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Summary:

This study presents a detailed analysis of collaborative interaction modes employed by 9-10 years-old children in a spatial problem solving task called the Kohs Cubes. All the children were videotaped during non-interactive pre and post test sessions (stages 1 & 4) and two types of interactive sessions (novice children training with adults (stage 2) and competent by instruction children or competent children interacting with novice children (stage 3). Dyadic sessions between competent and novice children have been more specifically analysed to show how children share their involvement with the task and how they manage to solve the problem depending on their level of competence on the task. Four particular dimensions of these interactive sessions have been studied: strategies explicitation, children's management of the task, modes of interaction and their evolution in the course of the task resolution, and each child's number of correct resolution attempts. Based on the analysis of eight case studies extracted from an experimental study, results highlighted the plurality and complexity of the socio-cognitive dynamics in dyadic interactions. The discussion focuses on the processes of collaborative learning involved in such interactions.

Keywords:

Dyadic interactions, learning, Kohs Cubes, socio-cognitive dynamics, children.

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Research in developmental psychology and education often aims to better understand the effects of social contexts on learning and development in children. Vygotsky (1930/1981) proposed that children's cultural development was first initiated through social interactions and later on consolidated at the psychological level: "every function in child's cultural development appears twice or on two planes. First, it appears on the social plane, and then, on the psychological plane. First, it appears between people as an interpsychological category and then, within the child as an intrapsychological category. (…) Social relations or relations among people, genetically, underlie all the higher functions and their relationships" (Vygotsky, 1930/1981, p.163). Although, Vygotsky did not study empirically how different modes of social interactions influence our behaviours and thoughts, his writings and hypotheses opened the path for many to explore this direction.

In such a perspective, some researchers studied adult-child interactions during learning activities, others focused on children collaborations while yet others tried to highlight which contexts may lead children to learn. Peer collaboration has been defined as "a coordinated synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem. (Roschelle & Teasley, 1995, p. 70). In this sense, peer collaboration (as distinct from peer tutoring) involves children working together to complete a single unified task that represents the shared meaning and communication of the group as a unit (Fawcett & Garton, 2005). Peer collaboration is not always associated with individual cognitive change (Doise & Mugny, 1984, Perret-Clermont, 1980; Tudge & Winterhoff, 1993). It is suggested that cognitive benefits may depend on a complex set of factors such as age (Hogan & Tudge, 1999), level of the partner (Gabrielle & Montecinos, 2001), confidence, (Tudge & al. 1996), gender (Perret-Clermont & Schubauer-Leoni, 1981; Psaltis, 2005) and the task (Phelps & Damond, 1989).

But, research on children learning had shown that social interactions may facilitate cognitive progress but the results are, in part, conflicting. Indeed, Perret-Clermont (1980) demonstrated that a particular type of interpersonal relation between children who have to solve the Piagetian liquid conservation task are favourable to positive cognitive shifts for the partners. Such findings point to the conditions under which "two heads are better than one"(Azmitia, 1988). In contrast, Tudge (1989) showed in one of his studies that the social interaction between peers solving a Piagetian task may lead to cognitive regression. Other results suggest that the short term effects of social interaction differ from their long term effects (Howe & al. 2005). As a result, researchers examined the efficacy of different configurations of the learning task, the role of the partners' social and cognitive characteristics and they contrasted cognitive development before and after the interaction. Such an experimental setting allowed researchers to evaluate the effect of the learning context by comparing children's responses before and after the social interaction. Other interpretations, however, have been proposed. In particular, it was suggested that children may redefine the objectives of the task during the interaction and thus, learn something that was different from what the researchers expected. Yet, few studies have examined how the definition of the task is discussed or redefined by the participants while they interact. Thus, the social context of learning may or may not lead to cognitive development while also contributing to the emergence of new objectives (Saxe, 1991).

As it has been shown (King, 1999; Light & Littleton, 1994; Teasley, 1995, Webb & Favier, 1999), a key element of effective peer collaboration is the active exchange of ideas through verbal communication. In this sense, the total number of utterances used in interaction between two children showed that it was associated with improvement in reasoning strategies or problem solving ability. Kruger (1992) showed that children who engaged actively in a debate were more likely to benefit cognitively than those who were describes as passive listeners. Peers who negotiated most explicitly and made more extensive use of verbal preplanning while working collaboratively tended to be the most successful at individual post-tests. It seems that the interaction in order to support learning and cognitive growth may provide elaborate explanation, asking appropriate questions, providing sufficient time for the partner to think and using supportive communicative skills such as listening, giving feed back and encouragement (Webb & Favier, 1995).

When studying the social facilitation of learning, it is necessary to go beyond an analysis of individual performance before and after the social interaction and to develop a *pluralistic perspective* of interaction that incorporate several levels of analysis of the collaborative work (Forman & Larreamendys-Joerns, 1995). It is in such a perspective that the present research offers a study of social interaction. This *pluralistic perspective* is used in research on situated learning (Minick, Stone & Forman, 1993; Perret-Clermont, Perret & Bell, 1991). In this tradition of research, the accent is put on the fact that the social context is not a static entity but is continuously created and recreated by the partners, hence developing in the course of interaction. Thus, the participants may learn the same things but not necessarily from a shared task. Different social conditions (e.g., working with a child trained by an adult or working with a peer who has not received such training) may or may not lead to cognitive progress (Nicolet, 1995; Grossen & al., 1997; Tartas & al., 2004).

