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Long-Term Memory and School Performance Following Cognitive Transition at Five to Seven Years[1]

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ABSTRACT

A longitudinal study tested the hypothesis that rapid cognitive improvement adversely affects young children's long-term memories encoded prior to cognitive transition. Seventy-one Year One (five- to six-year-old) children were assessed for recall for event and educationally-relevant information and cognitive ability (in operational reasoning) at four points to Year Three. Contrary to the hypothesis, recent cognitive transition appeared to slightly improve -not worsen - recall for educational material taught prior to cognitive transition. Earlier cognitive transition was associated with slightly better educational recall, significantly better event recall for actions (but not objects), and significantly better reading, writing, spelling and mathematics examination performance.

Keywords: Long-term memory; five to seven year shift; cognitive change; primary education; standard assessment tasks

INTRODUCTION

Mnemonic improvements are undoubtedly observed as children develop with age. In particular, between five and seven years, as cognitive development accelerates, changes occur in how information is organised (e.g. Bjorklund, 1985; Denney & Ziobrowski, 1972; Nelson & Hudson, 1988), retrieved (e.g. Ackerman, 1981; Melkman & Deutsch, 1977; Melkman, Tversky, & Baratz, 1981) and represented (e.g. Bruner, Olver, & Greenfield, 1966.; Piaget & Inhelder, 1971). In the UK, as children approach seven years of age, they are examined on their first formal school assessments, the Standard Assessment Tasks (SCAA/QCA, 1997), based on learning prescribed by a National Curriculum.

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Clearly, mnemonic abilities have implications for school learning in the classroom (e.g. Nuthall, 2000) and for school test performance. However, little research has examined the impact of rapid cognitive and mnemonic advancement on children's learning and retrieval.

The aim of this study was to investigate longitudinally whether rapid cognitive improvement that occurs between five and seven years might disrupt access to existing long-term memories encoded prior to this cognitive change. One cognitive transition thought to be significant during this period is the move from 'preoperational' reasoning to a more adult-like 'concrete operational' reasoning (Piaget, 1953). With this more advanced level of cognitive functioning, the child has the newfound ability to 'conserve' (to understand that some properties of an object remain the same even when its appearance is altered in a superficial way) and 'classify' (to use abstract properties such as shape, colour and verbal labels as a basis for classifying items into two or more dimensions at once). A shift in brain activity has been associated with concrete operational ability, supporting the notion that its onset entails a significant change in information processing (Stauder *et al.*, 1999). Thus, the move from 'preoperational' to 'concrete operational' reasoning appears to reflect a change in the way in which information is represented and/or organised and therefore its long-term retrieval. Even if the onset of concrete operational understanding does not reflect a generalised cognitive transition, a new understanding of conservation and classification could impact on the way in which memories are organised or represented (Piaget & Inhelder, 1973). We would predict that cognitive improvement leads to improvements in children's memory of new information, but it is unclear how children access long-term memories encoded or organised using the 'outdated' pre-transition strategy.

Several unpublished studies suggest that cognitive operational transition is accompanied by a disproportionately high long-term memory loss for school-relevant information. All studies measured cognitive task performance within a teddy bear play context to minimise context effects (Donaldson, 1978). Chitsabesen (1993) assessed fifty-six five- to six-year-old children on a conservation task (to measure of cognitive transition) and found that those who failed at Time 1 but passed at Time 2 (the 'transitional' group) showed significantly worse long-term recall for an event (episodic memory) that occurred prior to Time 1 than did children who passed or failed the task at both time points. The findings suggest that children who experience 'operational' change (or some other rapid cognitive change that manifests itself behaviourally as competence on the conservation task) have more difficulty retrieving memories encoded prior to the transition than even children who have not shown this cognitive transition. Bye (1998) found a similar memory loss for event information (N=61) when five- to six-year-old 'task failers' had better recall than did 'task passers'. This counter-intuitive finding may be explained by the poor performance of those 'passers' who had only recently acquired this cognitive ability bringing down the average memory test score for this group. Bye's (2000) longitudinal study assessed another year group cohort over three time points during Year One (five- and six-year-olds) and found that recent cognitive transition was associated with the poorest long-term recall of episodic (e.g. a school trip) and non-episodic (e.g. a rhyme) school information in five of six statistical comparisons. The non-significant finding was in the recall of an event that may have been contaminated by exposure to a similar, more recent event.

