SESSION TEN - INTRODUCTION TO SEQUENCING AND SERIATION

Introduction and Definition

Events occurring one after the other may be said to constitute a sequence.
The relationship(s) between events which result from their constituting a sequence may be primarily rhythmic, springing from the temporal spacing of the events or primarily ordered, arising from the temporal order of the events (see diagram).

Our concern is with the sequence of events which can be recognised as such and, at least theoretically, analysed and synthesised from the whole or from a part. Such sequences may have 'meaning' in that they culminate in a certain end-point familiarity with the particular sequence being necessary for extrapolation from a segment of it. For example, putting on one's clothes required that the actions and garments as well as the necessary order of donning them be familiar to us. Seeing someone put on the kettle and assemble the teapot, etc. allows us to predict the outcome only because of our long familiarity with such activities and their consequences or sequels.

Our understanding of some sequences however can be abstracted and expressed with mathematical precision in virtue of some intrinsic and persisting consistency. These infinitely extrapolable sequences, or series as I shall call them, tend to fall into two categories: 'iterative' or repeating series where the basic pattern occurs in some regular manner, and 'developing' or 'expansive' series where the basic pattern develops in a progressive manner.

Commonly in practice it is not so much the actual temporal sequence of events itself with which we are concerned as the after-effects or traces of the sequence which contain information about the behaviours producing them, and we often apply the terms 'sequence' and 'series' to these residue in which temporal order has been translated into spatial order and duration into length, as if they were the ordered sequence of activities themselves. If a tower is erected by the addition of cubes one by one the tower may be said to represent the sequence of events underlying its construction. If we did not actually witness its construction we may be aware that it might have been constructed in some completely haphazard manner but its regular form suggests the probability of its having been made by an ordered sequence of putting-on actions. The same bricks lying disordered in a bucket seem less to evidence the likelihood of their being added rhythmically one by one to the container. The cubes forming a horizontal chain again suggests the regular addition of components but unless one end is obstructed in some way there is a certain ambiguity about the way in which the chain might have grown. Greater complexity in the order, as when coloured or different sized cubes alternate or when there is a progressive change of dimension, implies even greater probability of the pattern's having been generated, at least in design, progressively and rhythmically. (In virtue of the greater amount of information such a pattern contains.) Again, as usual, there is some ambiguity about the sense in which the sequence evolved unless other information is available.

Early evolution of understanding of sequences and series

Rhythmic activity in the child resulting as it does in the child's enlargement of his understanding of his bodily characteristics, of space and of the things and behaviours of things within that space is thus also the origin of his understanding of sequential activities, and 'continuant' activity can be seen to be the source of sequential behaviours which leave spatial evidence of their temporal nature.

Thus continuant object piling in the early second year may be seen as a sequential activity which leaves a trace of the order in which the objects were added as well as of the spatial direction and sense of the movements and the nature of the things moved. As discussed briefly in Session Six (brick building) the organisation of space results eventually in the child's deliberately placing objects close to and side by side of other objects, as opposed to piling them, and in due course to the formation of chains or trains of contiguous elements. That such horizontally orientated sequential activities and their traces are much more advanced than piling will be apparent when the much greater range of possible directions and senses and the much weaker nature of the physical constraints guiding and directing the behaviours are recognised. In fact the physical resistance of one object's pressing against another and preventing their sliding past one another is perhaps the main physical force tending to generate a chain and to lead to the sorts of experience which will subsequently allow the child to plan chains of objects which do not need to touch one another and in due course to the consecutive addition of objects to a chain of adjacent receptacles (e.g. holes in a board, dishes, jars, blocks, etc.) – from about 36 months.

Such behaviours, different as they are from one another in many respects, require a considerable understanding of spatial structuring by the child. In the first case the addition of new elements necessitates the projection of an imaginary line traced through the elements already in position and extrapolated beyond them so as to guide subsequent placements. In the second the extension of the chain is obscured to some extent by the receptacles and although in one sense these supply a skeletal pathway for the sequence of actions and placements they also exert a distracting influence so that for a while their individual receptacle properties override their sequential arrangement so that in practice more than one object may be put in one vessel; one or more vessels may be missed; the vessels may be filled but in an haphazard manner; the child may require to fix on the most recently satisfied receptacle before moving on sideways to the adjacent empty or insufficient one, before the necessary directional adjustments are made ahead of the act of placing.

By the time the child has sufficient control/maturity to be able to distribute consecutively to a row of dishes with fair consistency he is also likely to be sufficiently influenced by size differences to recognise certain special properties in a row of objects when arranged in size order. From this time on he may be so influenced as to sometimes select objects more-or–less in size order when constructing such a row; however even when the size differences cause him no discrimination difficulty it is usually not until he is well into his fifth year, that his understanding is sufficient to maintain his intention to arrange in order of size six or more objects in the face of other distractions.

Earlier than this, his noticing regularly repeating patterns in his constructions leads to his being able to deliberately generate a simple pattern of alternating size, shape or colour.