Because a given experimental condition may lead to very different socio-cognitive dynamics, it is necessary to open the "black box" that is the social interaction (Carugati, 2001) in the pre- and post- test paradigm of research. Firstly, this will allow having a closer look at what is going on when two children are solving a problem together. Secondly, this will enable the development of tools or methods of analysis for describing what is going on. There are different ways in which this could be done: for example, one could analyse very finely the verbal exchanges using conversational analysis to show how conversation leads to cognition (see Sorsana & Trognon, Marro, in this volume). Another possibility would be to follow the dynamics of the interaction step by step, paying particular attention to the types of collaborative relations elaborated and their evolution in the course of the interaction, as we do here. This article has two objectives: Firstly, it aims to present the exploratory results of a study on the collaborative modes of interaction children use to solve a problem; Secondly, it aims to present a new research process which consists in permanently going back and forth between general laws and particular case studies in order to generate new hypotheses arising from the exploration of individual variations. It is this process that generated the results presented here. The initial results of this study allowed us to verify the general hypothesis stating that children who have been taught by an adult during a "scaffolding" training progress learnt more than the children who did not receive such training (see for more details, Tartas & al., 2004). Based on this hypothesis of a general law tested in an experimental setting, we develop, in the present research, a case study approach in order to study the individual variations inside this general law. The interaction is not a static object; it has a dynamic source of cognitive movements. It is never realises itself in the same way. Thus, even within the same experimental condition of interaction, the instruction "working together" may not involve its participants in the same way. This is because the experimental situation does not completely define the interactive dynamics. Within each dyad, each partner will try to exploit

the space given by the framework proposed in his/her own way. This will entail chain reactions from the partners. So, we expect that the same instruction of collective work will lead to very different socio-cognitive dynamics from one dyad to another. Nevertheless, we can expect that there will be similarities between interactions, depending on the type of competencies observed in the pre test and on the partner's level of competency.

The participants

The children were nine years old and were tested in their school by the first author of this paper.

There were three groups of participants:

- The Competent children (C) who demonstrated competencies to solve the task during the pre-test or stage 1.
- The Novice children (N) who could not solve the task at the pre-test.
- The Competent by Instruction children (CI) who were novices at the pre-test but who were then trained by an adult in the stage 2 of the experimentation in order to turn them into competent solvers of the task.

Thus, there were two types of competent children in stage 3: the children who had already constructed their competencies (C) to solve the task and the children whose modalities of acquisition of such competencies were controlled (CI). (See figure 1). These two groups of subjects interacted in stage 3 (interaction) of the experimentation. The CI children were taught so that their performances matched those of C children.

After the pre-test, and after the training for the CI children, the children worked in one of two types of dyads:

- The dyads composed of a competent peer and a novice peer (C+N, condition 1) and,
- The dyads composed of a competent-by-instruction child and a peer novice (CI+N) (condition 2).

No scaffolding or no tutoring was involved in these interactions since the children did not know their status or that of their partners. All the children were then tested again during a post test session.

<Insert here Figure 1>

Material and Procedure

Stages 1 (pre-tests) and Stage 4 (post tests): the same material was used in these two sessions. It consisted in presenting the Kohs cubes task as it has been elaborated by Kohs (1923/1972). The child had to solve seventeen items of increasing level of difficulty as the number of cubes needed to solve the task increased (from four to nine and then to sixteen cubes) and as the model to reproduce became more and more complex. The scale of the model was smaller than the scale of the figure the child constructed with the cubes (¼ to 1). The researcher testing the children recorded both the time taken by the child for finishing each construction and the accuracy of the construction. The test was stopped when the child made two consecutive errors.

Stage 2 (training): The training given to the future CI children consisted in teaching them strategies to solve the problem using an easier model facilitated the task because it was at the same scale as the cubes used to construct the figure and was based on an explicit grid.

Stage 3 (interactions): the material used during the third stage of interaction consisted of three items composed by sixteen cubes that the children had to construct together. These three items were new as the children had not seen them during the precedent stages. The scale used in this stage was ¼ without any squares.

All the stages of the experimentation were videotaped and the progression through the four stages took place over a week for a given classroom, given that no children passed two stages on the same day.

Coding

The interactions of the eight dyads have been transcribed and coded according to previous research whose objective was the study of the interactive dynamics (Liengme Bessire & al., 1994; Nihlohlm & Säljö, 1997). Four dimensions of the analysis of the interactive solving problem session (stage 3) are proposed:

(1) The first dimension consists of the active demonstration of strategies used or the fact that the strategies used are merely rendered visible to the partner. For example they could point a cube on the model or on the construction in order to draw their partner's attention. This pointing may also be addressed with verbal explications (for example, "look there we are on this line then we are going to try this block there, you see do it"). This dimension was coded on each cube placement for each of the children.

(2) The second one relates to the management of the task: shared responsibility or not shared responsibility. Does the responsibility is assumed by all the partners or by one of them only? It is thanks to the grid of analysis used in the third dimension that this responsibility is coded for each item during the stage 3 of interaction. Does the placement of a cube or a block come from a collective decision or an individual one? How does this shared or individual functioning evolve during the interaction? The children who are developing the modes of interactions 3, 4 and 5 belong to the category of shared responsibility between the partners of the task whereas the modes 1 and 2 refer to an individual responsibility of the task. This notion of shared responsibility has been studied in several researches about the mother-child interactions (Wertsch & Hickman, 1987, Werstch, 1979).

(3) The third dimension concerns the modes of interaction or the patterns of the relations between the children which are analysed according to a grid of analysis composed of five levels constructed from previous works on the interactive dynamics and on cognitive processes (cf. table 2). The levels one and two have the particularity of being individual modes of resolution even if the instruction is "working together" whereas the other three levels (3, 4 & 5) imply social coordinations.

<Insert table 2>

(4) The fourth dimension relates to the number of correct placements of cubes in interaction for each partner. We pick out the correctness or not of the construction (more precisely for each placement proposed) made by each participant during the realisation of the three items of the stage 3.

