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TRAINING CONSERVATION OF QUANTITY (LIQUIDS) IN WEST AFRICAN (BAOULE) CHILDREN *

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A developmental 'lag' is found in the Conservation of Quantity (Liquids) in a sample of 73 rural, schooled Baoulé children (Ivory Coast, West Africa) aged 7 to 14 years. This study was designed to investigate if this 'lag' could be reduced or bridged through training and whether it could be attributed to differences in 'performance' or in 'competence'.

A sub-sample of 28 children aged 7 to 9 years was divided into two matched groups, one being trained for Conservation of Liquids and the other for Class Inclusion (Lavallée and Dasen in press). Statistically significant training effects were observed, which generalized to other concrete operational concepts and remained stable over at least one month.

Since no 'actualization' or very fast learning occurred, the 'lag' was attributed to differences in competence; the training was sufficient to bridge the developmental lag.

Introduction

In most cross-cultural studies of 'Piagetian' concepts of the concrete operational stage, the qualitative aspects of cognitive development (*i.e.* the succession of stages and sub-stages, the types of answers given by children to standard tasks) seem to be universal (or 'weakly' universal, *cf.* Dasen 1979a), whereas the quantitative aspects (*i.e.* the 'rate' of development or the chronological age at which the stages are attained) are subject to wide cultural variations (Dasen 1972, 1977a, 1977b). Whereas the qualitative aspects are more important as far as Piaget's theory is concerned, the quantitative aspects are relevant to possible applications, such as the adequate matching of school curricula to children's cognitive levels.

These cultural variations usually take the form of a 'delay', 'time-lag' or 'developmental gap': compared to results obtained in Western, technological societies, the rate of development of concrete operations in non-Western, traditional societies

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usually appears to be slower. However these 'time-lags' are not uniform over different conceptual areas in any one society, the rates of development depending on various environmental factors, for example eco-cultural demands (Berry 1976; Dasen 1975a).

Such a 'delay' or 'time-lag' is illustrated in fig. 1. The 'rate' of development of the concept of Conservation of Quantity (Liquids) is reflected by the percentage of children at each age-level who give a full conservation ('stage 3') answer; this rate is faster in a sample of Western, technological background (Canberra, Australia, *cf.* Dasen 1974) than in a sample of non-Western, traditional background (Kpouébo, Ivory Coast, West Africa). [1] In the age-range 7 to 9 years, the combined differences between the proportions are statistically significant at the 0.01 level (statistic 'V' of Kamara and Easley 1977; details appear in table 4).

Several different interpretations can be given to such a developmental 'lag':

(1) The difference is attributed to *methodological artefacts*, such as Western bias of the tasks or difficulties of communication (linguistic and cultural) between a Western interviewer and the non-Western subjects (Kamara and Easley 1977). However, without wanting to minimise methodological problems, we do not consider that this interpretation can account for all the findings (Dasen 1977a).

(2) The 'lag' is attributed to differences in *competence.* This interpretation could be phrased in terms of a 'cultural deficit' model (2A): the development of the underlying structures of the concrete operational stage is 'retarded' in comparison to Western norms, an obviously ethnocentric point of view (Cole and Bruner 1971), although it may be relevant in some situations of social change (de Lacey 1974; Munroe and Munroe 1975; Nurcombe 1976). We prefer to phrase this second interpretation in terms of a 'cultural difference' model (2B): the development of the underlying structures of the concrete operational stage is different from the rate observed in Western children because of cultural variations, such as differences in 'cognitive ambience' (Heron 1974) or in eco-cultural demands (Dasen 1975a).

(3) The 'lag' is seen as a difference in *performance*: the development of the underlying structures of the concrete operational stage may well be universal even in quantitative terms, but cultural differences appear in the way these structures are expressed or functionally used, either in real-life situations or on experimental tasks (Dasen 1977c).

Whereas the distinction between hypotheses 2A and 2B lies mainly in the value judgement attributed to the developmental sequence (Dasen *et al.* 1979), relative to the social situation in which the 'lag' is observed, the distinction of these two interpretations from the third is open to empirical investigation. The problem is to assess to what extent overt responses truly reflect the underlying structures. Using Piaget's clinical method (now called 'method of critical exploration') instead of standardised tests, and the resultant 'structural analysis' (Kamara and Easley 1977), may provide part of the answer, although difficulties of communication in a cross-cultural situation may still interfere; using a variety of techniques instead of a single task is another possibility (Cole *et al.* 1971; Greenfield 1976). An alternative which has been suggested (Bovet 1974), but never fully explored, is the use of training techniques.

