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Effects of a cognitive acceleration programme on Year 1 pupils

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Background. Cognitive Acceleration has shown evidence of long-term far transfer with young adolescents. This paper reports a new application of the principle to 5- and 6-year-olds in a disadvantaged inner city area.

Aims. To investigate the effect of a cognitive intervention programme on the cognitive development of children in Year 1 of primary schools.

Sample. Approximately 300 children in 14 Year 1 classes in 10 schools for the experimental group and 170 children in 8 classes in 5 matched schools as controls.

Method. Quasi-experimental pre-test post-test with experimental and matched control groups. One of the pre- and post-tests was intended to probe for transfer. Children in experimental classes experienced a set of 29 activities designed to promote cognitive conflict and encourage social construction and metacognition over one school year.

Results. The experimental group overall made significantly greater gains in cognitive development over the period of the experiment than the controls, in both direct (effect size 0.47) and transfer (effect size 0.43) tests, although when genders were considered separately, experimental boys' greater gains than controls did not reach significance. There was no interaction with various social and linguistic variables.

Conclusion. In the context of this study, a cognitive intervention programme can have a significant immediate effect on the rate of children's cognitive development. Further work will investigate the longevity of this effect.

This study arose out of a desire by one inner city local education authority (LEA) to explore the possibility of increasing the life chances of children in its more disadvantaged areas by attempting to enhance their cognitive development at the start

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of their school careers. Having heard of the 'Cognitive Acceleration through Science Education' project, which had reported effects on cognitive development and academic achievement of 12–14 year-old students, the Chief Inspector of the LEA approached the researchers and together we planned, executed, and evaluated a cognitive intervention programme for Year 1 classes in ten schools.

The London borough of Hammersmith and Fulham is a medium sized borough which contains a wide diversity of social cultures. In the south of the borough, a terraced house may fetch half a million pounds and be occupied by an architect or an accountant who commutes to the City. The north of the borough contains a high proportion of social housing and a wide variety of ethnic minorities, some British of many generations but many new arrivals, new immigrants or refugees. There is also a substantial traveller population.

The LEA had obtained a single regeneration budget from the national government to enhance the economy and employment prospects in the north of the borough and were able to allocate part of this to an educational effort in Key Stage 1 ('KS1', the first period of formal education in the UK, Years 1 and 2, when children are 5 to 7 years old). The hope was that targeting the cognitive development of children at the start of their formal schooling would have long term effects on their academic achievement, social variables, and eventually on their employment prospects. Justification for this hope lies in the relationships between (a) cognitive development and academic achievement and (b) academic achievement and social effects such as employment, drop-out, drugs misuse and early pregnancies.

For (a) the evidence is fairly clear cut. An important factor in success in school-valued achievements such as progress through National Curriculum levels and test and examination results is the ability to process effectively information provided by teachers, books, and other sources. Better information-processing capability is a function of working memory capacity (Kyllonen & Christal, 1990; Logie, 1999) and the development of working memory is one way of describing cognitive development (Pascual-Leone, 1988). The promotion of cognitive development may not lead to immediate effects on school measures of achievement since, as Shayer and Beasley (1987) have argued, the better processing ability must have time to be applied to new learning before academic gains become apparent.

The effect on social variables (b above) of enhanced cognitive development is less certain. Reports from the Head Start programme of reduced school drop-out, crime rates, teenage pregnancies, and arrests of teenagers who experienced the programme in their pre-school years have been questioned. On the other hand, social problems are frequently associated with low self-esteem, and Ames (1986) and Dweck and Bempechat (1983) have shown how children's perceptions of self-efficacy rise in response to academic success. It seems at least worth exploring the possibility that higher academic success might lead to a reduction in socially disruptive behaviour.

This paper will report only initial effects on cognitive development. Subsequent effects on academic achievement, if any, will be reported in the future.

Bases of the intervention

Main theoretical considerations

Cognitive Acceleration programmes were instituted in the early 1980s at Chelsea

College, University of London. They targeted children aged 12–14 with a cognitive intervention set in a science context, called 'Cognitive Acceleration through Science Education' (CASE), designed specifically to promote the type of higher level thinking described by Inhelder and Piaget (1958) as 'formal operations'.

Some starting assumptions of this study were that:

(a) it is valid to work on the basis of some general intellectual function in children which had a context-independent component;
(b) this function develops through a process of interaction between maturation and environmental conditions; and
(c) children's intelligence (or stage of cognitive development relative to age norms) was sufficiently flexible to be amenable to change by a well-designed intervention which provided a cognitively stimulating environment.

Justification for (a) can be found in the extensive work on central cognitive processing mechanisms – for example Baddeley's (1990) account of working memory, Pascual-Leone's (1976) description of working memory capacity increasing with cognitive development, Carroll's (1993) remarkable analysis of the factors of intelligence and Anderson's (1992) mind models. In each of these models there is some kind of central processing mechanism or general intelligence which operates across all contexts, and the notion of 'cognitive acceleration' requires such a central processor since what is supposed to be accelerated is something which has a very general effect on the child's intellectual functioning. We are aware of the strand in cognitive psychology which argues that all cognition is context-dependent (e.g., Anderson, Reder, & Simon, 1997; McPeck, 1990), but for reasons argued more fully elsewhere (Adey, 1997), believe that it makes good educational sense to operate on the basis that there is some general cognitive function which can be influenced by pedagogical practice.

Assumption (b) is probably a commonplace of cognitive psychology, but if support is needed it can be found in the corpus of work of Jean Piaget and his colleagues – see Smith (1996) and of neo-Piagetians such as Demetriou, Shayer, and Efklides (1992) or Karmiloff-Smith (1991).

Assumption (c) may have been no more than an optimistic hope at the beginning of the CASE projects in 1981, but the CASE programme itself provided realisation of the hope. For example Adey and Shayer (1993) reported results of an experimental/control pre-test, post-test, and delayed post-test experiment showing that the CASE intervention in Years 7 and 8 had significant positive effects on grades achieved at GCSE examinations taken at the end of Year 11, and Shayer (1996, 1999) has shown that CASE schools show significant academic added value compared with matched non-CASE schools over a five-year period. These and other results reported by the CASE team over the last ten years (Adey & Shayer, 1990) provide evidence of long-term far-transfer consistent with the idea of modifiable context-independent intelligence which may be modelled as 'accelerating cognitive development'.

Turning to the more specific theoretical principles underlying the cognitive acceleration work, four ideas are pre-eminent:

(1) *Cognitive conflict*. Starting with Piagetian notions of equilibration being attained at a higher level of thinking when a child encounters a problem which cannot be solved with existing cognitive structures, the CASE intervention provided activities carefully designed to offer graded challenge to its target population of young adolescents. While there have been questions raised about possible

negative impact of cognitive conflict on students' self-worth (Fensham & Kass, 1988), there is substantial evidence for the positive effect of such 'anomalous events' on conceptual growth (Chinn & Brewer, 1993; Hertzog & Klein, 1997; Hewson, 1984; Niaz, 1995). Here we are investigating something a little more global: the impact of cognitive conflict on the growth of a general cognitive processor, as discussed above.