General results

The detailed analysis of the results of the present research is still in progress. The general results that have been treated, however, are close to those observed by Nicolet (1995). Indeed, the modalities with which the subjects have acquired their expertise appear to have little influence on their cognitive development during the experimentation. Nicolet (1995) did find, however, that novices who interacted with a peer made more progress than those who worked

with an adult. This result was not replicated by the present work. Moreover, in contrast to Grossen& al.'s (1997) results[3], CI children in our study did not regress. In addition, we did not observe differences between N children who interacted with CI children and N children who interacted with C children whereas Grossen & al. (1993) reported a more important development of novices who had interacted with CI children compared to those who interacted with C children. We also observed that, overall, novices' performances on the post-test were better than the novices' performances observed by Grossen (1997; see Tartas & al., 2003, Tartas & al. 2004, for more details about this finding).

Because of the different patterns of development observed in the different conditions of the experimentation, eight dyads were chosen according to the progress observed. Such progress was evaluated by comparing the performances of children between the post- and the pre-test. It is interesting to focus on "extreme" dyads' which either illustrate cases where the novices significantly progressed at the post-test (around 7 items or more) or cases where novices made little or no progress. Accordingly, we chose four dyads in the first condition (C+N interactions): two where significant progress was made and two where little or no progress was observed. We also selected four dyads from the second condition (CI+N interactions) following the same selection criteria (see table 1).

<Insert here table 1>

Results by case studies

1) Evolution of the active demonstration of the strategies during the interaction (dimension one)

In order to follow the interactive dynamic step by step, we focus on the way the partners make visible and accessible their strategies to their partner. We pick out if the child renders explicit his/her strategies to his/her partner using verbal indications or/and gestured ones. For example, a partner may direct his/her partner attention on a specific place on the model or construction, anticipate on what has to be done after or the child who is making the building may construct the figure without any means given to his/her partner which allow him or her to understand what it is done. The question we examine is: are the dyads different from each other in the way they rely on the active verbal and gestured demonstration of strategies? We attend that such a resort is rather present in the dyads in which the competent partner has acquired his/her competencies by scaffolding training with an adult than in the dyads of the condition 1.

We calculate the mean number of placements with active demonstration of strategies (that is to say the number of times the child verbalises or demonstrates by gesture how he/she solves the problem to the other divided by the total number of attempts to solve the task) for each of the three items of the interaction (stage 3).

The dyads Competent-Novice (condition 1: C-N)
<Insert figure 2>

There are many differences in the way the strategies are used and demonstrated explicitly to solve together the problem. In the dyads 1 & 2 (in which the novice progress a lot in the post test), the enounced strategies come essentially from the competent peer who both explains and shows how to solve the task. For example, Clement (C) explain to Benoit (N) in the dyad 1:"now, we will do the contrary… so the white triangle and here it is and then a red one (he shows at the same time his partner how to assemble two blocks in order to form a triangle). In the dyad 2, Martin (C) said "look like that there (he points the first line on the top of the figure), I have already done the top". These few interventions become explicit either because of the novice's request (for example, Thibault (N) asks his competent partner Martin: "Wait, wait how have you done that?!" or because the competent participant notices an error produced by his partner and wants to rectify it: Martin (C) said to Thibault (N): "no no because look! (pointing the building still in progress), there are already four blocks, look it's four by four", after this explication, he let Thibault correct on his own the cube he has posed on fifth position and then, they come back to an alternated mode of construction.

The dyad 3 is characterised by the fact that a majority of the strategies are clearly explicit to the partner (more than 70% of the actions produced are explicit) whereas the other dyads resort less to this explicitation of the strategies used. The particularity of the dyad 3 comes from the specificity of the novice's behaviour who always asks his partner what to do, how to do it, and what comes after and who accompanies his action of verbal comments. So, this dyad has a special functioning which relies on a lot of verbalisations and active demonstrations from both of the partners. But the novice does not take into account his partner's explicit strategies in order to solve the problem. Thus, the dyad 3 can be called "explicitations and verbalisations without consideration".

In the dyad 4 ("few explicitation without anticipation"), the explicitations are used to give the general framework to initiate the interaction and the building: "I have finished the first stair and then let's begin by another one" tells Alessi (C) so Aloys (N) answers "I do the bottom" then, they are concerned by what has already been done but never anticipate on what it remains to be done and on how to do it.

The dyad Competent by Instruction (CI) - Novice (N) (Condition 2)

<Insert figure 3>

The dyad 5 (learning and transmitting through active demonstrations, anticipations and verbalisations) is clearly different from the others: the percentage of strategies explicitly used for the partner is very important for each item compared to the other dyads. Henry who is became competent by scaffolding instruction (CI) uses, the learning script proposed by the adult during the stage 2 of training, and, proposes it to his partner: each pose is accompanied by verification on the model and anticipation is proposed. And then, he explains how he does to realise his objective. He gives the first instruction at the beginning of the interaction "let's begin by the corners" then, " we had to do the line", and then, he shows his partner how to divide the model with the cubes by building an entire line and by verbalising the colour and the forms of the cubes, then, he lets his partner practice this technique "now it is finished, so it's your turn, do the line" and he helps him when the novice makes a mistake or doesn't know how to do. The anticipations are numerous from the competent partner "we had to the two lines left" so it leads the novice to anticipate too, Mergim (N) "like that, three blocks are missing and then it will be finished!". This explains why there is an important co-constructive collaboration development in the last item (item 3): both of the partners remain explicitly to

anticipations and explanations about how to do. We can find here some traces of learning within interaction.

The dyad 6 (punctual active demonstrations without verbalisations) is characterised by co-ordinated actions between the partners without remaining on verbal instructions. The first intervention allows the participants to both focuses their attention on the same part of the figure, and then the two girls place a cube at a turn. Rachel forces sometimes her partner to realise a part of the figure whereas she builds another part. The negotiations and arguments and counterarguments are gestured, the partner prevents the other from adding a block by taking the block her partner poses in order to place it well on the building and proposes her a new configuration.

The dyad 7 and 8 are characterised by a strong implication of the competent peer trained by scaffolding. The novice intervenes very few in the dyad 7 (no strategies to render visible the ways to solve the problem).

