, 1980.

Pellegrino, J.W. and Kail, R. Process analyses of spatial aptitude. In, R.J. Sternberg (Ed.), Advances in the Psychology of Human Intelligence, Vol. 1. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1982. (pp. 311-365)

Perkins, D.N. The cognitive roots of scientific and mathematical ability. Harvard Univ., Cambridge, Mass. Graduate School of Education. In, J.I. Dreyden et al (Eds), Developing Talent in Mathematics, Science and Technology: A Conference on Academic Talent A Conference on Academic Talent. Durham, North Carolina, March, 1988.

Perkins, D.N. and Simmons, R. The cognitive roots of scientific and mathematical ability and discussant reaction: Alternative representations: A key to academic talent? In, J.I. Dreyden et al (Eds), Developing Talent in Mathematics, Science and Technology: A Conference on Academic Talent, Durham, North Carolina, March 28-30, 1988.

Piaget, J. Origins of Intelligence. New York: International Universities Press, 1964.

Piaget, J. Judgment and Reasoning in the Child. London: Routledge, 1967. (Original work published 1928.)

Piper, D. Syllogistic Reasoning in Varied Narrative Frames: Aspects of Logico-Linguistic Development. Doctoral dissertation, University of Alberta. ERIC Document Reproduction Service No. ED215587. 1981.

Polson, P.G., and Jeffries, R. Analysis - instruction in general problem-solving skills: An analysis of four approaches. In, J.W. Segal, S.F. Chipman, and R. Glaser (Eds), Thinking and Learning Skills: Vol. I. Relating Instruction to Research. Hillsdale, N.J.: Erlbaum, 1985. (pp. 417-455).

Posner, George J. and Gertzog, William A. The clinical interview and the measurement of conceptual change. Science Education, 1982, **66**, 195-209.

Pozner, M.I., Petersen, S.E., Fox, P.T. and Raichle, M.E. Localization of cognitive operations in the human brain. Science, 1988, **240** (4859), 1627-31.

Prigogine, I. and Stengers, L. Order out of Chaos: Man's New Dialogue with Nature. New York: Bantam, 1984.

Pylyshyn, Z.W. What the mind's eye tells the mind's brain: A critique of mental imagery. Psychological Bulletin, 1973, **80**, 1-24.

Pylyshyn, Z.W. The imagery debate: Analogue media versus tacit knowledge. Psychological Review, 1981, **88**, 16-25.

Quinton, G. and Fellows, B. "Perceptual" strategies in the solving of three-term series problems. British Journal of Psychology, 1975, **66**, 69-78.

Ragsdale, R.G. Empirically based myths: Astrology, biorhythms, and ATI's. Canadian Journal of Education, 1980, **5**, 40-51.

Ransley, W.K. The development of a psychometric model of information processing in young children based on Luria's model of brain function. Unpublished doctoral dissertation, University of New England, 1981.

Reddix, M.D. and Dunn, B.R. EEG Alpha production correlates of cognitive style differences and recall of metaphor and poetry. Urbana-Champaign: University of Illinois, Centre for the study of reading, 1984.

Reddix, M.D. and Dunn, B.R. Electrophysiological Determinants of Cognitive Style: Implications for Educational and Psychological Research. Paper presented at the Annual Meeting of the American Educational Research Association. April 1986.

Resnick, L.B. Education and Learning to Think. National Washington, D.C.: National Academy Press, 1987.

Rubenzer, R.L. The left-right information model for information processing. Paper presented at the Annual Convention of the C.S.C., Washington, D.C. Education Reproduction Document Service No. ED242109. 1978.

Salomon, G. Heuristic models for the generation of aptitude-treatment interaction hypotheses. Review of Educational Research, 1972, **42**, 327-343.

Schofield, N.J. and Ashman, A.F. The cognitive processing of gifted, high average, and low average ability students. British Journal of Educational Psychology, 1987, **57**, 9-20.

Scribner, S. Modes of thinking and ways of speaking: Culture and logic reconsidered. In, P.N. Johnson-Laird and P. C. Watson (Eds), Thinking: Readings in Cognitive Science. Cambridge: Cambridge University Press, 1977.

Sechenov, I. Selected Physiological and Psychological Works. Moscow: Foreign Languages Publishing House, 1978.

Segal, J.W., Chipman, S.F. and Glaser, R. (Eds), Thinking and Learning Skills: Vol. I. Relating Instruction to Research. Hillsdale, N.J.: Erlbaum, 1985.

Sells, S.B. The atmosphere effect: An experimental study of reasoning. Archives of Psychology, 1936, **29**, 3-72.

Semmes, J. Hemispheric specialisation: A possible clue to mechanism. Neuropsychologia, 1968, **6**, 11-26.

Shepard, R.N. Perceptual and analogical bases of cognition. In, J. Mehler, E. Walker and M. Garett (Eds), Perspectives on Mental Representation: Experimental and Theoretical Studies of Cognitive Processes and Capacities. Hillsdale, New Jersey: Lawrence Erlbaum & Associates, 1982.

Shigaki, I.S. and Wolf, W. Formal Syllogistic Reasoning of Young Gifted Children. Paper presented at the Annual Meeting of the American Educational Research Association, Boston, MA. ERIC Document Reproduction Service No. ED188376. 1979.

Siegel, L.S. The relationship of language and thought in the preoperational child: A reconsideration of non-verbal alternatives to Piagetian tasks. In, C.J. Brainerd and L.S. Siegel (Eds), Alternatives to Piaget: Critical Essays on the Theory. New York: Academic Press, 1978.

Skemp, R.R. The Psychology of Learning Mathematics. Harmondsworth: Pelican, 1971.

Smith, N.K. Immanuel Kant's Critique of Pure Reason. London: Macmillan, 1933.

Snow, R.E. Individual differences and instructional theory. Educational Researcher, 1977, **6**, 11-15.

Solan, H.A. A comparison of the influences of verbal-successive and spatial-simultaneous factors on achieving readers in fourth and fifth grade: A multivariate correlational study. Journal of Learning Disabilities, 1987, **20**, 237-42.

Spearman, C. General Intelligence objectively determined and measured. American Journal of Psychology. 1904, **15**, 202-293.

Spearman, C. The Abilities of Man. New York: Macmillan, 1927.

Stacks, D.W. The modular mind and intrapersonal communication processes. Paper presented at the Annual Meeting of the Speech Communication Association (75th, San Francisco), 1989.