Training studies of concrete operational concepts are usually designed to answer the following two questions:

- To what extent can the spontaneous rate of development be speeded up? — what Piaget (quoted by Kuhn 1974) has labelled the "American preoccupation"
- What are the mechanisms of transition from one stage to the next? and what are the developmental links between concepts? (Inhelder *et al.* 1974).

The present study is not intended to answer either of these, but rather two slightly different questions:

- To what extent can the 'developmental lag', discussed above, be reduced or bridged through adequate training techniques?
- Can training techniques help us to distinguish between 'performance' and 'competence'? and thus between interpretations 2 and 3?

One problem is to define the term 'adequate'. If the training is successful, we can be sure that the technique was adequate; if it is not successful, it may either be that the technique used was not adequate in the given situation (*e.g.* a technique may be

[1] This sample will be described below. The relevant development curve is the one marked "without training"; the second curve for the Kpouébo sample, "with training" will be discussed at the end of this paper.

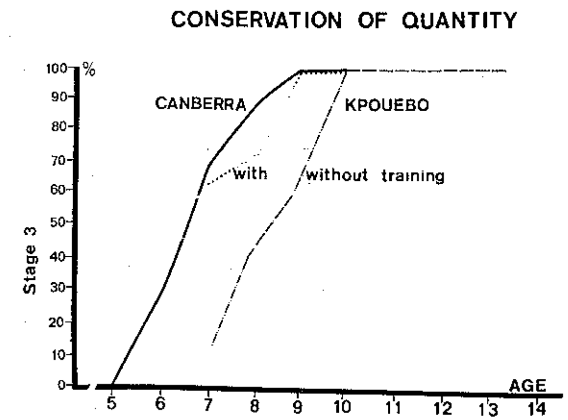

Fig. 1. Conservation of Quantity (Liquids): percentage of children giving full conservation (stage 3) answers over age.

adequate in one culture but not in another), or that the 'gap' cannot be bridged. As far as the second question is concerned, we can assume that, if we find a very rapid learning, the 'competence' or underlying structure was indeed present, but was not being expressed in the initial performance: in that case, the training would only serve to 'actualize' (Bovet 1974) the existing competence. If learning occurs, but is slow, we may assume that the competence was not present but is being achieved through training. If no learning occurs, again little can be said. The problem remains to define 'fast' and 'slow' learning.

On the basis of previous work showing a very rapid learning, 'actualization' or a 'triggering effect' (Pinard *et al.* 1973; Bovet 1974; Heron and Kroeger 1975; Dasen 1975a, 1977b), we may define 'rapid' learning, reflecting underlying competence, in the following way:

(1) The change in behaviour has to be important, *i.e.* the final sub-stage has to be reached and has to remain stable over time.
(2) This change has to occur under the influence of a minimal amount of stimulation, *e.g.* the mere exposure to the testing situation or simple re-testing, or only a very few training sequences, the exact number having to be defined in each case.

The experiment

Technique

Sample

The sample consisted of rural Baoulé children attending the local primary school in the village of Kpouébo, approximately 200 km NW of Abidian, the capital city of Ivory Coast, West Africa. The Baoulé are of the Akan group of tribes, having moved into their present habitat of savannah and rain-forest country from areas which are now in Ghana. The social structure and daily life of the Baoulé have been described by Etienne and Etienne (1965) and Guerry (1970); economic activities are characterised by subsistence agriculture (based mainly on yam, cassava and plantain banana) with some coffee and cocoa as cash crops. Concepts of quantity are likely to be relatively important in such a context, where produce has to be stored between crops and is extensively exchanged on markets.

The village comprised about 2000 inhabitants, with about 200 children (approx. 80% of the relevant age population) attending school. Of these, all children (73) having an accurate birth record and being aged 7 to 14 years, were tested on Conservation of Liquids (as described in previous research by Dasen, 1974), yielding the results presented in fig. 1. Of the 44 children aged 7 to 9 years (6;8–8;10), all of whom were in grades 1 and 2, 16 were found to be at stage 1 (non-conversation) and 12 at stage 2 (intermediate). These 28 children were dividied into two matched samples one of which is used in the present study, and the other in a study involving the training of Class Inclusion (Lavallée and Dasen in press).