In the dyad 8 (punctual verbal demonstrations without consideration), the novice manifests himself when he is disappointed not to have a possibility to intervene. The verbal explanations given by the competent peer seem to be rather addressed to himself rather than to his partner. Indeed, it seems that the competent child speaks in a loud voice what he does and this verbalisation seems to be regulative of his own actions on the task. His partner does not take into account the informations he gave during such verbalisations.

Our hypothesis on the strategies which would be more explicit in the dyads of the condition 2 (the ones where the competent partner have received an explicit training of strategies) is not verified on these eight dyads. Indeed, the active demonstrations of the strategies is very irregular depending on the dyad and does not depend only on the condition of acquisition of the competence but also depends on the way the children interpret the instruction "working together" and give meaning to the task and their partner's actions. Nevertheless, it seems that such a tendency is characteristic of the dyad where the novice's score in the post test increases a lot compared to the ones where there is no cognitive growth observed on the post-test. Indeed, in the dyads 1, 2 and 5 (it is less evident in the dyad 6) the use of verbal explanations during the building of the figure and the re-use of them by the partner whom they work with is more frequent than in the dyads 3, 4, 7 and 8. That is to say that the use of active demonstrations on their own is not sufficient to explain the progress for both partners. But, it is necessary that it becomes re-used by the partner, so that, it will be at the origin of the other's action. Further analyses on this particular point are needed on a large number of dyads.

2) How do the children share between them the control of the task or the common responsibility of the task? (dimension 2)

The notion of shared responsibility or shared control of the task is rooted in the first research of the study of mother-child interactions and the analysis of the transmission of knowledge depending on the control of the exchange by the adult (Nilholm & Säljö, 1997; Wertsch & Hickman, 1987; Wood, Bruner & Ross, 1976). They allow illustrating the interactive dynamics in terms of division or distribution of cognitive and manual work between the partners in order to solve the task. What does it take place in terms of such distribution between the two children when they have to work together?

Condition 1: dyads C-N

Dyad 1: Alternation between shared responsibility and individual control of the task

<Insert figure 4>

The two partners begin first by sharing the building of the first item between them to solve the task: the novice begins the exchange and both of the partners end it. Then, they construct the figure each other on their own without coordination. They place a cube at a turn and construct a part together. For the item 2, the competent peer initiates the exchange and the building and ends it. They go on the same individual mode to build the second item and then they coordinate their actions after an error made by Clement that is remarked by the novice partner, Benoit. Following this coordination, they go on this collaborative way of working. The last item is individually constructed: each child is building a part of the figure; the control of the task begins to be shared when there is an error which is detected and when they both engage in finding a solution. It is always the competent peer which initiates and ends the work. The collaborators mainly rely on doing rather than on verbal accounts to manage the task.

Dyad 2: Frequent shared responsibility under the competent partner's impulsion

Insert figure 5

For Martin and Thibault, "working together" means that they have to tell their partner what they are doing and how to do it when they don't know. Martin explains and shows his partner how he solves the task and he gives his partner a task to solve. For example, "you had to do this part of the figure on the bottom". Thibault, the novice, initiates and ends the exchange for the first item. For the second and third items, Martin initiates and ends the exchanges. For these two last items, the control of the task is shared between the partners and there are only few punctual moments where the building moves to individual work for one or another partner. The competent child is the one who fixes the objectives, reminds his partner of them in the course of the interaction and very often controls the building. The novice sometimes fixes rules that he loses during the problem solving activity and that his partner reminds him of.

Dyad 3: When shared responsibility becomes a constraint

Insert figure 6

The interactions through these three item building were particularly at the origin of doubting and questioning of the competent peer, Pierre's actions by the novice, Anton. Pierre begins to build the first line of the item 1 with two cubes without coordination with his partner Anton, then, the latter intervenes and places two other cubes. Pierre wishes to finish the line he has begun and explains it to his partner. The children disagree on how proceeding:
Anton : " Here it is, we have done all this part, now the side"
Pierre: "Wait we have to do the square"
Anton: "the side"
Pierre: "but it is already done we have to do here"
Anton: "no the side on the bottom we are going to do the bottom"

Pierre: "Ok"

Each placement done by the competent peer is argued by his novice partner so there are few moments where the competent peer tries to progress on his own. Anton (N) initiates the building and Pierre (C) ends it. This latter initiates and ends it for the second and third items. Pierre (C) spends his time asking his partner to wait in order to let him understand what to do and how to do it. It seems that the novice tries to build something without having a methodology to do so but simply he wants to impose his point if view. So it leads to a shared management of the task but this particular mode seems to destabilise the competent child who seems to loose his time by explaining his partner how to do and rebuilding incessantly the figure.

Dyad 4: None shared control of the task with very punctual shared responsibility

<Insert figure 7>

Alessi, the competent peer, initiates the work for the two first items and Aloys, N, initiates the last one. Aloys ends the constructions for the three items very often because his partner lets him place the last cube, so it is not a real shared responsibility. The first and last items are co managed punctually by both of the partners in part: the competent peer places the cubes and builds the figure whereas the novice intervenes to argue some placements or to confirm them. The item 2 is completely managed by the competent peer and the novice blames his partner for doing it on his own.

The dyads competent- novice (C-N) are very different in their ways of distributing the responsibility of the task. The patterns according to this criterion "shared responsibility or not shared responsibility" are very different according to the items (the distribution is not the same on the first one, neither on the second or the third one) and according to the way each partner engages himself in the work and according to the role he assigns to his partner.

Condition 2: The dyads Competent by Instruction- Novice   (CI-N)

Dyad 5: Invitation to construct a shared responsibility of the task

<Insert figure 8>

The shared responsibility characterises this dyad where the competent peer which have acquired his competencies by instruction makes his work explicit to his partner and asks him to build the figure with him. It seems that learning with the adult allows him to understand which question he had to ask in order to solve the task and how to do to answer it. Then, he brings his partner in this logic of learning (to know which kind of question you have to ask in order to solve the problem) which makes his partner begin to become an active member of the dyad. The competent partner initiates the three items and ends the first one, whereas the final two ones are ended by both of the partners.