There is no published evidence that long-term memory loss follows rapid cognitive or operational change at five to seven years, but memory retrieval difficulties have been documented concerning other periods of rapid cognitive development. During both late infancy and early adolescence, psychologists have theorised that memories, encoded in one context, later become inaccessible following cognitive reorganisation or the onset of a new cognitive strategy that characterises that developmental period. Infantile amnesia describes the lack of event memories recalled in adulthood that were encoded before the age of three (Dudycha & Dudycha, 1941; Eacott & Crawley, 1998) despite a good capacity for long-term storage in infancy (e.g. Hartshorn *et al.*, 1998; McDonough & Mandler, 1994) and good recall for childhood events after that age (see Howe & Courage, 1993). Although unresolved, most explanations of infantile amnesia focus on discrepancies between encoding and retrieval contexts leading to the inaccessibility of early memories (e.g. Rovee-Collier, 1997; White & Pillemer, 1979). Toward the other end of childhood, several empirical studies report reduced visual (Flin, 1980, 1985) and voice recognition accuracy (Mann *et al.*, 1979) in early adolescence followed by recovery to adult levels. The deficit here is not in long-term memory, but Flin (1985) similarly suggested that cognitive change, such as the onset of a new cognitive strategy, adversely affects mnemonic functioning.

The current study was a longitudinal study that spanned four phases between Primary Year One and Year Three. To support the hypothesis, we expected that the 'transitional group' (those who passed the concrete operational task *only* in the most recent assessment) would show poorer memory for 'previously-encoded' educational and event information than the 'stable preoperational group' (those who failed the task at two consecutive assessments) and the 'stable concrete operational group' (those who passed the task at two consecutive assessments). The 'previously-encoded' information refers to that to which children were exposed prior to the previous assessment (thus, prior to cognitive transition, for the 'transitional' group). However, we expected that the transitional group would *not* show poorer recall than the stable groups for 'recently-encoded' information (that is, for the transitional group, information to which children was exposed following cognitive transition). In other words, for children who had recently advanced to concrete operational reasoning, we predicted that recently-encoded memory would remain intact but memory for previously encoded material would be lost. Secondly, to test whether rapid cognitive change impacts on school performance (which depends to some extent on memory), we examined whether late (recent) cognitive change would impact negatively on National Curriculum examination performance (Standard Assessment Tasks -SCAA/QCA, 1997).

METHOD

Participants

English-speaking children were recruited following parental consent from a comprehensive primary school in the City of Manchester in the United Kingdom. At Time 1, during Primary Year 1, 82 children participated (42 male, 40 female; M=6.12 years; age range=5.06 to 5.83 years). At Time 2, during Primary Year 2, 78 children participated (39 male, 39 female; M=6.60 years; age range=6.01 to 7.18 years). At Time 3, later in Primary Year 2, 76 children participated (38 male, 38 female; M=7.24 years; age range=6.80 to 7.84 years). At Time 4, during Year 3, 71 children participated (35 male; 36 female; M= 7.52 years; age range=7.07 to 8.05 years). In all cases, loss to follow-up was due to changing school. The results of the final 71 children are reported in order to retain comparability between time points and since preliminary analyses showed that the findings were unaffected by sample attrition.

Procedure

The procedure at Time 1 and Time 2 was placed in a children's story play context in an attempt to minimise the kind of test context effects highlighted in Donaldson's (1978) seminal studies. The stories also served as a later measure of event memory recall, which had been successfully piloted by Bye (2000). At Time 1, children were individually invited to a 'teddy bear's picnic' within which conservation and classification tasks were embedded. Following the completion of this procedure (*see* Measures), each class group was also administered tests on memory for both recently-encoded educational material (of information taught recently, at 2 to 4 weeks prior to testing) and previously-encoded educational material (of information taught 3 o 4 months prior to testing). As far as was practically feasible, the class teacher and experimenter ensured that all children understood the instructions and did not cheat.