(2) *Social construction*. This draws on the Vygotskyan notion that the construction of knowledge and understanding is a social process. Understanding appears first in the social space, and then becomes internalised by individuals (Vygotsky, 1978). The process of talking around new ideas, exploring them through group discussion, asking for explanations and justifications, are all part of the process of building individual knowledge. The CASE intervention method involves working in the 'construction zone', a phrase developed by Newman, Griffin, and Cole (1989) from Vygotsky's idea of a Zone of Proximal Development, the 'difference between what a child can achieve unaided and what she can achieve with the help of an adult or more able peer'. Wegerif, Mercer, and Dawes (1999) have shown how explicit attention to the development of co-operative talk in children leads to gains in scores on Raven's Matrices, a language-free measure of general logical processing.

(3) *Metacognition*. Brown (1987) has done a noble job in trying to sort out the variety of ways that this term is used in the literature. In CA work we use it to mean the conscious reflection by a child on her or his own thinking processes (in contrast to some uses, where it often means little more than keeping a check-list of procedures for working). The requirement for consciousness means that it is a process that must take place *after* a thinking act since at the time a student is engaging in a problem-solving activity their consciousness must be devoted to that. Only afterwards can they think back to the steps they took, and become aware how their own conceptualisation changed during the activity. There is a substantial literature (for a small sample, see De Corte, 1990; Klauer, 1989; Kuhn, 1993; McGuinness, 1990; Perkins & Saloman, 1989) which testifies to the value of this type of metacognition in making general thinking processes explicit, and thus more readily available for use on other occasions.

(4) *Schema theory*. The CA work in secondary school uses the schemata of formal operations described by Inhelder and Piaget (1958), such as control of variables, equilibrium, probability, and formal modelling, as a framework within which each activity is developed. These general ways of thinking generally develop from about 12 to 16 years of age so would obviously be inappropriate for the current work with five-year-olds. Looking at the developmental profile of the population (see Figure 3.1, p.40 in Adey & Shayer, 1994) it seemed clear that five to six years is the entry point to concrete operational thinking, and thus it was decided (a) to target this primary level intervention in Year 1, and (b) to use the schemata of concrete operations (see, for example, Piaget & Inhelder, 1974; Piaget & Inhelder, 1976) as the structuring framework for the activities. Thus gains in cognitive development for the purpose of this study were modelled as the accelerated development of concrete operational thinking. Furthermore, whether or not the questions which have been raised by, for instance, Donaldson (1978) or Goswami (1998) about the Piagetian notion of 'stages' and the ages at which children can perform certain intellectual tasks are justified, the descriptions of concrete operational schemata provide a clear set of types of

thinking which can readily be operationalised into teaching and assessment activities.

Naturally it is going to be difficult to tease apart the separate effects of each of these elements on children's cognitive growth, and this is where a practical, large-scale, intervention funded by a local education authority must differ from a laboratory based psychological study funded by an academic research council. We will return to this issue in our discussion of the results.

Other considerations

Other, more pragmatic, considerations also served to frame the development and delivery of the intervention programme:

Duration: The original CASE programme in Years 7 and 8 had operated over two years on the grounds that significant previous successful interventions such as that of Feuerstein, Rand, Hoffman, and Miller (1980) had no shown no effects in less than two years. A supplementary reason was the time required to change the teaching practice of secondary science teachers. For the Key Stage 1 intervention it was supposed that with much younger children effects could be achieved in a shorter time and that a one year intervention should be tried. One year is 20% of a five-year-old's life. Furthermore, teachers of young children are more focused on pedagogy than on subject matter as compared with their secondary school counterparts. The training of the latter includes a significant focus on specialist subject matter content, while for primary teachers that time is devoted to more work on classroom management of the teaching-learning process itself. It was thus supposed that introduction of new methods would not involve such a radical change in outlook for Year 1 teachers as it did with subject-based teachers of Years 7 and 8. We are currently collecting data from teachers, trainers, and Headteachers which may substantiate this supposition.

A further variation from the CASE model was that whereas the CASE programme was set specifically in a science context, to be delivered by science teachers, that for Year 1 was to be more generic, guided by the schemata of concrete operations whether these appeared to relate to scientific thinking, numeracy, spatial awareness, or social point-of-view points of contact with the curriculum.

Finally, 'CASE@KS1.H&F' – the name of the project developed in Hammersmith and Fulham – was framed by the practicality of the origin of funding, which dictated that the methods to be tried must be practicable in a normal educational setting of ordinary schools with ordinary teachers and classes of at least 30 children. This could not be a laboratory study with experts providing a few children with one-to-one cognitive stimulation.

The experimental hypothesis which emerges from this theoretical framework and the practical constraints may be formulated as follows:

> Within a formal educational setting, the development of concrete operational thinking, as characterised by Piaget and Inhelder, can be accelerated in children aged five or six years with an intervention programme which provides well-managed cognitive conflict and structured opportunities for social construction, including the encouragement of metacognition.

This is the hypothesis which guided the design of the experiment and the development of the intervention programme.

Experimental design

The main first test of this hypothesis, which this paper reports, used a quasi-experimental design with pre-tests of cognitive development administered near the start of the school year to all of the Year 1 children in 10 experimental ('CA' for Cognitive Acceleration) schools and five control schools. Near the end of the school year, the same tests were administered to the same children. During the year, the children in CA schools experienced an intervention programme designed on the theoretical bases outlined in the last section. This section will deal first with equivalence of control and experimental groups, and then briefly with the nature of the tests. More detail of the test development and administration will be given in the next section.

CA and Control groups

The intervention programme was implemented in 10 schools which between them had 14 Year 1 classes and teachers. These were all of those schools falling within an area of the London borough of Hammersmith and Fulham for which the Single Regeneration Budget funding was available. During the year under study, two of the original 14 teachers left the sample and were replaced. A control group of five schools, with eight Year 1 classes, was also selected from adjacent areas as being as similar as possible in social and demographic character to the CA schools. All of the teachers were female and very few of them had more than five years of teaching experience at the time of the study. Table 1 provides some basic demographic data about the children in these 22 classes.

Table 1. Some social and ethnic data on the children in the study

	CA*	Control
Nos. for which this data available:	338	206
% eligible for free school meals	20.1	22.8
Ethnic composition (%)		
White	41.4	48.5
Black African	14.8	9.2
Black Caribbean	16.6	8.3
Black other	8.3	10.7
Indian	0.6	1.9
Pakistani	2.4	0.0
Bangladeshi	1.8	1.0
Chinese	0.9	0.0
Other	13.3	20.4

* The experimental group are designated 'CA' for Cognitive Acceleration

The data of Table 1 show that the populations were similar with respect to ethnicity and social status as measured by entitlement to free school meals, although there are somewhat more children designated as White in the control schools, and somewhat fewer designated as Black Caribbean or Black African.

Further comparisons between the CA and control schools are available from the 'baseline testing'. This is a series of assessments made of every child within four months of them entering the reception class (during the year before Year 1). In Hammersmith the 'Signposts' (Birmingham, 1997) scheme is used as the baseline test. Teachers, through observation and some individual task-setting, assess each child individually on a number of scales including three relating to language and three related to number. For the purpose of comparing CA and control groups, two composite scores, one for language and one for numeracy, were computed for each child. Mean scores and differences for the children in this study are given in Table 2.