Dyad 6: When the novice's dissatisfaction leads to shared responsibility

<Insert figure 9>

The shared responsibility characterises the dyad mainly for the two first items. The competent peer by instruction initiates the building for the two first items, the novice ends it for the first one and both of the partners end the building for the second item. For the last one, the competent peer, Rachel, acts on her own without taking into account her partner. It is on the demands of the latter that the control of the task moves from an individual one (the competent child controls the task) to a shared responsibility. There are social reasons (the fact that the novice is not satisfied not to have the possibility of intervening) which are the causes of the shared responsibility of the task.

Dyad 7: When not shared responsibility helps the solving for the competent peer

Insert figure 10

In this dyad, the competent peer by instruction controls the management of the task that is to say that she is the only one who decides to place cubes in order to build the figure. It is only very punctually that the novice intervenes or asks in order to intervene. When the novice made such an intervention, she transforms the interaction which moves from an initial individual mode of construction to a shared one. This shared mode of management is used at the end of the first item and is maintained through the second one but changes in the final one. The difficulty encountered by the competent partner in the third item leads her to maintaining her attention too much on the item so that she controls the situation without taking care of her partner. The latter's attitude alternates between a total passivity (she only looks at her partner's actions without action) and an acquiescent behaviour (she approves her partner's actions) as been defined by Gilly & al. (2001).
The competent child initiates the exchanges for the three items and ends them or let her partner ending them after explaining her how to finish the building (items 1 & 3). The competent peer seems to be "in danger" when she had to solve the task with the other, so the individual mode of resolution is for her a less costly and more efficient way of solving the problem.

Dyad 8: When the responsibility becomes increasingly shared through the interaction

Insert figure 11

The two modes of control of the task are found in this dyad: for the two first items, it alternates between an individual (*i.e.* none shared) mode of control managed by the competent child and a shared mode of control between the partners. The competent child first takes in charge the building and initiates the construction of the three items, and then the novice reminds him of the instruction "working together" which have an effect on the mode of management of the task. It leads to a collaborative mode of management between the children: each of them places a cube or two by alternative. The end of the item 1 is then managed by the competent peer on his own, who checks his placements compared to the model and makes corrections if necessary. This solitary mode of management goes on at the beginning of the item 2 and then, the novice intervenes in order to offer his partner some solutions. The item 3 is socially distributed for the control of the task. It is more often both of

the partners who end the task for the three items. The evolution towards an increasing shared control of the task appears in the course of the resolution of the third item.

The dyads CI-N of the condition 2 are characterised by a shared control of the task in particular for the dyads 5 and 6. The particularity of these two dyads is that the novices make a lot of progress in the post-test. But as the results show, the control of the task is shared on very different ways depending on the dyads and the items to solve.

3) Different levels of modes of interactions or different types of management of the interaction

We are going to analyse the ways the eight dyads construct the interaction in order to solve the task according to the five levels of analysis elaborated from different works on social interaction made in Neuchâtel and the works in socio-cultural psychology on adult-child relations (Wertsch & Hickman, 1987).

The dyads C-N (condition 1)

The dyad 1: Alternation between individual (mode 2) and collaborative modes (3 & 4) of resolution

<Insert figure 12>

The mode "individual construction without coordination" is characteristic of the dyad 1. However, the collaborative modes 3 "individual shared construction" and 4 "alternated construction" are also privileged by the two children to solve the problem. So, the children begin the building by placing a cube in turn (mode 4) and then, build, on their side, a part of the figure and construct together when they have to assemble their own construction (mode 3) and end the first item building by an individual construction assumed by the competent peer. For the item 2, it is mainly the competent peer who has in charge the building, the novice partner proposes sometimes his own building to assemble with the one built by his partner. For the item 3, the children begin to work individually without coordination (mode 2) and then, they build a part of the figure on their own side and assemble together their building (mode 3) and conclude by a common alternated construction (mode 4). This pattern is exactly the contrary of the one used for the item 1. More generally, the items are solved quickly by the children in less than two minutes each.

The dyad 2: Resolution on several collaborative modes (modes 3, 4 & 5)

<Insert figure 13>

The interaction evolves a lot in the course of the resolution of the three items in this dyad 2. The mode 3 of individual alternated construction and the modes 4 and 5 where the activity of resolution is more co-elaborated are the more frequently used. The ways to access to co-elaboration (mode 5) are never the same during the resolution of the three items. There are indeed important styles of interactive dynamics used by this dyad in order to solve the problem. The two first items are solved in two minutes and the third one in three minutes.

The dyad 3: Social conflicts and collaborative modes (modes 3, 4 & 5)

<Insert figure 14>

This dyad is very socially conflicted: the novice tries to impose his way of doing or contradicts his partner without reason and the competent child always reacts in an explicative way. It evolves on collaborative interactive modes through a shared individual mode (mode 3), an alternated construction (mode 4) and also co-elaboration (mode 5). The interactions are particularly long (the item 1 is solved in three minutes, the item 2 in twelve minutes and the item 3 in eight minutes) because of the novice who prevents his partner from following his ideas to solve the problem and who disturbs considerably his partner's strategies. The patterns of interaction develop in the course of the resolution.

The dyad 4: Individual modes of resolution (mode 2) with punctual moments of co-elaboration and co-construction (mode 5 & 4)

<Insert figure 15>

The mode 2 of interaction is constant in the resolution of the three items by this dyad 4. Indeed, the competent child seems to assume the building (mode 2) with moments of alternated construction between the two partners (mode 4) or co-elaborations (mode 5). The move from mode 2 to mode 4 or 5 is more often due to the detection of an error. The children work fast on these items resolved in two minutes. There is little evolution in the way they solve the problem.