Pre-test, training procedures and post-tests

The following tasks were used as pre-test:

(1) *Conservation of Quantity (Liquids)*: Following a few comprehension checks, equal amounts of water are poured into two identical glasses: when the equality is well established, the liquid from one of the glasses is poured into a long and narrow glass, and the child is asked whether there is still the same amount to drink, or whether there is more in one of the glasses. In a second part of the task, after the initial equality has been re-established, the liquid of one of the original glasses is poured into a wide dish.
(2) *Conservation of Number*: The child is asked to establish a one-to-one correspondence between two sets of objects; in this case, coffee and cocoa beans were used. The experimenter then modifies the lay-out, first by spacing out, then by moving together the objects in one of the rows, and finally by taking away or adding one or two units, and asks if there are still the same number or if there are more in one of the rows.
(3) *Liquid Pouring Problem (Compensation)*: The experimenter half fills a wide glass with water; the child is asked to pour about the same amount of liquid into a narrow glass. (Note that this task involves 'compensation' between the two dimensions, diameter and height, but not conservation as such.)
(4) *Conservation of Quantity (Matter or Substance)*: This task follows the same pattern as Conservation of Liquids; modeling clay or plasticine is used, one of two equal balls being first rolled out, and then flattened (the initial equality being re-established between the two parts).
(5) *Quantification of Class Inclusion*: the experimenter asks the child to name the subclasses (in this case, 10 oranges and 3 avocado pears) and the generic term (fruit; *wakama* in Baoulé, literally 'things which come from a tree') and then asks questions comparing the extension of one of the sub-classes with the general class (*e.g.* 'Are there more oranges or more fruit').
(6) *Horizontality*: The child is asked to draw the level of water in a bottle tilted in different ways. This task is designed to measure the development of a spatial coordinate system, and therefore deals with a different conceptual area than the five other tasks (*cf.* Dasen 1975a), and its results will be reported elsewhere.

Tasks 1 through 5 are fully described in Inhelder *et al.* 1974 (appendix). The pre-test was administered by the first two authors, with the help of trained Baoulé research assistants/interpreters. Task 5 (Class Inclusion) was always administered in Baoulé; the instructions for this task and for the training of Class inclusion (Lavallée and Dasen in press) had been translated into the vernacular by a Baoulé university student, and some of the interviews were tape-recorded, back-translated, and checked for accuracy. The other tasks were administered in Baoulé or in French, depending on the *S*'s fluency in the latter language. French is used as the language of instruction in all grades of primary school throughout the Ivory Coast, and since the advent of nationwide schooling through television, even first graders are becoming fluent enough in this second language to conduct a simple conversation in it; the experimenters had also learned enough Baoulé to allow them to monitor the interpreters' translations. The tasks were adopted for cross-cultural use, according to the following principles: the flexibility of Piaget's clinical method was maintained, but no 'counter-suggestions' were used, because these are easily perceived as criticism of the *S*'s answers. The children were asked to explain their answers, but justifications were not used for scoring in order to ensure comparability with previous work (*e.g.* Dasen 1974) and to avoid handicapping less verbal children. Each task was preceded by a number of check-items to ensure that adequate communication was taking place.

Each task was scored by classifying the answers into 3 stages: (1) Consistent pre-operational answers; (2) Intermediate or transitional answers; (3) Consistent concrete operational answers.

Training procedure for Conservation of Liquids

The procedure devised by Lefebvre (1971; Lefebvre and Pinard 1972) was used. The training started with a preliminary series of three situations, which was presented only once, in which the child was made to discover that the rule he was using ('Higher is more to drink') was not satisfactory, and that another rule – although just as inadequate – could be used ('Wider is more to drink'). This was followed by a sequence of 8 conflict situations, 4 based on compensation and 4 on operations of addition and subtraction, and dealing with inequalities in quantities (to avoid the simple learning of a response set). After each series of 4 situations, a situation similar to the 'Liquid Pouring Problem' (task 3) of the pre-test was used to monitor the effects of the training. This sequence was repeated 4 times over a period of 6 to 9 days, unless the S was successful on all situations of two successive sequences, in which case training was discontinued. The training was carried out by the first author, with the help of a Baoulé research assistant/interpreter. This sample also underwent a training procedure for the spatial concept of Horizontality, the results of which will be reported elsewhere.