Just as the production of simple chains requires greater understanding of the structuring of space than does the forming of a pile so size-ordered sequences in the horizontal are later understood than those produced vertically. Reducing such patterns of clearly three dimensional components to sequences of flat or two-dimensional shapes requires a further degree of seriational understanding and, generally speaking, children are well into their sixth year before being much influenced in this way by drawings of shapes, but by the early seventh year the child is commonly well established as an orderer of size so that he can reasonably accurately order elements of size differences he would have great difficulty discriminating in a matching task.

It is about this time that he readily recognises simple drawn iterative series and is able to extrapolate from them.

See diagram page 4

Evolution of sequencing and seriation

Earliest continuant addition of elements	12-15	months
Earliest piling	15	months
Gain of fluency in adding to pile	18	months
Earliest horizontal chaining of objects	24	months
Earliest distributing consecutively to a row of receptacles	36	months
Influenced by size differences in the selection of elements for a simple expansive series (tower of blocks)	42	months
Simple iterative alternation of size or colour in horizontal chaining	48	months
Equilibrial stage of 3D size ordering in the vertical	54	months
Two-dimensional size ordering in the plane	60	months
Earliest analysis of two dimensional drawn expansive series	60+	months
Equilibrial stage of simple drawn size expansive series	72	months
Recognition of & extrapolation from drawn series 1212	72	months
Extrapolation from incomplete drawn figures to whole	84	months

During these early years the capacity for following a sequence of events through the agency of their traces extends from virtually straight rows via simple curved lines to complicated convoluted figures. This ability strengthens and in due course maze-like pathways can be traced out, at first with the aid of a finger, despite 'noisy' distracting backgrounds and in the face of intersecting lines which tend to sidetrack the eye on to irrelevant pathways. This capacity to follow a series despite variation in the spatial pathways is clearly very important in that it allows the more ready abstraction of the superposed series; however the curve itself may represent a sequence which may be extrapolated according to the information encoded within its changes of direction.

For example a part of a figure may be sufficient to suggest not only the whole shape but also the positions of the component lines. A series of part figures in which from an initial small fragment increasing increments are added may be seen not only as an increasing amount of line on the paper but also as an actual growth of the figure. Even a figure whose contours are so improbable as to make complete extrapolation from a fragment impossible does contain sufficient sequential information within the parts for some assumptions to be made and to allow the selection of some possible solutions in favour of others within a multiple-choice situation. The use of such information in, e.g. the reconstruction of a jigsaw puzzle seems to occur more commonly from the eighth year. It is most readily to be observed in children when the puzzle consists of equally sized and shaped pieces so that the forms of the articulating surface gives no clues to the child. In fact, even at an age of nine or ten years, many children still tackle such tasks in a haphazard way, rotating and approximating pieces in the hope of making a match.

The adaptive importance of sequencing and seriation to development in the child

'Sequencing' and 'seriation' as human skills imply a power to arrange and order things sequentially according to any particular plan. Hence for the sufficiently mature child a fragment of pattern may be sufficient for him to complete the pattern if finite, or to extend it indefinitely. It allows him to draw reasonable inferences about what has gone before and about what is yet to come; it enables him to make deductions about the behaviours of others and to predict future behaviours. Conventional language is clearly sequential in nature but in association with seriating ability it allows the use of logically organised verbal reasoning.

The child's own activity, at first physical but later equally actively mental, imparts a momentum which produces frequent overshoot so causing him to behave as if he had intended to produce the additional behaviour and, in due course, to anticipate the form and outcome of such behaviour and eventually to plan for it. As we saw earlier (Session Nine), it is the inertial carryover of a familiar behavioural pattern which allows the young child, of nine months or so, to retain his hold on an image, of something he is attending to, for a short time after it has ceased to stimulate his senses. We also saw how the same behaviour when applied rhythmically led on to the all-important 'continuant' ability which forms the basis of all later on-going behaviours. From the beginning certain simple iterative sequences of behaviours are produced quite

frequently and innumerable short and finite sequences are superposed on the basic continuant carrier-phase.

From an early stage quite complex and seemingly teleologically governed and predictive sequences of behaviours are repeated effectively by a process in which each component or group of components in the sequence gives rise to the next so that the child, although behaving as if the complete plan were clear in his mind from the start, is actually working through a chain of elements in which (it is the case that) it is what has gone before that determines the form and timing of the next. The probabilities governing such behaviours create longer sequences, which come not only to be designed as complete units by the child, but also to act as elements in the generation of subsequent segments of sequences. It is not difficult to envisage this process gradually reaching the stage at which sequences of indefinite length can be coped with purposefully by the child.

Such an ability projected to the observation (implying interpretation) of the behaviours of other people and of independent objects leads to an increasing capacity for predicting subsequent events or the eventual outcome of such behaviours, as has been said, from a knowledge of the probabilities of outcomes based on experience and familiarity, or in the case of series, from practice in recognising the defining rules seeming to govern the behaviours or their resulting patterns.