Table 2. Comparison of baseline test means for language and for number for CA and Control children

		Language	Number
CA	*N*	339	339
	M	3.88	4.23
	SD	1.72	1.93
Control	*N*	206	206
	M	2.96	2.74
	SD	1.48	1.66
t-test CASE-Control		6.61	9.53
	p<	.001	.001

It appears that the children in the CA classes score significantly higher on the baseline testing than did those in the control classes. Some caution should be exercised in interpreting these results. At the time these data were collected, baseline tests were administered by teachers with little special training in their administration, and without independent verification. Furthermore, some teachers and headteachers have suggested to us that it was in a school's interest to report low baseline test scores as this would increase value added measures to the Key Stage 1 National Curriculum tests taken at the end of Year 2. While there is no suggestion here of conscious misrepresentation, in an atmosphere of high-stakes 'league tables' based on value-added measures and of competition between schools, the validity of baseline test scores is threatened. The effect may be greater in the control schools with a higher proportion of middle class parents where 'league tables' are likely to have a greater impact on school choice. It will be seen later that cognitive assessments made by the research team under controlled and cross-validated conditions, with nothing at stake for the schools' reputations, showed no difference between the CA and control schools.

The Cognitive Development tests

Two tests were used. The first ('Conservation') was a test of conservation of number, liquid amount, solid amount, and weight. The second ('Drawing') was a test of spatial awareness. The conservation test had to be administered individually by members of the research team and specially trained assistants. As it was impractical to do this for over 500 children, we chose a one-third stratified sample for this test. In each class, we selected at least one third of the children by looking at their baseline test scores and choosing a sample which included high scorers, low scorers, and mid-range scorers. The sample was not exactly representative of the population, but was chosen to include a wide range of baseline scores. It was ensured also that equal, or nearly equal numbers of boys and girls were included in this one-third sample.

The Drawing test could be administered by one of the researchers or a trained assistant to six children at a time, so the whole of the CA and Control groups received this test at pre- and post-occasions.

In summary, the experimental design is shown in Table 3

Table 3. Experimental design

Condition	*N* schools	*N* classes	Approx no. children	Pre-test Sept. 1999	Intervention	Post-test July 2000
CA	10	14	400	Conservation Drawing	CA intervention	Conservation Drawing
Control	5	8	240	Conservation Drawing	none	Conservation Drawing

The tests

Conservation

This test is based on the original Piagetian protocols (Piaget & Inhelder, 1974) which have been much argued over in the literature. For example Donaldson (1978) and her co-workers have claimed that the standard Piagetian protocol underestimates children's real ability by imposing the authority of an adult on non-conserving responses, and a similar argument is used by Dasen (1972) with respect to assessments made in non-Western cultures. On the other hand Eames, Shorrocks, and Tomlinson (1990) showed that when properly administered with an appropriate mixture of pro- and anti-conservation prompts and counter-suggestions, the results were reliable and much as originally reported by Piaget and his co-workers, given due allowance for the non-representative nature of the Genevan sample.

In developing a version for this work, we drew on the 'standardised' version proposed by Goldschmid (1967) and Goldschmid and Bentler (1968) and also on the versions used in the large international study of Shayer, Demetriou, and Pervez (1988). In the year prior to the main experiment, various items from these sources were tried on a one-to-one basis with samples of children drawn from the (then) Year 1 classes in some of the CA schools. A battery of 11 items was selected which offered an appropriate range of facilities. One mark was given for each item on which the child both gave the correct conservation answer and gave an adequate explanation for it.

In some of the criticisms of Piagetian tasks, it is suggested that subtle changes in language and facial expression may have an unwarranted effect on the outcomes but our experience throughout was that the children were very robust in their conservation or non-conservation beliefs. For example, having opined that two glasses of different shape contained different amounts water (when each had had three equal measures counted out and poured into it), we tried counter suggestion ('another child told me they must be the same because I just poured the same amount into each') and then appealing to real life situations ('if they were Coke, which would you have? . . . why?').

In the case of initial conserving answers, counter suggestions were also made ('Another child told me that this one had more because it is taller'). Such counter suggestions rarely led to any change in opinion.

The final test had eight items:

1. Number of eggs and eggcups, eggs in cups then cups in a row and eggs altogether.
2. Number of counters, placed one-to-one in two rows, then one row expanded and the other compressed.
3. Amount of liquid: three measures poured into each of a tall thin and a short fat glass.
4. Amount of solid: One of two equal balls of Plasticene transformed into a sausage.
5. . . . into a pancake
6. . . . into five little balls
7. Weight: One of two balanced balls of Plasticene transformed to a pancake
8. . . . to five little balls.

For each item, the child was shown, for example in item 3, three equal measures being poured first into a tall thin and then into a short fat container; asked if both contained the same amount; asked to explain why they thought so; offered various counter-suggestions and generally probed for stability of the idea. One mark was awarded for a conservation answer supported by a reason. No mark was awarded for non-conservation or for conservation without justification.

In practice, item 2 was given first. If a child showed any hesitation, then they were given item 1. Confident number conservers on item 2 were credited with item 1 without doing it. Children who were consistently non-conserving on solid amount were not given the last two, weight, items on the ground that no non-conservers on substance items 3–6 in the pilot had succeeded in the weight conservation items, 7 and 8.

Table 4. Discrimination data on the conservation test: percentages

Item: content:		1 Number	2	3 Meas.	4 Solid substance	5	6	7 Weight	8
Item level:		Eggs 1B/2A	Counters	amount 2A	sausage 2A/B	pancake	5 little	5 little 2B	pancake
Child level	*N* children								
1B	39	23.08	7.69	25.64	2.56	0.00	2.56	0.00	0.00
2A	19	94.74	94.74	78.95	10.53	10.53	5.26	0.00	0.00
2A/B	14	64.29	64.29	71.43	85.71	92.86	78.57	14.29	21.43
2B	4	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Key: 1B – late preoperational. 2A – early concrete. 2B – mature concrete.
The last four rows show the percentage of children assessed by the test overall as being at each level, who pass that item.

Cronbach alpha consistency for this test was 0.81 (0.85 with Horst's correction for limited range). Discrimination data for each item is displayed in Table 4. This shows, in the last four rows, the percentage of children at each level of cognitive development (by the test overall) succeeding at each item and the demand level of each item.

It can be seen that there is generally a sharp rise in facility at exactly the level anticipated (e.g., in the 2A/B items, facility for 2A children is about 10% and for 2A/B children around 85%). We are looking here for sharp stage-level discrimination, rather than a general discrimination coefficient which can be obtained with an item which gradually becomes easier for more able children. These seem to be satisfactory test characteristics and scores could be converted to stages as follows: 0, <1B; 1–2, 1B/2A; 3, 2A; 4–6, 2A/B; 7–8, 2B. In fact in treating the results we used raw scores as offering a continuous variable amenable to parametric statistics.