Stacks, D.W. and Sellers, D.E. Toward a holistic approach to communication: The effect of "pure" hemispheric reception on message acceptance. Communication Quarterly, 1986, **34**, 266-285.

Stacks, D.W. and Sellers, D.E. Understanding intrapersonal communication: Neurological processing implications. In, C.V. Roberts and K.W. Watson (Eds), Intrapersonal Communication Processes: Original Essays. Auburn, AL: Spectra Publishers, 1989. (pp. 243-267)

Stader, E.D., Webb, J.M., White, M.C., Kulhavy, R.W. and Stock, W.A. Children's retrieval of classroom materials: A test of conjoint retention. Paper presented at the Annual Convention of the American Psychological Association, July, 1990.

Staudenmayer, H. Understanding conditional reasoning with meaningful propositions. In, R.J. Flamagne (Ed.), Reasoning: Representation and Process in Children and Adults. Hillsdale, N.J.: Erlbaum, 1975.

Sternberg, R.J. The Development of Linear Syllogistic Reasoning. Journal of Experimental Child Psychology, 1980, **29**, 340-356.

Sternberg, R.J. How Can We Teach Intelligence? Research for Better Schools, Inc., Philadelphia, Pa. ERIC Document Reproduction Service No. ED242700. 1983(a).

Sternberg, R.J. Components of human intelligence. Cognition, 1983(b), **15**, 1-48.

Sternberg, R.J. Advances in the Psychology of Human Intelligence, Vol. 2. Hillsdale, N.J.: Lawrence Erlbaum, 1984(a).

Sternberg, R.J. Facets of human intelligence. In, R.A. Anderson and S.M. Kosslyn (Eds), Tutorials in Learning and Memory. San Francisco: W.H. Freeman & Company, 1984(b). (pp. 137-165)

Sternberg, R.J. Beyond I.Q.: A Triarchic Theory of Human Intelligence. New York: Cambridge University Press, 1985(a).

Sternberg, R.J. General intellectual ability. In, R.J. Sternberg (Ed.), Human Abilities: An Information Processing Approach. New York: W.H. Freeman and Company, 1985(b). (pp. 5-29)

Sternberg, R.J. and Weil, E.M. An aptitude x strategy interaction in linear syllogistic reasoning. Journal of Educational Psychology, 1980, **72**, 226-239.

Strawson, P.F. Introduction to Logical Theory. London: Methuen, 1952.

Sultan, E.E. A factorial study in the domain of creative thinking. British Journal of Educational Psychology, 1962, **32**, 78-82.

Thompson, G.H. Factorial Analysis of Human Ability. Boston: Houghton Mifflin, 1939.

Thurstone, L.L. Primary mental abilities. Psychometric Monograph, Nr. 1. Chicago: University of Chicago Press, 1938.

Thurstone, L.L. Multiple Factor Analysis. Chicago: University of Chicago Press, 1947.

Tobias, S. Achievement-treatment interaction. Review of Educational Research, 1976, **46**, 61- 74.

Tobias, S. Adapting instruction to individual differences among students. Educational Psychologist, 1981, **16**, 111-120.

Tobias, S. When do instructional methods make a difference? Educational Researcher, 1982, **11**, 4-9.

Travers, R.M.W. Human information processing. In, Instructional Development: The State of the Art, II; IR 013 273. ERIC Document Reproduction Service No. ED298898. 1984.

Try, K.W. Computer managed instruction and individualised learning in junior high school mathematics. Unpublished doctoral dissertation, University of New England, 1984.

Tulloch, M. An exploration of individual differences in young children's performance on number tasks. Unpublished masters dissertation, University of New England, 1986.

Vernon, P.E. Intelligence and Attainment Tests. London: University of London Press, 1960.

Vernon, P.E. The Structure of Human Abilities. London: Methuen, 1961.

Vernon, P.E. Personality Assessment: A Critical Survey. New York: Wiley, 1964.

Vernon, P.E. Intelligence and Cultural Environment. London: Methuen, 1969.

Vernon, P.E. Intelligence. In, W.B. Dockrell (Ed.), On Intelligence. London: Methuen, 1970.

Vernon, P.E., Ryba, K.A. and Lang, R.J. Simultaneous and successive processing: An attempt at replication. Canadian Journal of Behavioural Science, 1978, **10**, 1-15.

Vocate, D.R. The Theory of A.R. Luria: Functions of Spoken Language in the Development of Higher Mental Processes. Hillsdale, N.J.: Lawrence Erlbraum Associates, 1987.

Wachs, M.C. and Harris, M. Simultaneous and successive processing in university students: Contributions to academic performance. Journal of Psychoeducational Assessment, 1986, **4**, 103-112.

Walton, J.E. Sequential and simultaneous processing abilities and their interaction with instructional treatments in senior high school mathematics. Unpublished doctoral dissertation, University of New England, 1983.

Webb, L.F. Interaction effects between selected cognitive abilities and instructional treatment in algebra. Unpublished doctoral dissertation, University of Texas, 1971.

Webb, L.F. and Carry, L.R. Interaction of spatial visualisation and general reasoning abilities with instructional treatment in quadratic inequalities: A follow-up study. Journal of Research in Mathematics Education, 1975, **5**, 132-140.

Wechsler, D. The Measurement and Appraisal of Adult Intelligence. (4th ed.) Baltimore: Williams & Wilkins, 1958.

Weinstein, J. and Laufman, L. Teaching Logical Reasoning to Gifted Students. Gifted Child Quarterly, 1980, **24**, 186-190.

White, R.T. Assessing understanding by means of Venn diagrams. Science Education, 1986, **70**, 51-158.

Willatts, P. and Duff, S. Reasoning by Young Children: Knowing When and When Not To Make an Inference. Paper presented at the British Psychological Society Developmental Section Conference, Guildford, Great Britain. ERIC Document Reproduction Service No. ED310876. 1989.

Woodworth, R.S. and Sells, S.B. An atmosphere effect in formal syllogistic reasoning. Journal of Experimental Psychology, 1935, **18**, 451-460.