The dyads CI-N (condition 2)

The dyad 5: collaborative modes [co-construction (mode 4) & co-elaboration (mode 5)]

Insert figure 16

The modes 4 and 5 are particularly characteristic of the interactive dynamics of this dyad with more diversity of modes of interaction during the resolution of the third item. The placements of cubes are social constructions distributed between the partners. They more often accompany by verbal explanations (from the part of the competent peer) which are re-used by the novice. Each item is solved in five minutes for the two first items and six for the last one. In the course of the exchange between these two children, a "proximal zone of development" as Vygotsky (1978) proposed is elaborated in the sense that the competent partner has managed to create a space where he allows his partner to learn to solve the task first under his control and then, he gives his partner more space to solve on his own the problem. The novice relies on it and even becomes, at certain moments, the one who reminds his competent partner of the rules and strategies which have been initially proposed by the latter. The interactive dynamic develops in the course of the collaborative work.

The dyad 6: Punctual co-elaboration when assembling shared individual construction (mode 3)

< Insert figure 17>

These partners begin their work by a mode of shared individual construction (mode 3) which necessitates partial coordinations when they assemble their individual building and it evolves towards a co-elaboration (mode 5). This mode is used mainly after common alternate mode when they have to negotiate and confront their way of assembling their blocks. The interactive dynamic progresses also in the course of the resolution and allows the partners both to expose their strategies to the other and to learn from the other. The time used to solve the task increases: the first one is solved in two minutes whereas the second one took nine minutes and the last one eleven minutes.

The dyad 7: Individual modes of resolution (modes 1&2) are preferred to collective ones (mode 4)

<Insert figure 18>

The first item is solved on a no collaborative mode (mode 1 where only one of the two children, the competent peer, works) and finished on a more collaborative mode (mode 4) whereas the second item is solved on an alternated collaborative mode (mode 4). The last item begins on the same mode (mode 4) but it seems like if this mode becomes too costly to go on for the competent peer (competent by instruction) so she prefers to work on her own (modes 2 and then, 1). The dynamic is completely different in this last item and is exactly in the reversed order compared to the first one. The time taken to solve the problem decreases during the resolution (4 minutes for the first item; 3'30 for the second and 2'52 for the last one). Acting with the other, trying to work together takes more time than bringing on his owns the solution, so individual mode is finally preferred by the competent peer.

The dyad 8: Punctual moments of collaborative modes (3 &4) of resolution and individual ones (mode 2)

<Insert figure 19>

The two first items are solved with the same modes of management of the task by the partners: the building is first individual without coordination (mode 2) and then, becomes alternate construction (mode 4) that is to say that each child is placing a cube, one at a time, and controls his building as well as his partner's. Then, there is an individual mode with punctual moments of collaborative modes or resolution that is to say that the individual buildings become collaborative when the children try to assemble them (mode 3). The last item lies on a co-elaboration that is to say that negotiations are used to solve the problem. The novice does not make any benefits from the interaction as his post-test shown although the children managed to construct punctual spaces of negotiation. It seems as if the novice can begin to learn strategies in the last item but as if it seems too short to be able to grasp strategies and be able to re-use them later when he is alone in front of the task. The time used to solve the three items evolves few (4' for item 1, 5' for item 2 and 3'40 for item 3).

4) The number of correct poses during the resolution of three items in the interactive session

<Insert figure 20>

The results of patterns of correct attempts show a difference between the two conditions of being a competent child on the task. The competent (C) children in the pre-test made less errors than the children who have acquired their competence by instruction (CI) during the stage 3 of interaction $(F(1, 22)=7.891, p=0.01)$. So, when they act with a less competent partner, the competent children C of condition 1 made less errors compared to the competent children CI of condition 2 who are more susceptible to commit errors. Otherwise, there is no difference between the correct actions of novices who work with them. Further analyses are needed on a large number of dyads.

Discussion-Conclusion

The principal results, highlighted from this detailed case study analysis, show all the complexity and the diversity of the ways of interpreting and acting the instruction "working together" given at the beginning of the stage 3. In this sense, they confirm our hypothesis. In order to explore this diversity, the case studies analyses show the different interpretation of the instruction by the different participants.

When examining the dimension called "active demonstrations", we notice that some of the dyads try to verbalise their actions as they place a cube, preplanning the following actions in order to explain their partner how to do with the cubes to reproduce the model. In this sense, the qualitative sequential analysis proposed in this paper fits in with the quantitative results on effective verbal interactions between peers (King, Staffiero & Adelgais, 1998). But our sequential analysis allows going further and shows that the verbalisations of strategies seem to have multiple functions in the different dyads. For example, in the dyad 5, effective verbal interactions (i.e. providing explanations to solve the problem, asking appropriate questions, using supportive communicative skills) allow the novice to understand the actions and ways of solving the task by his competent partner which has been instructed. They have communicative function as well as a function of maintaining the attention of the other. But they also regulate the behaviour of the competent partner (function of regulation of the action as Luria (1961) proposed). This latter function is used in some of the dyads: the verbalisations of the strategies are as inner speech which allows the children to control their own behaviour. This kind of language has been particularly found in the dyad of the condition 2 that is to say those which are composed by a child competent by instruction (CI) and a novice. It is as if the interaction of the stage 3 allows the competent partner to strengthen the strategies learned from the adult more often without the intention of transmitting them to their partner. Otherwise, they can sometimes be re-used by the novice if they make sense for him/her. But more often these verbal strategies seem to help more the one who are verbalizing them than the one who hears them. Making the strategies explicit for the other seems to be a necessary condition to solve the Kohs Cubes together but not a sufficient one in order to make them learned and used by the partner. The children, except the ones of the dyad 5, do not automatically verbalise their strategies but they can be verbalised when the novice intervenes and asks his/her partner how he/she has done or what he/she has to do. The verbalisations can also arrived in reaction to an error found by the competent peer (C or CI). These verbalisations have hybrid functions that should be further studied with more details in order to show if the children trained by the adult who are invited to verbalise their strategies use the language to regulate their action more frequently than the children competent as soon as the pre-test and what are the incidences on the partner. It would allow bringing some precisions on the children who learn strategies from the interaction and distinguishing on the one hand, how the children learn and on the other hand, how they transmit them to their partner. These

results are supportive of the research of Fawcett & Garton (2005) in which they have shown that children who were instructed to talk in a particular way in a collaborative phase were subsequently able to complete a relatively greater number of items from pre to post test compared to those children in dyads where there are minimal verbal interactions.