Table 5. Discrimination data on the drawing test: percentages

Item no:		1	2	3	4	5	6
item level:		1A	1B	1B	2A/B	2A	2A/B
N children at that level							
<1A	11	9.1	0	0	0	16	13
1A	19	32	5.3	24	16	21	27
1B	13	85	27	52	23	26	34
2A	51	86	67	79	36	47	51
2A/B	19	95	82	96	46	74	86
2B	2	100	100	100	80	90	90

The last six rows show the percentage of children assessed by the test overall as being at each level, who pass that item.

Drawing

This test also was based on original Piagetian protocols (Piaget & Inhelder, 1976) and on a group version developed by Shayer, Wylam, Küchemann, and Adey (1978). It assesses children's ability to perceive the horizontality of the surface of water in a bottle as the bottle is tilted, and the verticality of a plumb line under similar circumstances. They were required to draw in the level in ready-drawn bottles both in anticipation of the bottle being tilted and after they had seen it. Scoring depended on both anticipation and the perceptual learning which occurred when they saw the tilt. The final version was a six-item test (upright bottle, bottle upside down, on side, tilted; plumb line on side and tilted.) The Cronbach alpha internal consistency measure for this with a pilot sample of 114 children was 0.74. This is not high, but acceptable for a six-item test. Discrimination data for items in this test are shown in Table 5. Items 1, 2, 4, and 5 have quite sharp discrimination, using a two-thirds principle as the cut-off (Shayer, Adey, & Wylam, 1981), and all items are positive discriminators.

The intervention

Activities

As outlined in the section on theoretical bases, the intervention consisted of a series of activities designed to provide cognitive conflict to five-and six-year-olds, to be delivered in a way which maximised opportunities for social construction, including metacognition. It was felt that it would be difficult to maximise social construction in whole-class settings, so the activities were designed to be used with groups of six children. The total programme for this experiment consisted of 26 CA activities plus three introductory 'listening' activities intended to introduce children to the working methods of the activities (listening to others, respecting others' views, finding ways of disagreeing constructively, and so on). In practice, the teachers would do the CA activity with one group of six children on Monday, while the rest of the class carried on with other work set from the 'task board', sometimes with the help of a teacher assistant. Each day of the week a different group would get the CA activity, so that a whole class of 30 children could be covered in each week. The activities typically took 30 to 40 minutes.

Each activity related to one of the schemata of concrete operations described in detail by Piaget and Inhelder, and scaled by Shayer *et al.* (1988). This latter work, especially, provides comprehensive data from a large international study on the relative difficulty of each schema. One set of concrete schemata, however, was specifically excluded from the intervention programme for this experiment: those related to conservation. This was in order to provide an opportunity to measure transfer effects. Since conservation formed one of the pre- and post-tests, the absence of intervention activities related to conservation would allow any general development of concrete operations to be assessed, distinct from more direct learning effects on schema included in the intervention programme.

A list of the CA activities in the intervention programme for this experiment is given in Table 6.

Table 6. List of activities in CA intervention programme, 1999/2000

Schema	Activity	Schema	Activity
Seriation	1 Sticks	Seriation	16 Library books
Seriation	2 Flowers	Points of view	17 Shapes
Seriation	3 Marble run	Points of view	18 Crossroads I
Classification	4 Shapes	Points of view	19 Crossroads II
Classification	5 Farm animals	Space/Time	20 The same time
Classification	6 Buttons	Classification	21 Clowns
Classification	7 Dinosaurs	Classification	22 Bottles
Time Sequence	8 Giant's boots	Time sequence	23 Cat and snail
Causality	9 Cars I	Classification	24 Shadows
Investigation	10 Cars II	Rules of a game	25 In this town
Seriation	11 Stones	Rules of a game	26 Making a game
Seriation	12 Boxes	Causality	27 Transformations
Time Sequence	13 Cooking	Points of View	28 Farmyard
Classification	14 Living/non-living	Causality	29 Find the cause
Classification	15 Animals		

Each activity has a pattern in its delivery. There is initial 'concrete preparation' in which the situation, apparatus, and any unfamiliar words and phrases are introduced. Then there is a phase of cognitive conflict where the problem is presented and the difficulty of reasoning comes to the fore as attempts are made to find a solution, with all in the group contributing to the construction of new understanding. Whilst metacognition may be included in this phase, it is often also made specific after the construction ('How did we solve that problem?'). Finally there is a bridging phase, when the teacher shows other opportunities where that schema can be used.

One example of a CA activity will be described to illustrate these phases, and two others outlined to show the application of the concrete schema.

Activity 1 relates to the schema of seriation. The teacher and six children are seated around a table. The teacher puts a stick on the table, and they discuss what to call it. She puts a second stick on the table, and the phrases 'shorter than' and 'longer than' are introduced and practised as necessary. A third stick allows the idea that one stick may be both 'shorter than' and 'longer than' at the same time. So far, this is all concrete preparation. Now the teacher produces 10 sticks of different lengths. The children's task is to place them in order, with the longest at one end and the shortest at the other. This proves to be quite difficult, and the teacher must work hard to ensure that all participate, that they listen to each other, and that they explain and justify their actions to each other (also, that the bottom ends of the sticks are kept level!). When the 10 are in order, and all are agreed that the order is good, the teacher gives out more sticks to each child. These are of intermediate lengths, and have to be fitted in the right place in the sequence, again with justifications, and with more successful children explaining their strategy to less successful ones. This has been the main conflict/construction phase. There may now be a specific metacognitive phase, reflecting on how they solved the problem, what was difficult, and how difficulties were overcome in both cognitive and social contexts. Finally, the teacher will ask bridging questions to elicit where else they might use the idea of putting things in order.

Activity 8 concerns the schema of classification. A collection of dinosaurs are introduced, and the children sort them in simple, one variable, ways such as by colour or by type. The teacher now invites them to put all T Rexes in one hoop and all blue ones in another. Conflict arises about the blue T Rex. The resolution constructed eventually is to overlap the hoops.

In *Activity 18* (spatial perception), the children have a model crossroads with various buildings, cars, bus shelters, and other urban furniture. They are seated two at each of three sides of the table, so no pair can see all of the objects. They have to select from a set of pictures, firstly the one that represents what they can see, and then what another pair of children can see.

Teacher professional development

Effective delivery of these activities depends on the teachers having a good understanding of the underlying theory and much practice in generating cognitive conflict and encouraging social construction and metacognition involving each child. Such pedagogical skill cannot be delivered by printed materials alone, but requires a carefully designed professional development programme. All of the authors of this paper have extensive experience of working with practising teachers to support the development of their pedagogy and we drew both on this experience and on research on effective staff development (e.g., Joyce & Showers, 1995) to design a course of six in-service days and three or four coaching visits to each teacher to help them develop the necessary skills. The programme introduced the basic theory of cognitive acceleration, allowed the teachers to experience the specific activities, and gave them plenty of opportunity to share their experiences of using the method with their children. Teaching methods on the professional development programme mirrored the methods of cognitive acceleration, especially with respect to social construction and metacognition.