Zaidel, E. Biological and physiological studies of hemispheric specialisation. In, D.F. Benson and E. Zaidel (Eds), The Dual Brain: Hemispheric Specialisation in Humans. New York: Guilford Press, 1985. (pp. 47-63)

APPENDIX A

TESTS DEFINING SUCCESSIVE INFORMATION PROCESSING (Study 1)

NUMBER SPAN TEST

ADMINISTRATIVE INSTRUCTIONS

This is a test of your ability to remember sets of numbers. The teacher will read out the numbers. After the teacher has finished each set of numbers you are to write down the numbers in the exact order in which they were read out. Please do not write any numbers of a set until the whole set has been read out and you are told to begin writing. There will be 16 sets.

Some of the sets may be too long for you to remember all of the numbers. If you do not remember a number, put a cross in the space where you think it should go. Try to remember all the numbers in the exact order in which they were read out.

It is very important that you do not write numbers while a set is being read out.

Here is a practice. Turn to your **ANSWER SHEET 1 - NUMBER SPAN**.

"Ready. Practice Sequence. 7 2 4. Begin. Now write the numbers in the exact order."

NUMBER SPAN - TEST ITEMS AND MARKING KEY

1	8	1	9	5	7	2					
2	4	6	2	9							
3	3	7	1	4	9	2	5	8	1	6	
4	9	2	6	2	8	6	1				
5	7	9	5	3	8						
6	5	2	9	4	1	6	8	3	7		
7	2	6	3	1	5						
8	2	4	8	5	1						
9	6	8	2	4	1	3	9	7	2	5	3
10	9	2	8	5	7	1					
11	7	4	2	9	3	5	8	6			
12	4	3	7	2	3	9					
13	5	7	3	1	6	9	4				
14	6	2	5	9	7	1	8	3			
15	4	7	9	3	6	1	5	8	4		
16	5	1	8	7	2	3	1				

LETTER SPAN TEST

ADMINISTRATIVE INSTRUCTIONS

This is a test of your ability to remember sets of letters. The teacher will read out the letters. After the teacher has finished each set of letters you are to write down the letters in the exact order in which they were read out. Please do not write any letters of a set until the whole set has been read out and you are told to begin writing. There will be 16 sets.

Some of the sets may be too long for you to remember all of the letters. If you do not remember a letter, put a cross in the space where you think it should go. Try to remember all the letters in the exact order in which they were read out.

It is very important that you do not write letters while a set is being read out.

Use capital letters for your answers.

Here is a practice. Turn to your **ANSWER SHEET 2 - LETTER SPAN**.

"Ready. Practice Sequence. H R L. Begin. Now write the letters in the exact order."

LETTER SPAN - TEST ITEMS AND MARKING KEY

1	K	F	C								
2	H	S	L	Y	G						
3	P	F	R	C	W	S	G	K	Y		
4	P	L	S	C	W	K	R	F			
5	R	G	S								
6	L	W	C	Y	K	R	P				
7	F	S	Y	L	C	H					
8	S	C	F	K	W	L	P				
9	Y	C	G	P	W	L	S	K	H	R	F
10	W	Y	S	C	L						
11	P	G	L	F	H	K	Y	W	C	R	
12	C	F	G	W							
13	H	Y	R	W	S	P					
14	S	F	L	H							
15	C	P	R	K	H	S	W	F			
16	S	F	W	G	P	L	K				

WORD SPAN TEST

ADMINISTRATIVE INSTRUCTIONS

This is a test of your ability to remember sets of words. The teacher will read out the words. After the teacher has finished each set of words you are to write down the words in the exact order in which they were read out. Please do not write any words of a set until the whole set has been read out and you are told to begin writing. There will be 12 sets.

Some of the sets may be too long for you to remember all of the words. If you do not remember a word, put a cross in the space where you think it should go. Try to remember all the words in the exact order in which they were read out.

It is very important that you do not write words while a set is being read out.

Here is a practice. Turn to your **ANSWER SHEET 3 - WORD SPAN**.

"Ready. Practice Sequence. MAN CAT ICE. Begin. Now write the words in the exact order."

WORD SPAN TEST - TEST ITEMS

1. MAN, LETTER, STRING
2. HORSE, PEN, THORN, BABY, TIN
3. HALL, TABLE, CAMP, PARTY, LAKE, BODY
4. PAPER, MOSS, RIVER, DREAM, SKIN
5. GRASS, CUP, HOUSE, DOOR
6. AIR, CHIN, CORN, ICE, SOCK
7. SUN, GOLD, BOOK, TAP, DRESS, HILL
8. SALT, CLAW
9. KISS, FOX, ARM, FISH. LIP, CARD, BELL
10. TOY, FUR, FORK, ANT, LAND
11. SHIP, TOE, IRON, TANK, SKY, FLOOR, DOLL, CAR
12. HAIR, QUEEN, HEAD, STEP

APPENDIX B

TESTS DEFINING SIMULTANEOUS INFORMATION PROCESSING

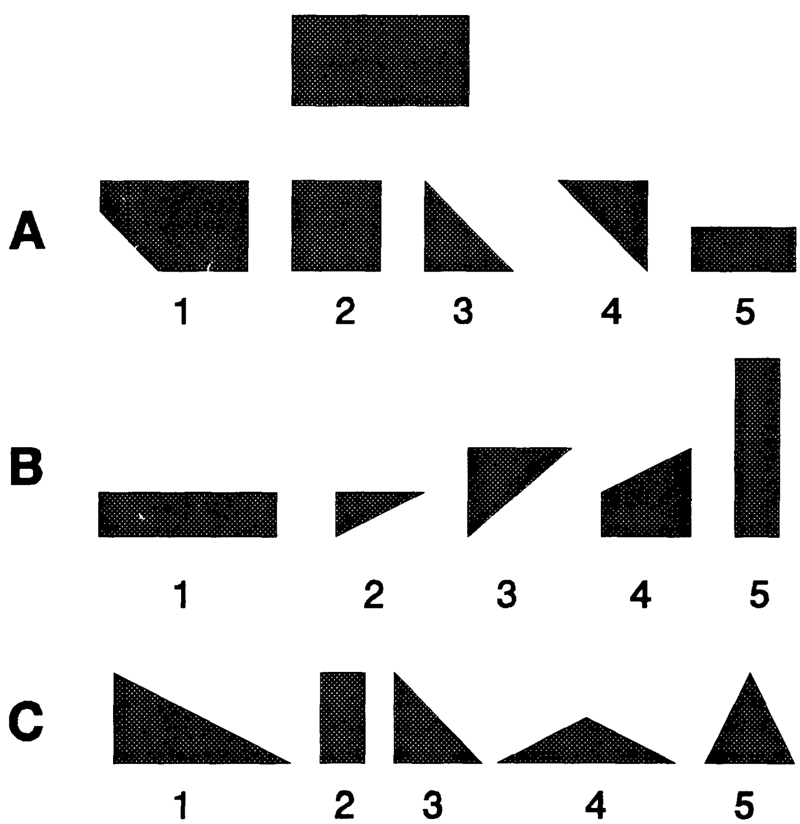
(Study 1)