Post-tests

A first post-test (PT1), which was administered immediately after training, consisted of the tasks of Conservation of Liquids and of Class Inclusion. The second post-test (PT2), identical with the pre-test, was administered one month after PT1.

Results

Individual results are presented in table 1, which shows the stages attained on each task on the pre-test and on both post-tests. A summary of the results observed on the Conservation of Liquids appears in table 2.

Training effect and stability. All 6 children starting at stage 2 moved to stage 3, either on PT1 (4) or on PT2. On the other hand, of the 8 Ss starting at stage 1, only 2 moved to stage 3 on PT2. Three others gave stage 2 or 3 answers immediately after training, but this acquisition was not stable. Of these, two children (no. 54 and 39) immediately answered correctly in all situations of the training procedure, for two successive sequences, so the training was discontinued; had training been continued with these Ss, a more stable progress might have been induced. The remaining 3 children showed no progress throughout. These results confirm previous findings (*e.g.* Inhelder *et al.* 1974) that progress through training is clearly dependent on the child's initial level of reasoning.

Over-all, the training leads to statistically significant improvement ($\chi_r^2 = 8.714$, $df = 2$, $p < 0.02$; Friedman two-way ANOVA by ranks) in the Conservation of Liquids. Some delayed progress occurred between the two post-tests for 4 children, but 3 returned to lower stage answers, and the effect was not statistically significant ($l = 3.702$, NS; Log. likelihood ratio test, Spitz 1965).

Rate of learning and 'actualization'. In using the criterion of two successive training sequences correct, only two Ss showed immediate learning, but as we have seen before, their achievement was not stable; 6 other Ss needed 3 or 4 sequences, and 6 did not fulfil the criterion, although three of these still showed consistent learning on the post-tests. Thus the learning, although successful for at least half of the children, was not faster than the average of 3 sequences needed by French Canadian children (Lefebvre and Pinard 1972). Using our definition of 'rapid' learning as requiring important behavioural change through minimal stimulation, we can hardly conclude to any 'actualization' of underlying competence; it is more likely that the operational structures have been developed through training.

Generalization. That the training was actually successful in inducing a restructuration of the concrete operational structures, and not only a response limited to one concept, is shown by the impressive generalization which occurred. All 7 children who moved to stage 3 on PT2 in

Table 1
Individual results of training for Conservation of Liquids (stages).

Subjects: Subject no.	Subjects: Age	Subjects: School grade	Pre-test: Liquids	Pre-test: Number	Pre-test: Compensation	Pre-test: Substance	Pre-test: Class inclusion	Training: Number of sequences	Post-tests PT1: Liquids	Post-tests PT1: Class inclusion	Post-tests PT2: Liquids	Post-tests PT2: Number	Post-tests PT2: Compensation	Post-tests PT2: Substance	Post-tests PT2: Class inclusion
22	9	2	2	3	2	3	1	3	3	1	3	3	3	3	3
6	8	2	2	3	1	3	3	4	3	3	3	3	3	3	3
51	7	1	2	1	3	2	1	4	3	3	3	3	3	3	3
48	7	1	2	1	1	2	1	4	3	2	–	–	–	–	–
55	7	1	2	2	2	2	1	4[a]	2	1	3	3	2	3	3
27	8	1	2	2	1	2	1	4[a]	2	1	3	3	3	3	3
34	8	1	1	3	2	1	3	4	2	2	3	3	3	3	3
15	8	2	1	2	1	3	1	4[a]	2	2	3	3	3	3	1
54	7	1	1	1	1	1	1	2	3	2	2	2	2	2	1
39	7	1	1	2	2	2	1	2	3	1	1	1	2	2	1
44	8	1	1	1	1	1	1	4	2	1	1	1	3	1	1
14	8	2	1	2	2	2	1	4[a]	1	1	1	3	3	2	2
46	7	1	1	1	1	2	1	4[a]	1	1	1	1	1	1	1
43	7	1	1	1	2	1	1	4[a]	1	1	1	1	2	1	3

Note: The tasks are described in the text. Each task is scored in 3 stages.