Results

The simplest question to ask about the effect of the intervention is 'Did it work, in the sense of increasing the rate of cognitive development in the CA classes relative to the control classes?'. The answer is yes, it did.

Our method of analysis is based on the gains made by each child in scores on the two tests of cognitive development. That is, for each child, their score on the drawing post-test minus their score on drawing pre-test, and their score on the conservation post-test minus their score on conservation pre-test. To get an overall picture of the effect of various factors on these two gain scores, we did an analysis of covariance (ANCOVA) of the following factors with each of the gain scores:

- Experimental or Control Group (CA/Ctrl): to test the main hypothesis that the intervention impacts on gain in cognitive development.
- Teacher (tchr): to test whether the cognitive gains of children are significantly affected by their teachers.
- Gender: to test whether boys and girls make different cognitive gains during Year 1.
- Baseline test scores, composite for language (b'line lang.): to test whether cognitive gains are related to a starting achievement level in language.
- Baseline test scores, composite for number (b'line numb.): to test whether cognitive gains are related to starting achievement level in number. Baseline test scores were included because of the apparent significant difference in these between CA and control classes (Table 2 above).
- English language proficiency of child (Engl.): to test whether cognitive gains are related to the child's proficiency with English. (This is based on a categorisation used in the Borough and assessed by teachers: native speakers – 5; fluent – 4; becoming confident – 3; familiar with English – 2; new user – 1.)

The baseline test scores are continuous variables, all of the others are categorical. We tested also all of the two-way interactions, except for (teacher * CA/Ctrl), where one variable wholly determines the other. That is, each teacher had to be either CA or Control so there could be no interaction. (We did also run analyses on possible effects of age at entry, receipt of free school meals and of ethnic group but none of these approached any significance of effect. In order not to overload the ANCOVA table with peripheral variables they are not included in the analyses given here and will not be discussed further.)

Table 7 shows the result of this analysis for the gain scores on the drawing test, and Table 8 the same analysis for the gain scores on the conservation test.

This first analysis suggests that there is a strong effect on both gain scores of being in a CA or Control Class with CA classes having significantly greater cognitive gains than controls and a strong effect of the individual teacher, but no other significant effects and no strong interactions. The fact that there is no interaction with baseline test scores discounts any possible differential effect arising from the fact that the CA and Control groups had significantly different mean baseline test scores. The issue of gender is not as simple as it appears from this global analysis and we will need to look at it further.

The main CA/Control effect will be now considered in more detail, followed by further analyses looking at effects by gender and by individual class (i.e., by teacher).

Table 7. Analysis of covariance of various factors with gains in drawing scores ($N = 445$)

Source	d.f.	Σ Squares	Mean Sq.	*F*-ratio	*p*
Const	1	13041	13041	585	≤ 0.0001
CA/CTRL	1	691	691	31.04	≤ 0.0001
Tchr.	20	919	45.95	2.06	0.006
Gender	1	7.88	7.88	0.35	0.552
CA/CTRL*Gender	1	24.52	24.52	1.10	0.295
Tchr.*Gender	20	466.3	23.32	1.05	0.407
b'line lang.	1	40.34	40.34	1.81	0.180
CA/CTRL*b'line lng.	1	27.29	27.29	1.23	0.269
Tchr.*b'line lang.	20	574.2	28.71	1.29	0.185
Gender*b'line lang.	1	11.22	11.22	0.50	0.479
b'line numb.	1	6.62	6.62	0.30	0.586
CA/CTRL*bline num	1	1.68	1.68	0.08	0.784
Tchr.*b'line numb.	20	459.8	22.99	1.03	0.424
Gender*b'line numb.	1	67.18	67.18	3.02	0.084
bline lang.*bline num	1	119.1	119.1	5.35	0.022
English	4	128.1	32.02	1.44	0.222
CA/Ctrl*Engl.	4	181.7	45.43	2.04	0.089
Tchr.*Engl	55	1067	19.40	0.87	0.727
Gender*Engl	4	206.6	51.66	2.32	0.057
b'line lang.*Engl	4	65.17	16.29	0.73	0.571
b'line numb.*Engl	4	24.53	6.13	0.28	0.894
Error	279	6214	22.27		
Total	444	11304			

CA versus Control

The ANCOVA shows that there is a significant effect for CA classes over control classes, but it does not show the effect size. We obtained this from an analysis of gain scores for the Control and CA children separately. Table 9 provides detail of mean pre-test and post-test scores and mean gain scores (post minus pre for each child) with standard deviations for each on the two cognitive tests for CA and Control pupils.

As established by the ANCOVA, there are significant effects on the CA pupils compared with the Control children but this analysis shows that the effect sizes are 0.43 and 0.47 standard deviations on conservation and drawing respectively, values which can be considered to be substantial.

Table 8. Analysis of covariance of various factors with gains in conservation scores (*N* = 188)

Source	d.f.	Σ Squares	Mean Sq.	*F*-ratio	*p*
Const	1	531.1	531.1	135.0	≤ 0.0001
CA/CTRL	1	39.13	39.13	9.94	0.003
Tchr.	20	233.5	11.67	2.97	0.001
Gender	1	0.020	0.020	0.005	0.943
CA/CTRL*Gender	1	4.03	4.03	1.02	0.316
Tchr.*Gender	19	124.5	6.55	1.67	0.072
b'line lang.	1	18.60	18.60	4.73	0.034
CA/CTRL*b'line lan	1	18.54	18.54	4.71	0.034
Tchr.*b'line lang.	20	203.1	10.16	2.58	0.003
Gender*b'line lang.	1	0.95	0.95	0.24	0.626
b'line numb.	1	1.58	1.58	0.40	0.529
CA/CTRL*bline num	1	0.30	0.30	0.08	0.785
Tchr.*b'line numb.	19	68.63	3.61	0.92	0.565
Gender*b'line numb.	1	2.93	2.93	0.74	0.392
bline lang.*bline num	1	2.30	2.30	0.59	0.448
English	4	7.69	1.92	0.49	0.744
CA/Ctrl*Engl.	4	2.04	0.51	0.13	0.971
Tchr.*Engl	25	164.5	6.58	1.67	0.057
Gender*Engl	4	56.02	14.01	3.56	0.012
b'line lang.*Engl	4	25.29	6.32	1.61	0.186
b'line numb.*Engl	3	24.82	8.27	2.10	0.110
Error	55	216.4	3.93		
Total	187	1214			

Table 9. Significance and effect sizes of differences between CA and Control pupils

		Conservation			Drawing		
		pre	post	gain	pre	post	gain
CA	*N*:	122	122	122	302	302	302
	M:	2.03	4.05	2.02	7.53	13.93	6.40
	SD:	2.25	2.95	2.83	5.55	4.58	4.65
Control	*N*:	66	66	66	166	166	166
	M:	1.47	2.53	1.06	8.40	12.17	3.77
	SD:	2.11	2.25	1.77	5.62	5.50	5.28
	overall SD:	2.21			5.59		
	Diff. CA-Ctrl			0.956			2.636
	t			3.73			9.85
	p<			0.001			0.001
	Effect size			0.43			0.47

Figures 1 and 2 show the distribution of gain scores. Frequencies of each score are shown as percentages of the total number in that group (CA, Control) since there are more CA than Control children.