SHAPES TEST

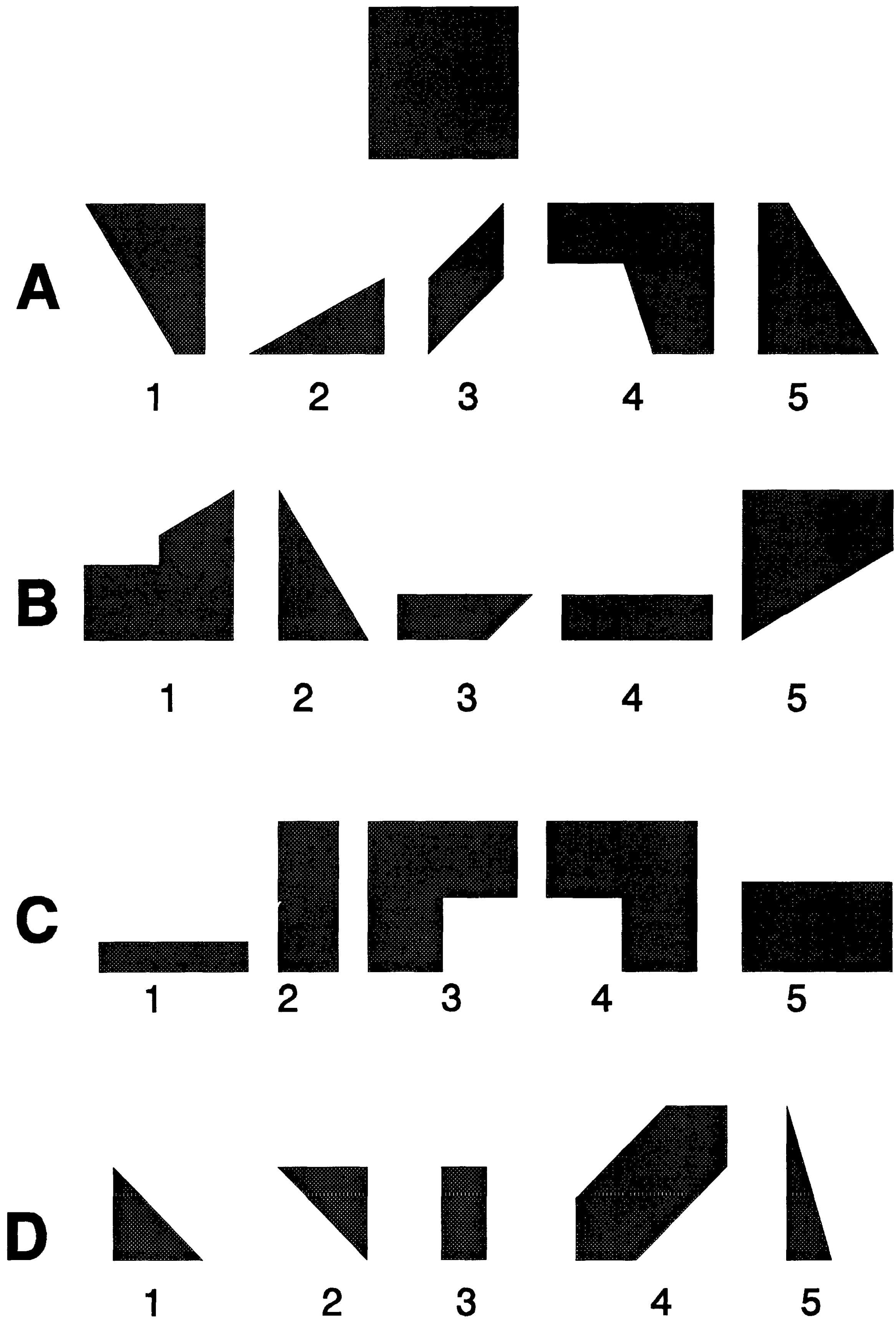
ADMINISTRATIVE INSTRUCTIONS

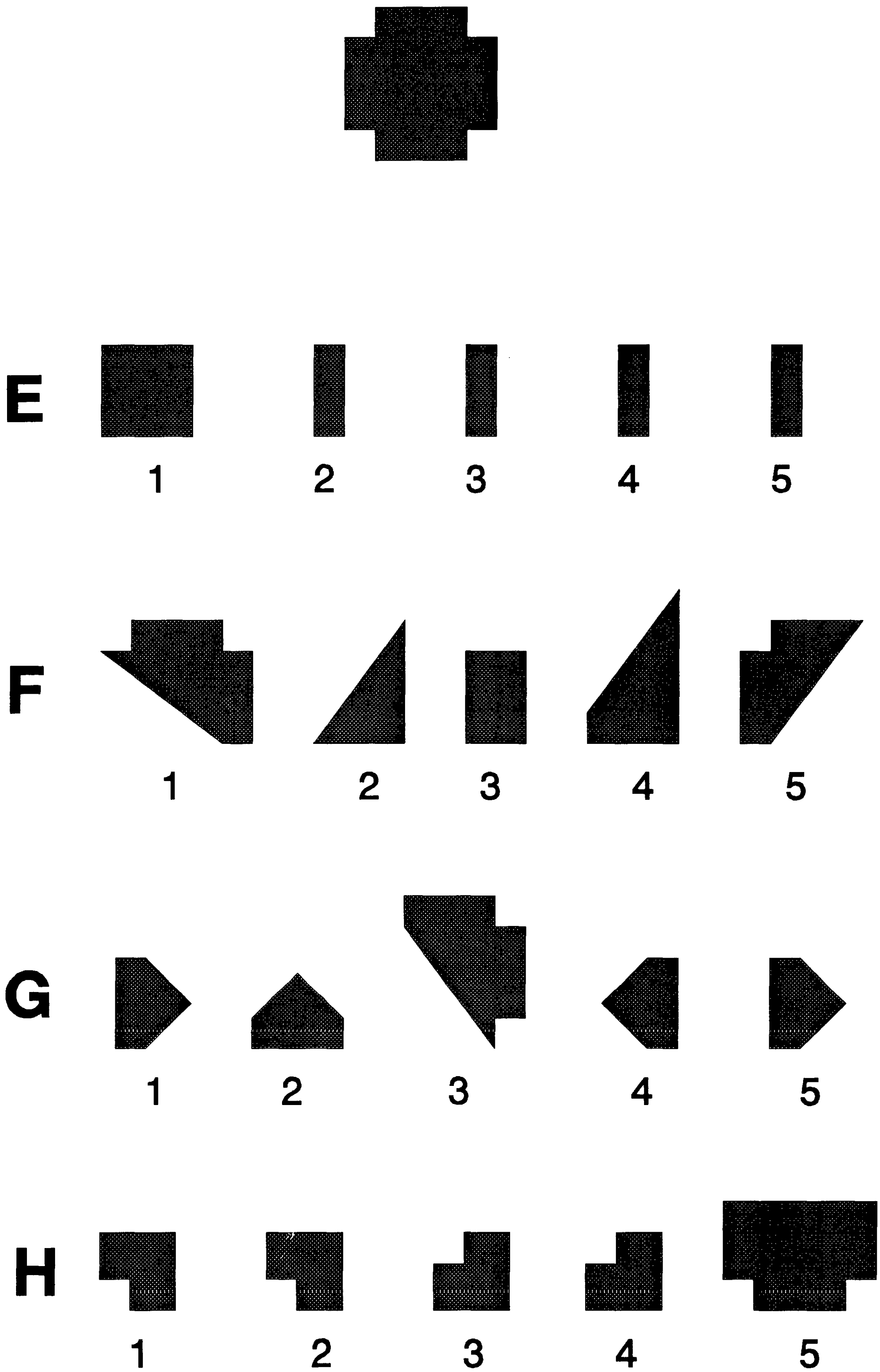
This is a test of your ability to tell which shapes can be put together to make a certain figure. At the top of each page is the figure that you have to make with the shapes. Beneath each figure are four rows of shapes. Each row has five shapes in it. Your task is to decide which of the five shapes in each row will make the complete figure of the same size when put together. Any number of shapes, from two to five, may be used to make the complete figure. Each figure may be turned around to any position but it cannot be turned over. It may help you to sketch the way the shapes fit together. You may use any blank space for doing this. When you have decided which shapes make the complete figure, circle each of the numbers underneath the shapes that you would use. You have seven minutes for this test. If you finish early, check your answers.