At Time 2, children were individually invited to a 'teddy bear's tea party' within which new versions of the conservation and classification tasks were embedded. Before the end of the individual session, a verbal test was given on event memory for recall of the teddy bear's picnic in Time 1. They were administered tests of memory for recently-encoded and previously-encoded educational material. The test that was used for 'recently encoded' memory in Time 1 was now employed as the test of 'previously-encoded' memory in Time 2 (for practical reasons and since we know that participants were exposed to this information prior to Time 1 which was also likely to be encoded).

At Time 3, children were assessed using a different version of the classification task. By Time 3, the story play context no longer facilitated task completion and appeared to hinder the child's performance (mainly as it distracted them), so the measures were no longer embedded in a story play scenario, which was deemed age-inappropriate. National Curriculum Standard Assessment Task results were also collated. At Time 4, children were individually assessed on classification and on long-term memory for source and item event information.

Measures

Conservation and classification tasks: Both tasks were used as an index of cognitive development. At the first two time points, the tasks were administered individually within a structured story play context. Different versions of the tasks (with varied scenarios and props) were devised to minimise practice effects. At Time 1, a liquid conservation task was administered in which, after liquid equivalence was agreed, the experimenter poured the liquid from one glass into a taller, thinner glass under the pretext that a teddy wanted the glass changed due to a dirty sticker underneath. Participants who insisted that quantity remained unchanged despite the discrepancy in appearance, supported by a justification of compensation or reversibility, were credited with conservation understanding.

To set up a classification task, 'sandwiches' were made of card and sponge and the child was asked to sort them into different kinds of the premise that one of the teddies was 'very fussy' and only liked one kind of sandwich. The child was then asked twice, with encouragement, whether they could sort the 'sandwiches' into groups 'in a different way' on the basis that the fussy teddy 'says that the sorting was not how he liked it'. Sandwiches could be grouped into three possible classifications: on white and brown bread, salad and ham sandwiches, or square and triangle cut sandwiches. To pass the classification task, the child must be able to sort the 'sandwiches' into at least two different classifications.

At Time 2, yellow and brown coloured rectangular biscuits made out of modelling clay were used as part of the 'tea party' and served as the conservation task stimuli. After equivalence of quantity was agreed by the participant, one teddy 'tells' the experimenter that he wants a sausage-shaped biscuit. After manipulating the shape of the biscuit, the child was then asked if this biscuit was still of the same amount as the other biscuits. Participants who insisted that quantity remained unchanged despite the discrepancy in appearance, supported by a justification of compensation or reversibility, were credited with conservation understanding.

Based on the premise that the teddies were 'very fussy' (as in Time 1), the classification task required the sorting of cakes made of sponge material into at least two of the following three category types to pass: chocolate and sponge, jam and cream filling, and square and triangular.

Due to time constraints, only the classification task was employed at Time 3 and Time 4. At Time 3, children were asked to place modelling clay objects into 'two different types' in one way, then in another way. To pass, the child had to show at least two ways to classify out of the following possibilities: large and small, red and blue, and cubes and spheres. At Time 4, children were asked to complete the same task but with pieces of card. Possible classifications were: large and small, grey and pink, and triangular and square.

Memory for educational material: At Time 1 and Time 2, two class-based tests of long-term memory for educational material were administered, counterbalanced across class groups, one on information taught three to four months prior to the test session ('previously-encoded') and the other on information taught two to four weeks prior to testing ('recently encoded'). Crucially, the tests and timing were designed to coincide with the transitional group's recall of information taught previous to and following cognitive change respectively. The tests had been carefully devised in consultation with their class teachers to include material that was temporally localised in exposure, that was sufficiently salient to have been encoded and that relied minimally on non-mnemonic skill. Examples are matching three dimensional shapes with their name, matching computer keys with their symbols, circling the ingredients needed to make a pancake, and circling items that are fruit or vegetables. Each test carried a total score of 20.