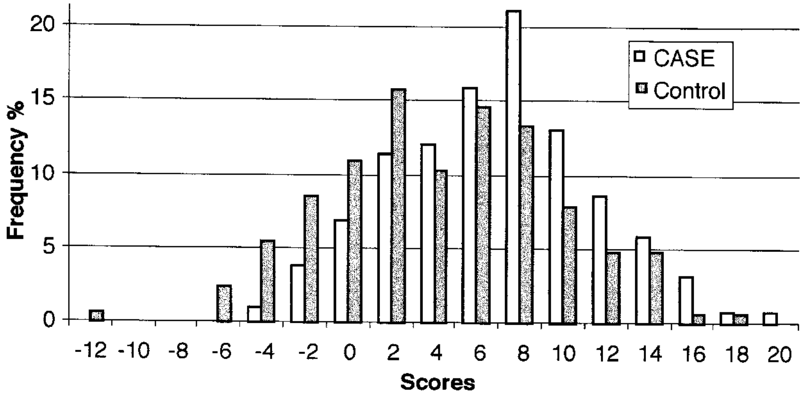


Figure 1: Distribution of gain scores: Drawing

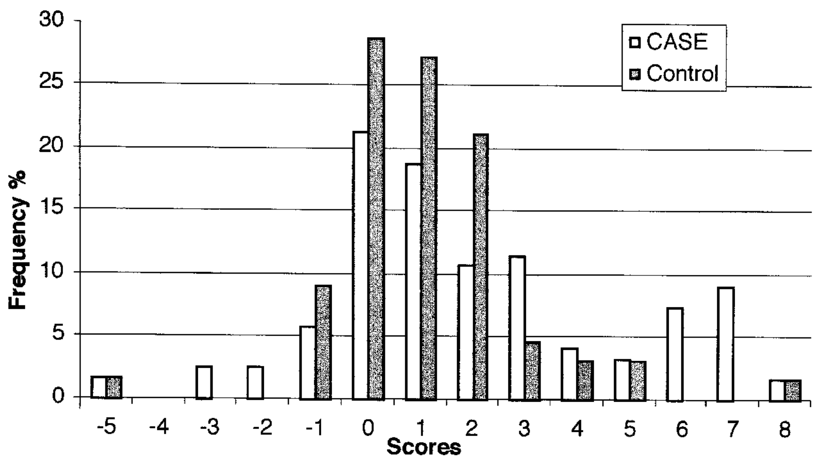


Figure 2: Distribution of gain scores: Conservation

For Drawing, the distribution is generally shifted to the right, gains made by CA children peaking around +6 to +8, compared with control children peaking around +4 to +6. For Conservation there is evidence of bimodality, with a second peak appearing at +7. Interestingly, this reflects the pattern of gains obtained in the original CASE@KS3 experimental results, where many of the gain scores showed a bimodal distribution (Adey & Shayer, 1994, pp. 99–102). There are 20 CA children who form the second peak with gains of 6, 7, or 8. Of these, 11 are girls so there is not obvious gender bias here. The 20 come from nine out of the 14 CA classes, but 11 come from three classes: 31 (4), 2 (4), and 8 (3). There is a suggestion here of a special teacher effect, but the numbers are too small to be conclusive. The issue of teacher effect will be discussed more fully later.

Gains by gender

Table 10 shows the gains made separately by girls and boys in the CA and control groups. These data suggest that in control classes boys made somewhat greater gains in cognitive development over the year than did girls, although this difference does not reach significance on either test (and hence did not show in the ANCOVA). In the CA classes, girls make the same gains as boys, and both boys and girls make greater gains than their peers in control classes, although not reaching significance for boys on the Conservation test, where the number of control boys is only 33.

Table 10. Gains on conservation and drawing tests by CA and Control boys and girls

		Conservation			Drawing		
		pre	post	gain	pre	post	gain
CA Girls	*N*:	63	63	63	150	150	150
	M:	2.13	4.24	2.11	7.79	14.11	6.33
	SD:	2.39	3.16	3.06	5.42	4.43	4.43
Control Girls	*N*:	36	36	36	80	80	80
	M:	1.72	2.53	0.81	8.40	11.60	3.20
	SD:	2.35	2.04	1.65	5.12	5.45	4.66
	SD overall:	2.37			531		
	CA-Ctrl diffs:			1.30			3.13
	t:			2.76			4.93
	p<			0.01			0.001
	effect size:			0.55			0.59
CA Boys	*N*:	59	59	59	143	143	143
	M:	1.93	3.85	1.92	7.33	13.71	6.38
	SD:	2.11	2.72	2.60	5.81	4.72	4.85
Control Boys	*N*:	33	33	33	83	83	83
	M:	1.21	2.39	1.18	8.40	12.72	4.33
	SD:	1.85	2.46	1.96	6.11	5.58	5.75
	SD overall:	2.04			5.93		
	CA-Ctrl diffs:			0.74			2.05
	t:			1.53			2.74
	p<			n.s.			0.01
	effect size:			0.36			0.35

Teacher/class

It will be clear from the description of the intervention given earlier that the teacher plays a central role in delivery of effective cognitive stimulation. As described, all teachers in the 14 CA classes participated in a professional development programme, including in-class support.

The analyses of covariance shown in Tables 7 and 8 reveal, unsurprisingly, a main effect for teacher on the post-test scores on cognitive tests. In order to investigate the effect in each teacher's class separately, the mean of the *residualised gain scores* of each the children in each class was calculated for both the drawing and conservation tests. The 'residualised gain' for each child is calculated by subtracting from their raw gain score (post-test minus pre-test) the *mean* gain score of the whole control group. This is a measure of the extent to which each child's gain score is greater or less than would have been expected had they been no different from an average control group child. Mean residualised gains of all control children together must be 0 by definition.

Figure 3 shows the mean residualised gain (r.g.) scores for each class, for drawing and conservation tests, by class with CA classes on the left, and control classes on the right. Within the groups, classes are arbitrarily ordered by the magnitude of the class mean drawing residualised gain score. The number of children contributing to each mean r.g. score is shown below the figure.