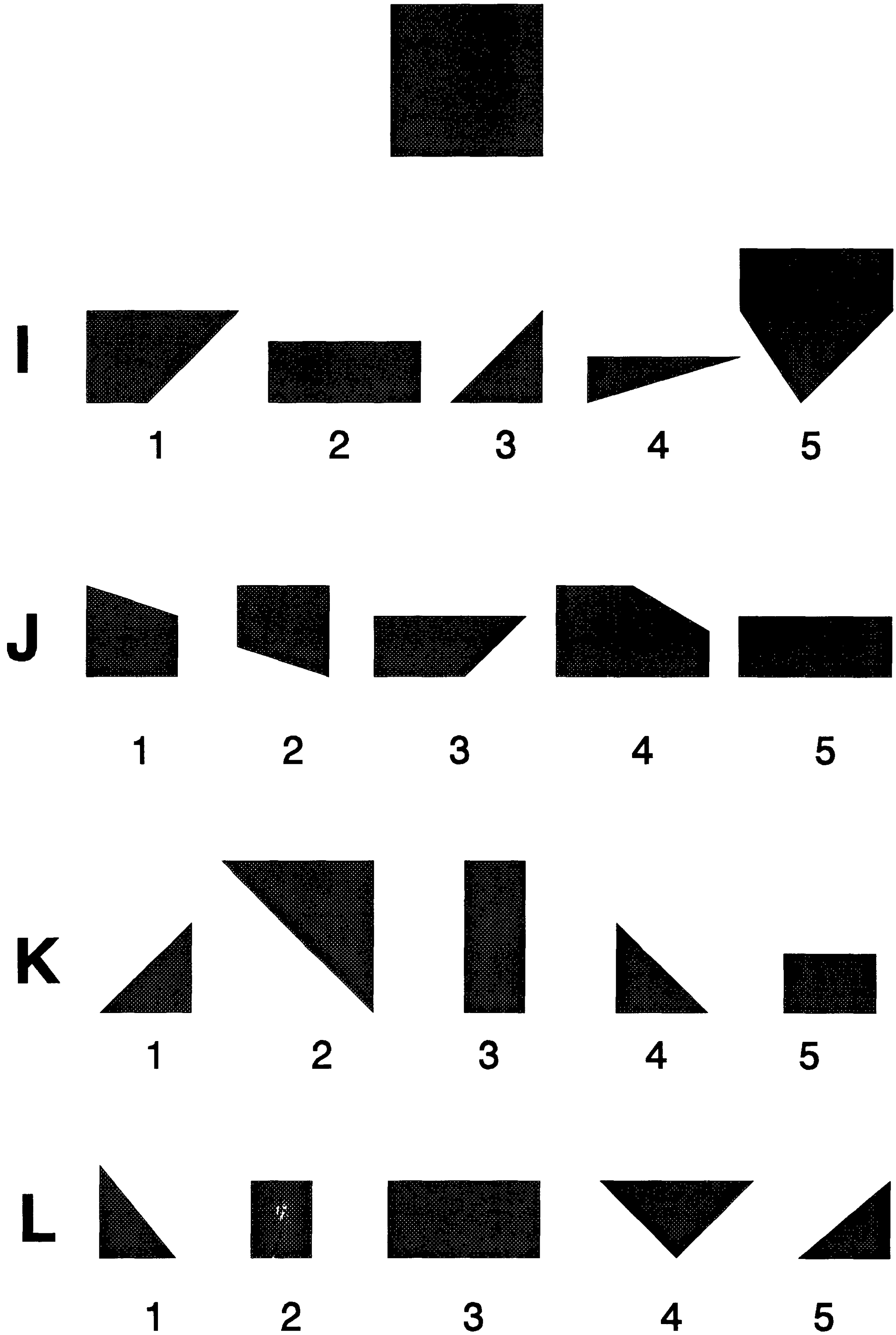
PRACTICE EXAMPLES



SHAPES TEST - TEST ITEMS




E
1 2 3 4 5
F
1 2 3 4 5
G
1 2 3 4 5
H
1 2 3 4 5


I
1
2
3
4
5
J
1
2
3
4
5
K
1
2
3
4
5
L
1
2
3
4
5

SHAPES TEST - ANSWERS

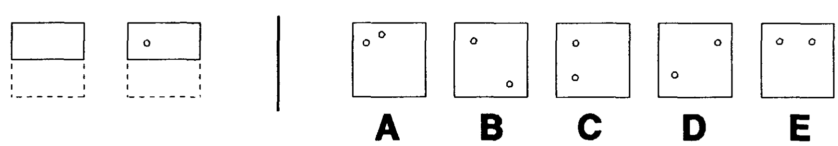
A	1, 5
B	2, 5
C	2, 5
D	1, 2, 4
E	1, 2, 3, 4, 5
F	1, 5
G	1, 2, 4, 5
H	1, 2, 3, 4
I	1, 2, 3
J	1, 2, 5
K	1, 3, 4, 5
L	1, 2, 3, 5

PAPER FOLDING TEST

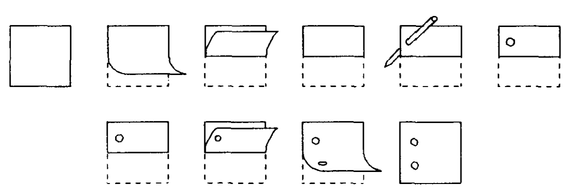
ADMINISTRATIVE INSTRUCTIONS

In this test you are asked to imagine the folding and unfolding of pieces of paper. In each problem in the test there are some figures drawn on the left of a vertical line and there are others drawn on the right of the line. The figures on the left represent a square piece of paper being folded, and the last of these figures has a small circle drawn on it to show where the paper has been punched. The hole is punched through all the thicknesses of paper at that point. One of the five figures on the right of the vertical line shows where the holes will be when the paper is unfolded. Your task is to decide which is the correct figure, and then circle the letter under your choice. If you finish early, check your answers.

Now try the practice problem.

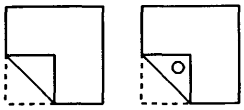
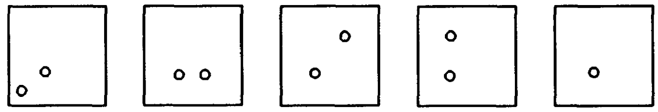


The correct answer to the sample problem is C and so the letter C should be circled. The figures below show how the paper was folded and why C is the correct answer.