Event memory: At Time 2, each participant was individually asked to recall the play scenario at Time 1 under the pretext that the "teddies" wanted to know how well they could "remember the picnic". Performance was scored against a checklist of 7 objects that were present and 10 actions that occurred. For each of 7 objects, a score of 4 was assigned for its free recall (e.g. "We had some Smarties"), 3 for a correct response following prompted questioning (e.g. Experimenter: "Did we have some chocolate?"; Child: "Yes, we had Smarties"), 2 for forced-choice recognition (e.g. Experimenter: Did we have Smarties or a Kit Kat?"; Child: "Smarties") and 1 point for yes/no recognition (e.g. "Did we have Smarties?"), resulting in a possible total score of 20 for objects. For each of 10 actions, 4 points are given for its free recall (e.g. "We poured out drinks"), 3 points for a prompted response (e.g. Experimenter: "What did we do with the drinks?"; child: "we poured them out"), 2 points for forced-choice recognition (e.g. "Did we pour out drinks?") and in four action items, it was possible to assign 1 point for yes/no recognition (e.g. Experimenter: "Did you call your teddy Danny?"). The total possible score for actions is 40.

In Time 4, a test of long-term memory for events that occurred in previous assessments was employed which differentiated between source and item memory to explore the possibility that source memory rather than 'action' memory was affected by cognitive change. The test consisted of 10 source information items (e.g. Where did we sit the last time I was here?) and 10 item information items (e.g. Can you tell me two things I asked you to do the last time I was here?). The total possible scores were 10 for item recall and 10 for source recall.

National Curriculum Examinations (Standard Assessment Tasks): Shortly prior to Time 3, teachers individually administered four attainment tests as part of the National Curriculum requirement. For reading and writing, only the National Curriculum 'levels' achieved was reported (e.g. 1, 2a, 2b, 2c, 3a etc.), so were converted to a seven-point scale, whereas raw scores were available for spelling and mathematics.

Analysis

Our group of interest was the transitional group; that is, children who passed the concrete operational task only in the most recent assessment. Our hypothesis was that this group would show poorer memory for previously-encoded information than the stable preoperational group (those who failed the task at two consecutive assessments) and stable operational group (those who passed the task at two consecutive assessments) at each longitudinal comparison. There were 2 'regressers' at Time 1-2 and Time 3-4, but 7 at Time 2-3, which may have been due to the change in context in which the cognitive task was embedded (since it was no longer judged age-appropriate), leading to an underestimation in ability (Donaldson, 1978). The 'regressing' group was omitted from the reported analysis, although their inclusion in the stable operational group did not alter the significance of the findings.

Longitudinal comparisons in memory and school performance were made according to cognitive change/stability between Time 1>2, Time 2>3 and Time 3>4 (*see* Table 1). Time 1 performance itself is not reported here because no longitudinal assessment was conducted. At Time 2, 'previous EdM' tested memory for information taught in school prior to Time 1 assessments when the transitional group were 'pre-operational' but were currently 'concrete operational'. The 'recent EdM' test refers to information taught in school at three to four weeks prior to Time 2 when the transitional group was likely to have moved to concrete operations, but was taught sufficiently long ago to be in long-term memory. Thus, for the stable groups, they remained as preoperational or operational at exposure and the testing of all test material. One-way (rather than repeated measures) ANOVAs were conducted because the memory tests of previously- and recently-encoded material at a single time point were necessarily not of identical stimuli. Time 2's event memory test refers to that to which the child was exposed in Time 1, when the transitional group were preoperational and were currently concrete operational. Again, the stable groups remained so at the time of exposure and recall of all test material. One-way ANOVAs compared event memory performance between operational change groups. At Time 3, the transitional group were those children who were highly likely to have been concrete operational during the SATs (as they were assessed for concrete operational ability three weeks later), but were highly likely to have been preoperational when they were taught material relevant for the SATs. Again, one-way ANOVAs were calculated to examine differences in SAT performance between cognitive change groups. At Time 4, children were tested on memory for item and source information on events for which the transitional group were exposed prior to operational change. The stable pre-operational group remained pre-operational for the full duration whereas the stable concrete operational group remained so for varied amounts of exposure of previous events.

RESULTS

With 24% of the cohort passing the classification task at Time 1 compared to 87% at Time 4, the study observed cognitive improvement in 63% (N=45) of the sample over a mean total time period of 1.4 years. The average time elapsed between test phases are as follows: Time 1 to 2: 0.48 years; Time 2 to 3: 0.64 years; Time 3 to 4: 0.26 years. Although the stable operational group were, on average, slightly older than the other cognitive groups, the mean ages of each cognitive group did not differ from each other significantly at Time 2 (by conservation: $F_{(2,66)}$=2.27; n.s.; by classification: $F_{(2,66)}$=1.81; n.s.), Time 3 ($F_{(2,61)}$=2.27; n.s) or Time 4 $F_{(2,66)}$=2.0; n.s). As reported earlier, 'regressers' in cognitive performance were omitted from subsequent analysis.