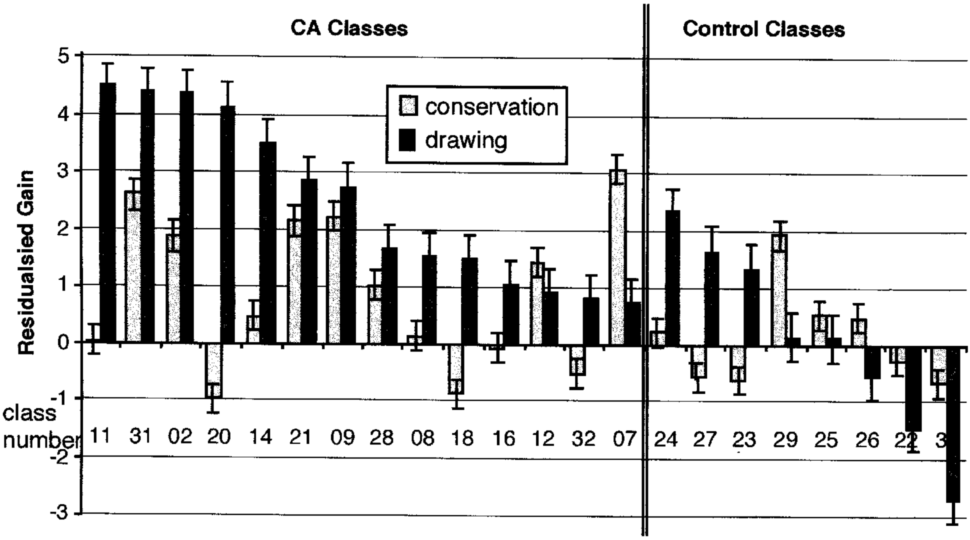


Figure 3. Mean residualsied gain scores by class

Numbers contributing to each class mean r.g. score:

Class	11	31	02	20	14	21	09	28	08	18	16	12	32	07	24	27	23	29	25	26	22	30
Conservation	9	9	16	10	9	9	10	11	5	10	4	4	9	7	7	6	9	3	10	11	10	10
Drawing	23	23	24	27	24	22	22	24	13	22	23	13	27	15	17	19	25	11	27	18	26	23

At the class level of data, the numbers of children per group are reduced considerably and the relative influence of uncontrolled error sources of variation increases. Thus class level data must be treated with considerable caution – especially with respect to the conservation tests given to one-third of the total sample. With this caution in mind, if the CA intervention is to be shown to be effective, it is necessary to demonstrate that it can be effective in the hands of a high proportion of the teachers who have been introduced to it. If the overall effects described earlier proved to be attributable to just three or four excellent teachers out of the 14 who participated in the experiment, that would not be convincing of the effect of the general method of cognitive acceleration described as the intervention in this experiment.

Figure 3 shows that the effect is not limited to just a few special teachers. Five out of 14 of the CA classes show greater gains on the drawing task than the best control class, and 12 CA classes show greater gains on drawing than five out of eight of the control classes, beyond the limits shown by standard error bars.

On conservation, special consideration must be given to class 29. As shown, data on conservation gains were obtained from only three children in this class, which was a set of just 14 children. At the time of the testing, it was noted that these children gave confident conservation answers, but started their justification with words such as 'because my teacher told me'. This type of response was unique to this class. Part of the agreement of the control schools to participate in testing only, without intervention, was that they would be given the intervention in the following year. During the week previous to their post-testing, control school teachers had attended a meeting explaining how they would participate in the following year, including a description of the experimental method and the nature of the conservation test. It seems that the teacher of class 29 had misguidedly returned from that session and given her children specific instruction in conservation. In spite of this, of the three children tested, two made no gains while one made an apparent gain of 8 so that the class mean gain was nearly 2. While 'teacher told me to say that' explanations were not accepted as evidence for conservation in themselves, it seems that one child may have been both influenced by the teacher to give the 'correct' answer, and been sufficiently convincing to the tester that she really was conserving. Because of the semi-anecdotal nature of this explanation, we have not excluded class 29 data from the whole analysis (which might be expected to raise the relative residualised gain scores of all of the CA classes), but will exclude class 29 from the conclusion from Figure 3 that, for conservation gains, seven out of 14 CA classes scored higher than any of the seven remaining control classes.

Discussion

Analyses of covariance of factors influencing post-test scores and *t*-tests of differences in mean gains show that the Year 1 classes who participated in a cognitive acceleration programme did indeed make greater cognitive gains over one school year than did pupils in similar classes who did not experience the intervention. However, there are a number of issues which need to be explored in a little more detail: the distinction between acceleration of general cognitive development and instruction in specific types of thinking; the generalisability of the results; the longevity of the effects; the dependence of the intervention on special teacher skills; the relationship of the results to the theoretical principles; and the implications of the effects for the model of acceleration adopted.

'Cognitive Acceleration' versus instruction

The distinction between learning and development and the influence of one on the other has been much discussed in the literature (see for example, Adey & Shayer, 1994, pp. 2–5; Anderson, 1992; Case, 1978; Karmiloff-Smith, 1991). Generally learning is seen as the result of action or experience (including instruction). It may occur in response to short instructional inputs and may be reversed (forgotten). While complex learning may be constrained by developmental stage, simple learning is relatively independent of maturation. Learning has no natural sense of direction: one morning one can choose to learn some French verbs, or learn how elements bond to form compounds, or learn to drive a car. None is a prerequisite for the other. Development on the other hand is uni-directional. It cannot be reversed (except, in a sense, with senility or other degeneration of the central nervous system). It is a slow process related to maturation and it has a natural direction of progression, such that a more developed person is expected to be more developed in a general sense within broad areas, physically or cognitively or emotionally.

Cognitive acceleration claims to promote the process of cognitive development. That is, it claims more than that it provides instruction in some specific skills or knowledge, but that it leads to more fundamental, deep-seated changes which are irreversible and general. Such a claim requires evidence of either or both of (a) transfer and (b) longevity. The latter will be considered in a later section. Transfer occurs when a child shows evidence of increased ability in some field in which she has received no instruction. Piaget and Inhelder considered operational thought, such as concrete operations, as *structures d'ensemble* – complete wholes, albeit represented by identifiably distinct schemata. While the schemata may develop at different rates (horizontal décalage), they have common logical features which identify them as aspects of the same stage of intellectual operations. Shayer *et al.* (1988) provide an empirically validated account of the development of the schemata of concrete operations and a comprehensive model to show how décalage may be explained in terms of nodes which occur at each of the main stages of development.

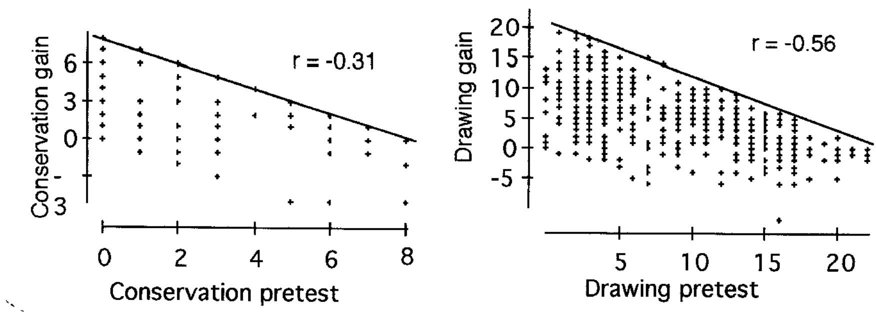
For present purposes, it is important to note that cognitive development over the year of the experiment was assessed by two different tests, each relating to a different schema of concrete operations. The drawing test in which children had to predict the horizontality of a water surface as a jar is tipped taps the schema of spatial perception. The intervention programme did have a number of activities related to spatial perception (see Table 6 and the sketch of Activity 18) but none of them referred even remotely to the subject matter of the drawing test. Greater gains in drawing scores by CA over control classes may be taken as evidence of near transfer. It may be argued that this effect has been one of instruction in the general principles of spatial perception, although that would require a more specific abstraction of such principles from the particular activities than did occur in the delivery of the activities.