[a] For these subjects, training was discontinued after 4 sequences even though they had not completed two successive sequences successfully.

the Conservation of Liquids also moved to stage 3 on PT2 in the other conservation tasks (2, 3 and 4) and 6 of these also showed a progress of 1 or 2 sub-stages on Class Inclusion (to some extent through delayed progress between PT1 and PT2). The effect of training on Class Inclusion is summarized in table 3.

Training for Conservation of Liquids not only generalizes to Class Inclusion ($l = 10.624$, $p < 0.01$), but also to Conservation of Number ($l = 9.952$, $p < 0.01$), Liquid Compensation ($l = 14.07$, $p < 0.001$) and Conservation of Substance ($l = 6.71$, $p < 0.05$).

Table 2
Training for Conservation of Liquids: summary of results.

Stages Conservation of Liquids	Pre-test	Post-test 1	Post-test 2 [a]
3	0	6	7 (+1)
2	6	5	1
1	8	3	5

[a] One subject was absent at the time of the second post-test; his result on the first post-test is shown in parentheses.

Table 3
Training for Conservation of Liquids: generalization to Class Inclusion.

Stages Class Inclusion	Pre-test	Post-test 1	Post-test 2 [a]
3	2	2	7
2	0	4	1 (+1)
1	12	8	5

[a] One subject was absent at the time of the second post-test; his result on the first post-test is shown in parentheses.

Discussion

In summary, our training procedures have been successful in producing significant change in the acquisition of concepts of conservation; this change is not limited to the single concept of Conservation of Liquids, but is generalized to other conservation concepts of about the same level of difficulty (Conservation of Number, Conservation of Substance). It cannot be said from this experiment whether generalization to more difficult conservation concepts would also occur; Inhelder *et al.* (1974) found some generalization to Conservation of Weight both through training for Conservation of Liquids and for Class Inclusion. The conflicts generated by the training procedures seem to trigger a differentiation and re-coordination of structures which go beyond the limited concept being trained.

How specific a skill is the Conservation of Quantity? In the cross-cultural literature, this question has arisen from the study of the influence of daily activities, such as pottery-making, on conservation concepts, but answers have remained ambiguous: in Mexico, Price-Williams *et al.* (1969) found that the effect of pottery-making was limited to the Conservation of Matter (Substance) in one sample, whereas in another sample, transfer occurred to Conservation of Number, Liquids, Weight and Volume. In Adjei's (1977) study, pottery-making was found to have a significant effect on the Conservation of Substance, Weight and Volume in a group of Ghanaian adults, whereas in children, the effect was significant on Weight only. In our study, successful training for Conservation of Liquids generalized to other conservation concepts, indicating that, beyond the learning of a specific skill, concrete operational structures had been activated.

This conclusion is confirmed and expanded by the finding that there is not only transfer from Conservation of Liquids to other conservation concepts, but there is also transfer from one conceptual area to another, *e.g.* between conservation and classification. In this respect, our results are exactly parallel to those of Inhelder *et al.* (1974), and indicate "that the acquisitions were truly operatory and that, during training, the children's mode of reasoning had altered in an essential way" (p. 257).

In view of the interesting findings on the relationships between Conservation and Class Inclusion (*cf.* also Lavallée and Dasen in press), the decision to use two different training groups instead of a single training group and a control group seems to have been a wise trade-off, given the small number of subjects available. The amount of progress obtained through training could obviously not be obtained through spontaneous development alone, over such a short period. On the other hand, we cannot exclude the possibility that a control group would have shown similar improvement through the 'triggering' effect of mere testing and re-testing (such as was found by Heron and Kroeger 1975).

There is little evidence in these results in favour of the 'actualization of underlying competence' hypothesis: although significant learning does occur, it seems to happen through a gradual building up of the operational structures. Thus, if this study is to help us to distinguish between interpretations 2 (difference in competence) and 3 (difference in performance), the results point towards the former. This does not mean that the competence/performance distinction is irrelevant in every case; 'actualization' may be more likely to occur in older children and in adults. In the Eskimo training study (Dasen 1977b) it was the 12 to 14 year-olds who showed actualization, not the 10 and 11 year-olds; Bovet (1974) reports actualization within a single interview in adults only, and Heron and Kroeger (1975) assume latent competence (for multiple classification) in 10 to 13 year old children. Our 7–9 year olds may have been too close to the age at which Conservation of Liquids is normally acquired to show any actualization. In other words, the competence/performance distinction may not explain the initial developmental gap, but possibly the asymptotic development curves (Dasen 1979b) when these occur.