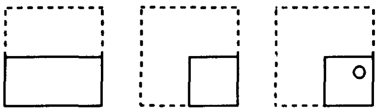
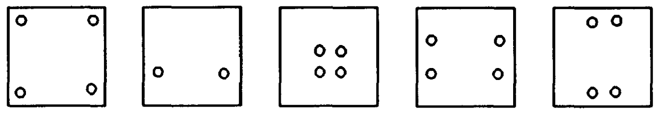


In these problems, all of the folds that are made are shown in the figures on the left of the line, and the paper is not turned or moved in any way except to make the folds shown in the figures. Remember, the answer is the figure that shows the positions of the holes when the paper is unfolded. Circle the letter of the your answer.

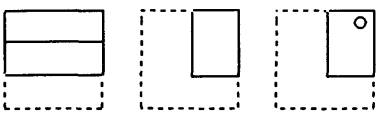
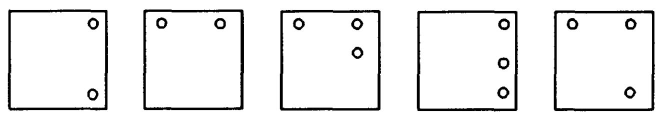
PAPER FOLDING TEST - TEST ITEMS

1  

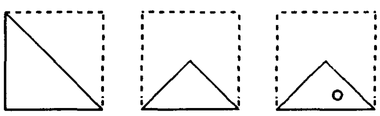
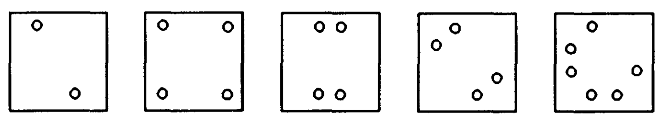
A B C D E

2  

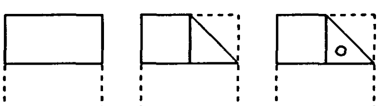
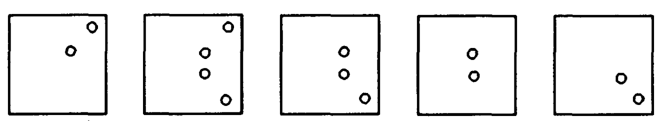
A B C D E

3  

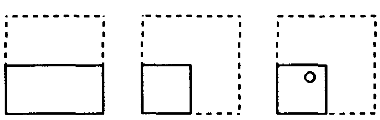
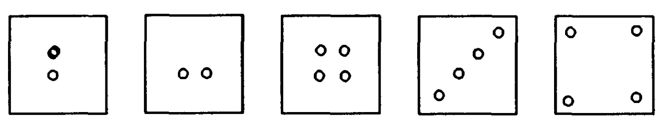
A B C D E

4  

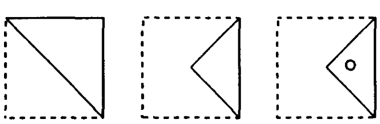
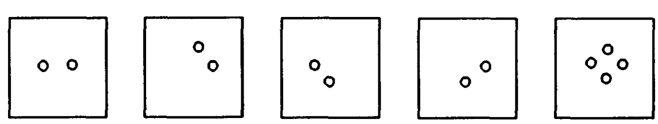
A B C D E

5  

A B C D E

6  

A B C D E

7  

A B C D E

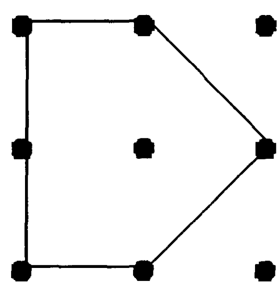
PAPER FOLDING TEST - ANSWERS

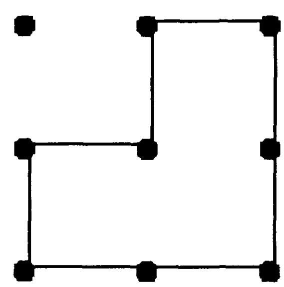
1	A
2	D
3	B
4	D
5	B
6	C
7	E

MATRIX A TEST

ADMINISTRATIVE INSTRUCTIONS

If you look at Answer Sheet 8 you will see that there are a number of sets of nine dots. Within each group it is possible to draw many shapes by joining up the dots with lines.