Even more convincing is the effect on the conservation scores. There were no activities relating to conservation in the intervention programmes precisely because it was proposed to look for far transfer. The significant effects on conservation scores of the intervention programme provides evidence for the intervention having very general effects on children's cognitive development.

Generalisability

To what extent can we generalise from the results reported here? Most obviously, they refer to work with one limited age group, five- and six-year-olds. Whilst work with 12–14 year-olds has been shown to be effective for the promotion of formal operations, these results give us no reason suppose that cognitive acceleration would work at any age. Theoretically, in terms of the ages of transition in cognitive acceleration (Shayer *et al.*, 1988; Shayer, Küchemann, & Wylam, 1976; Shayer & Wylam, 1978) and of brain growth spurts (Epstein, 1986, 1990) one would not expect the same effect to be attainable at any age.

Secondly, the social environment in which this study was conducted was specifically one of inner city deprivation. It may turn out that such effects would not be attained with children whose home lives had already provided them with adequate cognitive stimulation. Related to but distinct from this, it may be asked whether those who made large gains were those who started from a low base, and therefore had much to make up. Negative correlations between pre-test scores and gains appear to support this hypothesis, but plots of pre-test against gains for the two tests (Figure 4) indicate that this is a spurious ceiling effect. A child who gains 5 on a pre-test with a maximum score of 8 cannot make a gain of more than 3 points.



Diagonal lines indicate maximum gains attainable from each pre-test score

Figure 4. Correlation plots of pre-test scores against gains for conservation and drawing tests

There does seem to be some evidence of a differential effect of the intervention on boys and girls, although this does not reach significance in the analysis of covariance. Whereas in control classes boys make (non-significant) greater gains in cognitive development than girls, in the CA classes their development is parallel. It has been suggested, post-hoc, by some of the CA teachers that in the year 2000, 'boy's underachievement' was a frequent topic of concern and discussion in the educational press and within the Authority and that consequently many teachers were making special efforts to give boys special attention during that year. This would need further investigation to validate.

In contrast with these possible limitations to generality, no interaction was found between the effects of the intervention on cognitive development and a number of social variables, including ethnicity, English language proficiency, and receipt of free school meals. In other words, no particular social or language group appeared to make greater or less gains than any other as a result of the intervention. The evidence discussed under 'Teacher / class' in the Results section above also supports the contention that the intervention effect can be generalised across a range of teachers and that a limited in-service professional development programme was sufficient to introduce the CA teachers to the principle of cognitive stimulation and make them generally more effective than the control teachers in terms of generating well-managed cognitive conflict and scaffolding social construction. Qualitative evidence for this assertion is the subject of a separate submission, but the data of Figure 3 provide some quantitative evidence.

Longevity of the effects

The effects reported here were attained at the immediate end of the intervention programme. A further test of their stability and depth (in the sense of impact upon development) will be made when the children who experienced this intervention (and the controls) are assessed for National Curriculum levels at the end of Year 2, one year after the end of the intervention programme. Experience with secondary age children showed that cognitive acceleration effects lasted at least three years after the intervention, but it will need to be shown that a similar effect can be obtained with much younger children.

What conclusions can be drawn about the theoretical bases of the intervention?

As described in the introduction, the cognitive acceleration intervention rests on four theoretical principles: cognitive conflict, social construction, metacognition, and schema theory. Do the results reported here confirm the importance of each of these theory bases? No. In principle, unless one conducted a controlled experiment in which each of these four bases was independently varied one cannot conclude unambiguously that all four are necessary, or that they contribute equally to the overall effect. However, we are dealing here with a real-life large scale educational investigation funded by an education authority whose main concern is the improvement of the life-chances of its students, rather than the theoretical investigation of sources of cognitive growth. In that context, we need to consider the intervention programme as a whole, building pragmatically on theory bases established in other contexts as providing plausible grounds for optimism in the search for cognitive stimulation. The results reported here indicate that this intervention package can be effective, even if we cannot be certain about the several contributions of each of its elements.

Having said that, it may be useful to consider what a series of experiments designed to tease apart the four elements might look like. To start with, we would argue that it is not practically possible to separate cognitive conflict and social construction. We may be able to characterise each separately and point to somewhat different (but overlapping) origins in Piagetian and Vygotskyan psychology but in the practice of teaching one cannot have one without the other. They are two sides of the same coin – the hammer and anvil of Hegelean dialectic from which intellectual growth is shaped. A puzzle (the conflict) generates questions, questions are directed at others, tentative suggestions are offered, and the group feels its way towards some resolution of the conflict, with the teacher forestalling too early closure on inadequate solutions. All of this constitutes social construction and a group doing this generates cognitive conflict in its members. The very act of sharing a puzzle, of asking a question, of inviting a partner to contribute to the solution, creates challenge.

Of the other theoretical bases, one could imagine investigating the effect of metacognitive reflection by managing two intervention groups both employing conflict/construction, but only one of which paid attention to metacognition. There might be practical difficulties in managing such groups to ensure clear separation of methodology, but in principle it could be done.

The role of schema theory in the formulation of the intervention is somewhat different. The schemata of concrete operations adopted from Geneva are no more than convenient and well worked-out descriptions of various types of thinking which underpin all rational thought. We are making no special claims for Piagetian schemata as the only way of describing reasoning and could well imagine a set of interventions based on conflict/construction, with or without metacognition, being devised with reference to other classifications of reasoning. We doubt whether the establishment of an experiment to test this would be worth the effort as it would not add much of importance to our understanding of cognitive acceleration.

Implications for the model of acceleration

Even if we consider the intervention method as an integrated whole, to what extent do the positive results reported here validate the model of cognitive acceleration proposed? On the basis of this experiment alone, the best one could say is that the model has provided a useful framework for the development of a stimulating intervention, and that the construct has survived an attempt at falsification. If the intervention had had no effect, and could be shown to be a reliable practical interpretation of the theory, then that would have called the theory into question.

But when one considers this study as part of a series of studies – all of the CA work in science and mathematics with older children referenced earlier, as well as work such as that of Wegerif *et al.* (1999) showing the effect of high quality social interaction on cognitive functioning – then one can become somewhat stronger in asserting that the theory base is becoming validated. Such support is strengthened when, as in the present study, the same theoretical constructs appear to produce positive effects when imported into a very new context.

Conclusion

The experiment described here has demonstrated that a cognitive intervention programme based on Piagetian ideas of cognitive conflict and the schemata of concrete operations and on Vygotskyan ideas of social construction and scaffolding can have a significant effect on the rate of cognitive development of five- and six-year-old children in Year 1 classes in a disadvantaged inner city environment. While there are some limitations to the generalisability of the findings, even within these limits we would claim that the effects have real social and educational potential. Anything that can be done to increase the intellectual processing capability of young children from disadvantaged backgrounds must be of general value in a society which has moved rapidly from one needing much thoughtless manual labour to one requiring independent and individual thought-in-action from a far higher proportion of the populace than ever before.

As well as the practical social value of the work, this study has contributed another plank to our understanding of the theoretical underpinnings of the process of general cognitive development.

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