Finally, let us return to our first question: can the developmental gap be reduced or bridged through adequate training techniques? The answer appears in fig. 1. The second development curve for the Kpouébo sample, marked 'with training', combines the percentages of children reaching stage 3 spontaneously and those of subjects who attained it through training (either Conservation or Class Inclusion). The details of the results are given in table 4 for both post-tests.

Although these percentages are still somewhat lower at ages 7 and 8 years than

Table 4
Conservation of Quantity (Liquids): Percentage of children giving full conservation (stage 3) answers in a sample of Western technological background (Canberra, Australia) and a sample of non-Western, traditional background (Kpouébo, Ivory Coast, West Africa), before and after training.

	Age (years) 5	6	7	8	9	10	11–14
Canberra	0	30	70	90	100	100	–
Kpouébo (without training)	–	–	14	39	71	100	100
p			0.003	0.003	0.034	$V = 30.071$ [a] $p < 0.01$	
Kpouébo (with training)							
PT1	–	–	64	70	100	100	100
p			0.378	0.109	0.500	$V = 7.758$ *NS*	
PT2	–	–	38	83	100	100	100
p			0.058	0.255	0.500	$V = 9.810$ *NS*	

N: Canberra 10 *Ss* per age; Kpouébo respectively 14, 23, 7, 5, 24 per age.
[a] The statistic *V*, distributed like chi-square, tests the combined differences between the proportion of conservers in the Canberra and the Kpouébo samples, for ages 7 to 9; *cf.* Kamara and Easley 1977.

in the Canberra sample, the difference (calculated over the range 7–9 years with the Kamara and Easley, 1977, statistic 'V') is no longer statistically significant. Considering that some methodological artefacts (*cf.* interpretation 1, above) may have occurred in the testing as well as in the training, we can safely conclude that the gap has indeed been bridged.

This finding, if it can be more widely replicated, will have important implications. Firstly, it shows that the developmental lag which has been reported so many times does not reflect some basic incapacity, and can be bridged through adequate educational experiences, without having to resort to major social changes such as urbanisation (*e.g.* Opper 1977; Kirk 1977) or complete acculturation to Western ways (Seagrim 1977). The fact that schooling does not always produce the expected effects (*e.g.* Kamara and Easley 1977; Kiminyo 1977; Kelly 1977; Seagrim 1977) may reflect the commonly criticised fact that education does not usually rely on activity and self-discovery methods. However the passage from individual training through conflict-inducing techniques, such as were used in this study, to class-room practice is obviously not an easy one. In any case, in conducting this research we had no direct educational applications in mind: we have demonstrated that, in the limited circumstances of our study at least, it is possible to bridge the developmental 'lag' – whether this is a worthwhile educational goal is not for us to decide.

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Dans un échantillon de 73 enfants Baoulés (Côte d'Ivoire), ruraux, scolarisés, et âgés de 7 à 14 ans, on trouve un 'décalage temporel' dans le développement spontané de la Conservation des Quantités (Liquides). Cette recherche devait répondre à deux questions: (1) ce 'décalage' peut-il être réduit ou supprimé par apprentissage? (2) peut-on attribuer ce 'décalage' à des différences dans la 'performance' aux épreuves ou à la 'compétence' sous-jacente?

28 enfants âgés de 7 à 9 ans sont répartis en deux groupes appariés, l'un étant soumis à un apprentissage de la Conservation des Liquides, l'autre à un apprentissage de la Quantification de l'Inclusion des Classes (Lavallée and Dasen in press). On observe un effet d'apprentissage statistiquement significatif, avec généralisation à d'autres concepts du stade des opérations concrètes, et stable sur un mois au moins.

Puisque aucune 'actualisation' ou apprentissage très rapide n'a été observé, le 'décalage' a été attribué à des différences dans la 'compétence'; l'apprentissage est suffisant pour supprimer ce 'décalage temporel'.