The teacher will show you a number of shapes, each drawn on a large sheet of paper. Each sheet contains a shape drawn by joining up some of the nine dots. Each sheet will be shown for five seconds. Look at it carefully while it is displayed. When the teacher takes it away, copy the same shape onto your set of nine dots. You will have ten seconds to do this before the next sheet is shown.

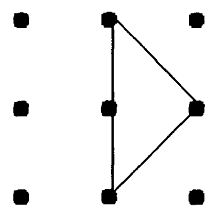
Let us have a practice using the two sets of nine dots labelled "A" and "B" on Answer Sheet 8. Copy the first practice example onto the set of dots labelled "A". Copy the second practice example onto the set of dots labelled "B".

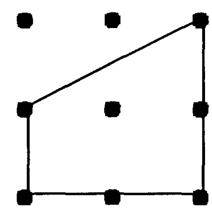
Remember:

1. Each shape will be shown for five seconds.
2. When the shape is taken away copy it onto the set of dots. You have ten seconds to do this.

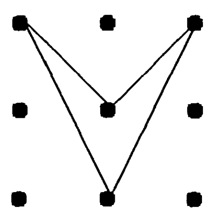
MATRIX A TEST - TEST ITEMS

PRACTICE

A


B


TEST

1


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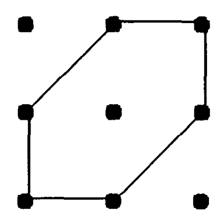

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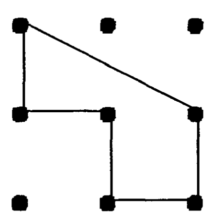

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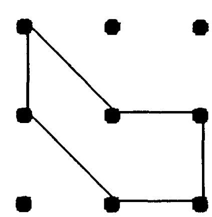

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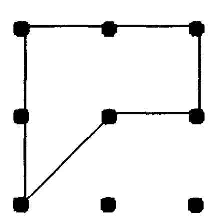

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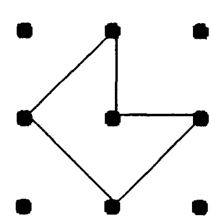

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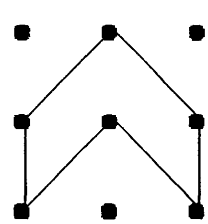

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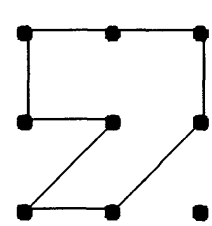

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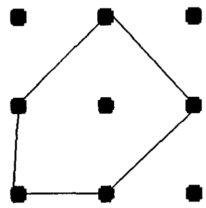

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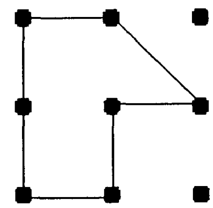

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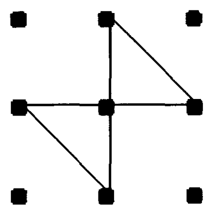

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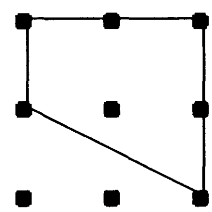

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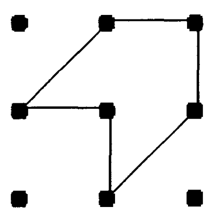

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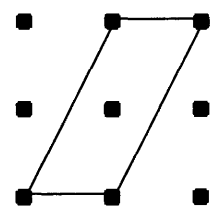

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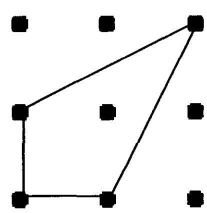

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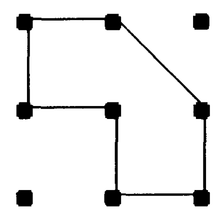

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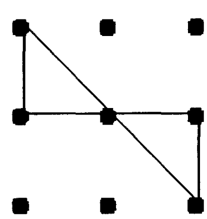

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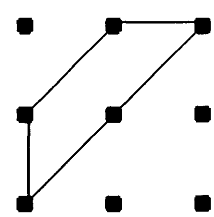

APPENDIX C

STUDY 1 RESULTS

Page

<u>OBSERVED MEANS AND STANDARD DEVIATIONS OF THE SIX TEST VARIABLES USED IN STUDY 1 for COMBINED (N= 296), ABBOTSLEIGH (N=89), PYMBLE (N=147), RAVENSWOOD (N=60) SCHOOLS</u>

TEST	$\bar{x}$	s
NUMBER SPAN (COMBINED)	60.93	13.92
Abbotsleigh	59.70	13.19
Pymble	61.90	14.35
Ravenswood	60.37	13.99
LETTER SPAN (COMBINED)	55.29	12.34
Abbotsleigh	53.35	12.52
Pymble	55.98	12.25
Ravenswood	56.50	12.14
WORD SPAN (COMBINED)	36.37	7.91
Abbotsleigh	35.31	7.14
Pymble	36.69	8.45
Ravenswood	37.13	7.59
SHAPES (COMBINED)	6.59	2.10
Abbotsleigh	6.48	1.82
Pymble	6.82	2.25
Ravenswood	6.18	2.09
PAPER FOLDING (COMBINED)	3.76	1.79
Abbotsleigh	3.52	1.70
Pymble	4.03	1.84
Ravenswood	3.47	1.71
MATRIX A (COMBINED)	14.66	2.80
Abbotsleigh	14.34	2.77
Pymble	15.15	2.64
Ravenswood	13.92	3.01

PEARSON'S CORRELATION COEFFICIENTS BETWEEN THE SIX TEST VARIABLES: NUMBER SPAN, LETTER SPAN, WORD SPAN, SHAPES, PAPER FOLDING AND MATRIX A (N=296)

	NUMBER SPAN	LETTER SPAN	WORD SPAN	SHAPES	PAPER FOLDING
LETTER SPAN	.73**				
WORD SPAN	.62**	.63**			
SHAPES	.13	.12	.16*		
PAPER FOLDING	.09	.12	.17*	.52**	
MATRIX A	.19**	.18**	.24**	.47**	.39**

1-tailed significance: * <.01 ** < .001

REPORT TO CLASS TEACHERS - APTITUDE TEST RESULTS

Dear [Teacher],

[6N] CLASS RESULTS - RESEARCH PROJECT

Thankyou very much indeed for your cooperation in making your class available to participate in the research project. The results for your class are attached to this note. Perhaps you may have time to read the following which may help you to interpret the results.