The analysis of distributed or shared responsibility (dimension 2 we examine) of the task between the partners (elaborated from the different levels of modes of interaction, modes 1 & 2 leading to a non shared responsibility whereas the modes 3, 4 & 5 relate to a shared one) highlights the important diversity of the management of the control of the task by the children. Some competent children (C or CI) found it easier to solve the task on their own rather than solve it with the novice child since taking the other into account was time-consuming and cognitively demanding. This analysis shows that the meaning of the task develops in the course of the resolution of the three items. The moves in the control of the task may more often come from an explicit demand of the novice who reminds his partner of the instruction given by the adult in order to participate in the resolution of the problem. This leads the competent partner to work no more on his own but with the other. This responsibility of the control of the task could be analysed by the means of who initiates and who ends the activity for the three items. Do the children take both the initiatives of beginning the task and ending it or does only one of them assume this responsibility? It seems that the analysis of such criterions shows some regularities when it is done on a large number of dyads (see Psaltis, 2005).

The sequential analyses of the development of the modes of interactions (dimension 3) during the three item solving provide great interest for research on collaborative learning. The results shown some of the children directly engage in the interaction to find a shared solution of the problem. In these cases, the ways to reach this shared solution are then diversified and varied: to count the number of cubes and then equally shared them between the two children, then to place in turn a cube or a block (mode 4) or in some cases, the children construct a part of the figure on their own and then try to assemble it with the one of their partner (mode 3) and then, initiate negotiations when their building does not fit the model, so they may sometimes move to a co-elaboration mode of resolution (mode 5). Some of them firstly co-elaborate (mode 5) during the first poses of blocks and try to find a common definition of the situation and get along with each other in order to attain the solution. Others, although they received the same instruction "working together to solve the problem", engage themselves in an individual work with an inactive partner or with a partner who loses his way of acting and adopts his partner's way of solving the task (modes 1 & 2).

The children who are solving Kohs Cubes move from a mode of interaction to another one as they act to construct the figure while the meaning of the task is changing too and so, whatever the experimental conditions. The implicit objectives each child constructs on the task lead him/her to interpret the instruction as a work to accomplish with the partner even if it takes time and if it is difficult to work with the other, and even if they make errors and are obliged to begin again… whereas for others, it is above all building quickly the item which is important or being the first to solve the task. The fact that the pre-test is chronometric may led such an interpretation of the instruction, so the partner choose to work on his own rather than with his partner in order to quickly finish. The task hasn't got the same meaning for the partners and all of them did not manage to agree with the definition of the situation. It will be interesting, in further analysis, to follow what the children interpret and understand of the task in the pre-test and how the comprehension of the task develops then in the following stages of the experiment. There is so a necessity of developing further studies in a longitudinal way on all the stages of the experimental plan. In this sense, the relations between the sharing of the same objectives on the task (for example to do quickly the construction or not to add a block

without the accord of his partner…) and the modes of interaction to solve the task will need to be studied.

Moreover what such sequential analyses offer is mainly to focus on the moves where an individual cognitive solution become a collaborative shared one, and open new questions. It seems that it is rather in the moves from one mode of interaction to another one that the learning may occur rather than being a part of a particular mode of interaction. So what we need now is to explore the changes or "crossings" from one mode to another one and try to analyse which moves or patterns of moves are likely to be important ones in cognitive growth. Examining the number of accurate placements during the interaction by the different partner, we highlight the fact that the CI children make more errors than the C children in these eight dyads. Further analyses on this particular aspect are needed on a large number of dyad.

The four dimensions of the cooperative learning activity analysed here represent some elements of a larger research program rather than complete results. At this state of our research, we have at least illustrated the variety and the complexity of cooperative problem-solving activity.

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Tables

Tableau 1 . Presentation of the eight dyads

	Dyades Condition 1 (C+ N)	Dyades Condition 2 (CI + N)
Progress in the post-test (number of solved item in addition compared to pre-test)	1. Clément - Benoît (+9 items) 2. Martin - Thibault (+7 items)	5. Henri - Mergim (+8 items) 6. Rachel - Ioana (+6items)
Stability in the post-test (number of solved items in addition compared to pre-test)	3. Pierre - Anton (0 item) 4. Alessi - Aloys (+3 items)	7. Marika - Marie (0 item) 8. Ismet - Fabrice (+3 items)

Tableau 2: Different levels of modes of interaction of the stage 3 of the experimental plan

Level	Non competent and competent child s' contributions
1)	*Modelling*: one child is solving the problem whereas the other one is looking at him being sometimes active (pointing the model, making oral interventions, suggestions…) or inactive.
2)	*Individual construction with no co-ordination*: each child works independently without taking notice of their partner's actions. The pattern is done without co-ordination eventually one child gave up his/her building in order to let his/her partner finish the pattern.
3)	*Individual shared construction*: it can be summarized with this child's suggestion: "you do the bottom and I do the top", each child has to build a part and then they have to assemble their construction.
4)	*Alternate construction*: each child is in turn putting a block. They thus construct the pattern together: the one who pauses one block is then the one who checks her/his partner's pause. The alternating of the role can be explicit or implicit.
5)	*Co-elaboration*: the partners construct the pattern together consult or even confront each other, negotiate the placing of each new block. They engage clearly in negotiation to find a common solution.