Contrary to the hypothesis, the transitional group's memory performance for educational material, irrespective of when encoded, was not worse than those of the stable groups (Table 1). Instead, earlier onset of concrete operational ability afforded slightly better recall for both recently-encoded and previously-encoded information. ANOVAs found no significant between-groups differences in the recall of previously-encoded information (classification: $F_{(2,66)}$=0.37; n.s.; conservation: $F_{(2,66)}$=2.52; n.s). The only significant result in educational recall was that for recently encoded information across conservation status groups ($F_{(2,68)}$=3.24; $p<0.05$) but not across classification groups ($F_{(2,66)}$=1.41; n.s.). A Bonferroni post-hoc test found the effect to be due to the differences between the stable groups. The slightly higher mean score for 'previously-encoded' material than for 'recently-encoded' material was likely to be due to practice effects since this test was also used as Time 1's recent EdM test.

In the recall of previously-encoded event information, object recall performance was remarkably similar between groups (classification: $F_{(2,66)}$=0.34; n.s.; conservation: $F_{(2,66)}$=0.56; n.s.). However, action recall performance varied significantly across operational groups, with the stable concrete operational group scoring, on average, almost full marks: 19.4/20 when based on classification ($F_{(2,66)}$=3.97; p=0.02) and 19.2/20 when based on conservation ability ($F_{(2,66)}$=3.50; p=0.04). Bonferroni post-hoc analyses found that the effect across conservation change was due to the recall difference between the transitional group and stable conservers but that, across classification change, the difference between the stable groups was responsible. Time 4 event recall did not differ between groups (source recall: $F_{(2,68)}$=1.5; n.s.; item recall: $F_{(2,68)}$=0.67; n.s.). However, by Time 4, only 10% of the sample was transitional and 14% was stable preoperational. The relatively low scores on this test suggest that the

Table 1. Long-term memory and attainment mean scores and standard deviations according to operational transition*

		Memory and educational achievement scores									
		Time 2 (mean age: 6.6 years**)				Time 3 (mean age: 7.2 years)				Time 4 (mean age: 7.5 years)	
		Educational memory		Event memory		National Curriculum tests				Event memory	
		Recent	Previous	Objects	Actions	Reading	Writing	Spelling	Maths	Source	Item
Highest score		20	20	20	40	7	7	***	***	10	10
Transitional	**M**	**15.65 (15.44)**	**16.45 (16.07)**	**11.39 (11.56)**	**16.61 (15.77)**	**3.06**	**2.50**	**36.44**	**16.37**	**3.80**	**6.20**
	N	31 (27)	31 (27)	31 (27)	31 (27)	16	16	16	16	10	10
	SD	3.18 (3.02)	2.71 (2.89)	3.56 (3.17)	4.40 (5.01)	1.61	0.97	10.49	6.94	1.69	1.62
Stable pre-operations	**M**	**13.34 (14.32)**	**14.40 (15.27)**	**11.00 (11.05)**	**15.13 (16.18)**	**2.60**	**2.30**	**33.60**	**13.50**	**4.86**	**6.00**
	n	23 (22)	23 (22)	23 (22)	23 (22)	10	10	10	10	7	7
	SD	2.69 (4.73)	2.60 (2.39)	3.50 (3.42)	4.80 (2.95)	1.43	1.49	12.32	5.99	1.68	1.15
Stable operations	M	**16.60 (15.60)**	**17.20 (17.00)**	**11.93 (12.15)**	**19.40 (19.20)**	**4.79**	**3.79**	**44.05**	**25.11**	**4.85**	**6.77**
	n	15 (20)	15 (20)	15 (20)	15 (20)	38	38	38	38	52	52
	SD	3.02 (3.46)	1.86 (2.25)	2.84 (3.62)	3.57 (5.57)	1.70	1.17	10.63	7.46	1.75	2.18

*All calculations are based on classification task performance (or conservation task performance in parentheses where available)
**Mean age at Time 1 was 6.1 years (when the transitional group had failed but at Time 2 passed the operational task)
***We were unable to find out the highest possible marks that could be obtained on these National Curriculum tests.

children found this level of long-term recall, particularly of source information, difficult.