INTELLIGENCE

Human intelligence has defied a commonly accepted definition even though there has been a century of formal multi-disciplinary research in the area. For practical purposes, it is appropriate to accept: (i) the single number that for years has provided an "IQ" can be misleading, because there is an understanding emerging that an individual can have various levels of intelligence in different domains; (ii) most intelligence tests used in our schools today have a cultural bias and also depend heavily on a knowledge base; and (iii) an individual's intelligence, partly genetic and partly environmentally influenced, can fluctuate over time.

SIMULTANEOUS AND SUCCESSIVE PROCESSING

There is a distinct advantage in research that examines the way an individual *processes* input into the brain, because the complications of an existing knowledge base and cultural influences are then removed. According to extensive American, Australian, British and Russian research, the successful completion of a learning task depends upon the integration of simultaneous and successive information processing activities. Simultaneous and successive processing are involved with the acquisition, storage and retrieval of all knowledge.

The Russian Luria was the principal early worker in the area, conducting neurological studies on brain-damaged patients which allowed him to identify the two information processing skills and relate them to brain function. He suggested that certain regions of the brain are responsible for the integration of individual stimuli arriving consecutively into *simultaneous* surveyable groups; and other regions are responsible for the organising of successive analysis / synthesis of incoming stimuli into temporally *successive* series. The individual's choice of one or other process depends upon:

- the demands of the task
- the person's habitual mode of solving that type of problem
- the person's competence in each type of process

These aspects interact and represent the individual's uniqueness. Each girl in your class completed six aptitude tests, constructed to quantify her successive and simultaneous information processing abilities. You will note from the results that there is a wide diversity of aptitudes in your class.

Simultaneous Processing

Luria used numerous tests for the diagnosis of his individual patients, which included the following, classified by Luria as examples of simultaneous processing:
locating a sound in space;
recognising an object by touch;
copying geometric figures;
inverting a figure and re-drawing;
using place value in arithmetic;
showing time on clock face;
comprehending inflective, prepositional or comparative grammatical structures.

Simultaneous surveyability of the coded information is the characteristic of this mode of processing, any portion being surveyable without reference to the whole.

Successive Processing

Luria classified these tests as examples of successive processing:
repeating rhythm patterns;
reproducing sequences of words, numerals or pictures;
certain simple close processes;
recoding of internal speech for self expression;
following verbal instructions.

Individual stimuli, such as letters or digits in a series, are each processed as discrete events and then integrated into temporally organised successive series. Order of the coded information is the characteristic of this mode of processing. Information is available only in a linear fashion and meaning is only possible when the sequence is complete, because there is no intrinsic relationship readily apparent among the individual elements.

CEREBRAL ORGANISATION OF HUMAN COGNITION

There is a recurring perception in the neuropsychological literature of most of this century that there is an asymmetry of function in the brain's two mirror-image hemispheres - the two hemispheres of the brain connected by cortical pathways known as the corpus callosum.

Much of the early research on hemispheric functioning was conducted on patients with brain lesions or split-brain patients. Labels of abilities and roles for the hemispheres have been traditionally characterised as:

LEFT HEMISPHERE: verbal, successive, temporal, analytic, rational
RIGHT HEMISPHERE: non-verbal, visuo-spatial, simultaneous, intuitive.

Early studies suggested that the "basic skills" of language, reading and mathematics were left hemisphere functions, whereas the right hemisphere was utilised to interpret and remember complex visual patterns. Nevertheless, it has subsequently become apparent that the more complex the task, the more whole-brained is the response. In general, hemispheric differences seem to be relative rather than absolute. Either hemisphere can probably function in either mode, depending partly upon the nature of the task and partly on the experience and preference of the learner. This conclusion is supported by recent experiments mapping electrical activity in the brain by electrical stimulation which has also led researchers to the belief that mental functions are not as localised as had been historically differentiated[1].

SUMMARY

Simultaneous and successive information processing pervade the acquisition of all knowledge in intellectual activity associated with motives to meet intellectual goals. This is in contrast to many of the psychometrically-based Western models of intelligence that tend to reflect the characteristics of the individuals' educational environment and culture, rather than the characteristics of the functional aptitudes of the brain per se.

Simultaneous analysis / synthesis integrates the elements of experience without temporal ordering or stepwise relationships, whereas successive analysis / synthesis processes the elements of experience as discrete events into temporally organised successive series. Simultaneous surveyability of the coded information is the characteristic of simultaneous processing, whereas order of the coded information is the characteristic of successive. The extent to which simultaneous or successive information processing may be used is dependent upon the individual's "cognitive style" or preferred mode of problem solving, relative aptitudes, as well as the demands of the task.

THE RESULTS

The attached results show the successive and simultaneous aptitudes for each of the girls in your class, as measured by the tests administered in February / March this year. They are assessed as "high", "medium" or "low" for each aptitude, based upon absolute scores. Each girl is also ranked within Year 6 at your school.

I hope you find the results of interest.

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1 As a teacher, you may be interested to know that there are four EEG ("brain") wave categories: delta, theta, alpha and beta. The theta and alpha wave patterns have been used to describe variances in individuals' learning styles. The Alpha Child is the "soul" of the culture; the Theta Child is its technology, socially and verbally active. It has been suggested that the Theta child has basic personality imperatives to become highly socialised and achievement oriented in school. Competition and achievement goals, of little concern to the Alpha child, become a fixation for the Theta child who feels lost without definite guidelines and rules. It is suggested the Theta child who gives so much pleasure to the parent and teacher.