The praxic ability to recognise a series and mentally generate it and extrapolate from it, endows the child with the power to make inferences about past and future states, or simply about the hidden or inaccessible parts, of a series: it enables him to complete a partly formed/partial figure from certain fragments. In due course the kinds of inferences which can be made about expected outcomes can be translated to verbal form, and combinations and intersections of such sequences can form the basis of complex verbal reasoning.

The teaching of sequencing and seriation

Basically rhythmic activity and particularly that which produces recognisable patterns, whether these are transient (as sounds) or leave lasting traces in space, form the origins and source of sequential understanding. Hence it is banging and continuant picking-up/putting-in activities which need first to be strengthened.

If necessary the piling of flat objects can be encouraged but if the child has reached a twenty-four months level in this respect, the rhythmic production of chains of cubes etc., and the rhythmic allocation of elements to rows of cubes or beer cans, or holes in a block, etc. in all directions and senses, will extend this understanding towards the child's being able to notice the nature of the superposed patterns.

During the third year the use of nesting cups or boxes in piling and of graded diameter cylinders which fit into approximately sized holes in a block begin to introduce experience towards the understanding of expansive series whilst

activities alternating differently sized, shaped or coloured bricks in a chain introduces the principles of iterative series.

The former types of apparatus include at least some 'self-corrective' features such that the 'recognition' of some aspects of the serial nature of the elements is virtually inevitable. These once produced may be extended by having the child transpose the elements of the series systematically one by one from one situation to another. For example following the child's construction of a tower with self-correcting cups etc. or his 'nesting' them one inside the other, he can be encouraged, by the systematic transfer of the elements, to form chains embodying the progressive nature of the series. Such an exercise, which might also be done with graded height or diameter cylinders etc. arranged in a self corrective block, should be deliberately caused to progress sometimes from big to small and sometimes from small to big, sometimes to progress towards, sometimes away from, the child, sometimes from his left to right, right to left, etc. The one-by-one successive transfer of the elements of a chain from one location to another, with or without changes or orientation, direction and sense, represents a very suitable activity for providing experience of such pattern as is superposed on it. However although such piecemeal transfer of chains will, if rhythmically performed, continually exercise the underlying continuant and chain-producing abilities, the actual act of transfer in no way forces the child's attention to the pattern. Clearly it is during the seconds prior to picking-up an element that opportunity for becoming aware of the pattern within and connecting the components of the diminishing chain and during the seconds following its placement that a similar chance to see the emerging pattern occurs. Therefore the teacher must devise ways of 'forcing' the child's attention just prior to picking-up and just following putting-down, especially in the case of the child with any sort of early primary movement disorder or arrested early secondary movement disorder.

Ideally the child's eye should 'follow' the chain to the element to be picked up and follow on along the new chain from the point of putting down placement, so as to encourage inertial extrapolation of the sequential patterns. Eventually following the pattern along its length leads continually to the anticipation of the successive segment so that visualising it simply confirms what had been expected. Arrival at the limit of a truncated series is associated by this time with or succeeded by a prediction of the missing segment so that the mind is relatively prepared for the recognition of the most likely candidate, in the case of a multiple choice situation or for its production.

This being so the child should be encouraged to 'look along' the pattern before the visual scanning which is a necessary precursor to reaching. This is particularly important with children with primary movement disorders who are the most likely to have sequencing difficulties as a result of their poor experience of early rhythmic activity and whose integrational inadequacy commonly leads to the habit of reaching manually before looking. This habit, which is obstructive in matching and in copy-building and drawing, can indefinitely delay seriational capacity in some otherwise relatively able children.

Suitable materials for this work would be the various sets of graded plastic cups, cubes, barrels, boxes etc. available on the market, wooden cubes, cylinders and rods collected, made or modified from waste materials. Sets of squares,

oblongs, and if possible, circles cut from plywood can facilitate, in due course, the transition from an understanding of three-dimensional series to those of two-dimensions. Graded cardboard cut-outs used at first as individual elements but subsequently pasted onto equally sized squares of card can represent further stages towards the child's dealing with drawn forms as if they were objects. These sets of cards with outlined or coloured-in shapes become almost indispensable.

A variety of series can be depicted on cards utilising colour, form, orientation, number and pattern or variation in size, intensity, number, orientation etc., as criteria.

The capacity for working in linear sets can be utilised in coping with the contents of the columns and rows of 'intersection sorting', whether or not these form series and in the use of coordinates, as well as facilitating the display of overlapping propositions in matrices.

Compound series may be synthesised and analysed and linked with various mathematical activities.

Summary

The practice of 'continuant' behaviours with their various superposed patterns give rise in due course to the individual's recognition of his own patterns of behaviour and to a capacity for extrapolating from fragments of the behaviours of others and from the lasting traces of such behaviours.

Those sequences, whether behaviours or the traces of behaviours, which can be defined mathematically are here called series and classified as 'expansive' (progressive) or 'iterative' (repetitive).

It is suggested that the ability to derive logical conclusions from multiple premises, to draw rational inferences from information whether verbally or non-verbally requires at least a minimum understanding of sequential and seriational ability.

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