Significant between-groups effects were found in all school attainment tests, with the stable concrete operational group achieving the highest scores and the stable preoperational group achieving the lowest scores (Kruskal-Wallis test: reading: χ=16.64; writing: χ=16.24; ANOVA: spelling: $F_{(2,61)}$=10.69; mathematics: $F_{(2,61)}$=15.17; all p<0.001). In particular, the mathematics scores of the stable operational group (25.11) were almost twice as high as those of the stable preoperational group (16.37). Bonferroni post-hoc tests on the interval data revealed that the differences responsible for the effects in spelling and maths lay between the stable groups and between the transitional and stable operational group.

DISCUSSION

This study is the first to the author's knowledge to examine long-term memory consistency with cognitive transition in a relatively large sample of children at four time points between five and seven years of age. The study found no evidence for a difficulty in accessing previously-encoded educational or event information following operational change, and no dip in school test performance following recent operational change. The results support the alternative hypothesis that long-term recall improves gradually with cognitive advancement, which suggests that children are able to retrieve information that was encoded prior to cognitive change. In particular, earlier cognitive transition was associated with slightly better memory for educational information and markedly better memory for event information relating to actions but not objects, and better formal examination performance. Moreover, the findings suggest that cognitive transition does not simply reflect the child's age. However, cognitive change does not appear to lead to immediate improvements in the mnemonic system. A slight improvement in attainment and memory was found with operational change but marked improvements emerge only later –perhaps when encoding as well as retrieval skills have improved or when they are compatible. The developmental trend supports the domain-general view that operational tasks are an indicator of general cognitive level or at least reflected general school attainment level in this study.

However, the findings are discordant with previous studies (Bye, 1998, 2000; Chitsabesen, 1993). The design of this study differed from previous studies in some ways that form the basis for limitations in the current study. Although the long follow-up period was one of the study's strengths, the intervals between assessment points may have been too long to pinpoint the individual's onset of new cognitive ability. Previous studies had tested for memory for semantic information learnt within the school context, but this study was the first to examine educationally-relevant material. Through close liaison with teachers, great care was taken to choose material for the memory tests that was unlikely to be or to have been practiced or rehearsed later, but obviously the possibility of rehearsal could not be controlled (e.g. at home). In practice, a lot of curriculum learning that was tested for in the National Curriculum SATs was regularly rehearsed and recall required other cognitive skills as well. Therefore, the study's attempt to use memory stimuli that were personally and educationally relevant introduced confounding factors. The similar scores on event memory tests suggest that the questions may be have been too difficult on the whole. Future investigation would need to involve standardised long-term memory tests (with an initial test following exposure to ensure encoding) and shorter test intervals.

Although there is evidence for memory loss following other developmental periods of cognitive transition, the findings here suggest that such rapid change at five to seven years has no negative effect on the recall of existing long-term memories. The weight of evidence suggests that even if long-term memories are adversely affected by cognitive change, recall of school material is protected as the most important material is regularly rehearsed (Nuthall, 2000). Cognitive operational change seems to reflect more than the child's age, however, and coincides with mnemonic improvement in long-term recall (and possibly more effective encoding) and improved school performance in the long term.

It may be tempting to use the findings as support against the use of school examinations during this age range, since results arguably reflect the cognitive level of the child rather than mirror the school's standard of teaching in any way (which is a primary reason for these examinations in the UK). However, the direction of causality is unclear –that is, cognitive task performance may result from individual school success. With reference to event memory, operational advancement seems to bring with it improved memory for actions but not for objects –an area that merits further research using standardised tasks. As yet, it is unclear how long-term memories that are not regularly accessed remain accessible following rapid changes in cognitive strategy and reorganisation. Future longitudinal work should employ measures that tap into mnemonic changes, such as the retrieval strategies used by children, which may inform teachers of the most effective ways to teach children by exposing them to classroom activities that would facilitate encoding and retrieval.

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BIOGRAPHICAL NOTES

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