Figure Captions

Phase 1	Phase 2		Phase 3	Phase 4
	N		**Interaction:**	
Pre-test C			C + N (condition 1)	**Post-test**
	CI	**(Instruction)**	CI + N (condition 2)	
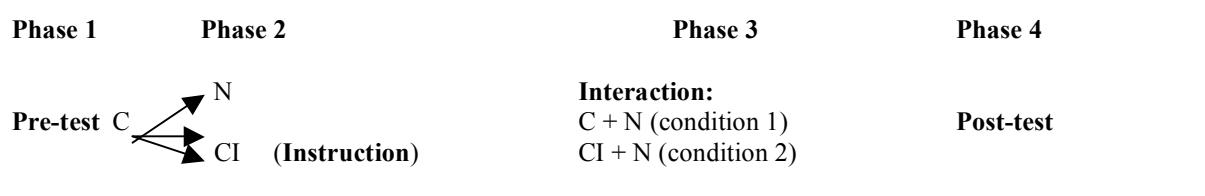
Figure 1. Experimental Plan of the research
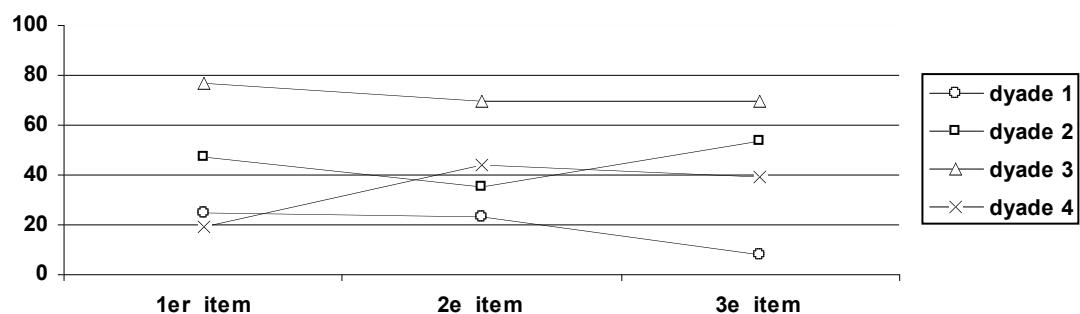
Figure 2. Percentage of active demonstrations of strategies in the course of the interaction for the dyads of the condition 1 (C-N)
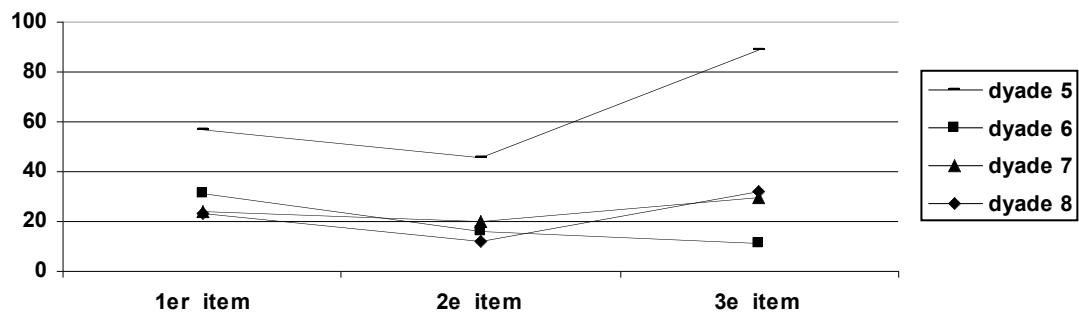
Figure 3. **Percentage of active demonstrations of strategies in the course of the interaction for the dyads of the condition 2 (CI-N)**
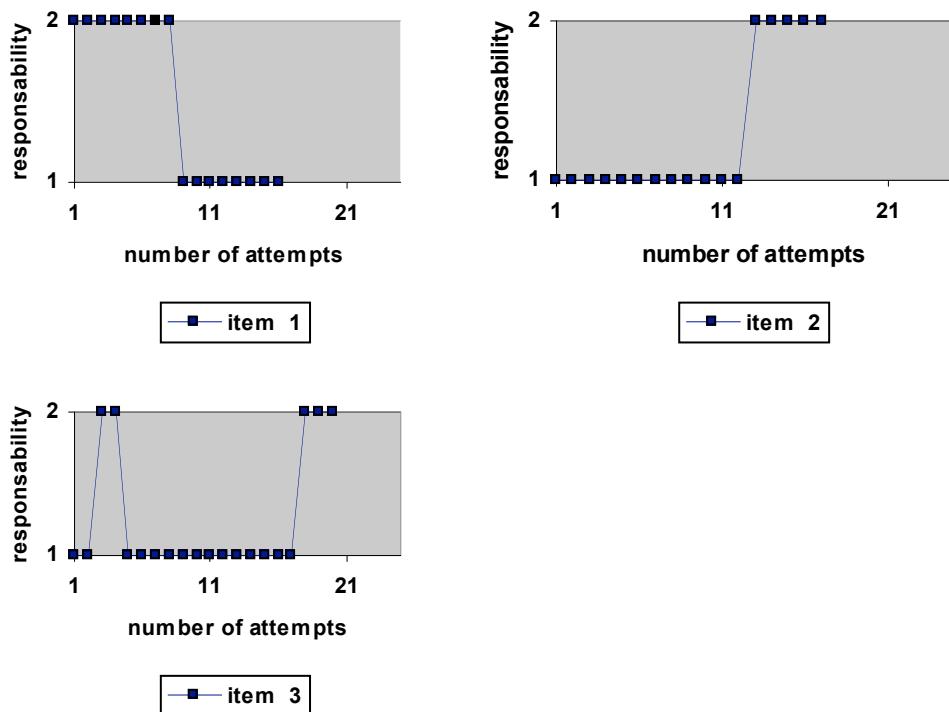
Caption :   1= not shared responsability
              2= shared responsability

Figure 4: Shared or not shared responsibility of the three item resolution of the stage of interaction by the dyad 1
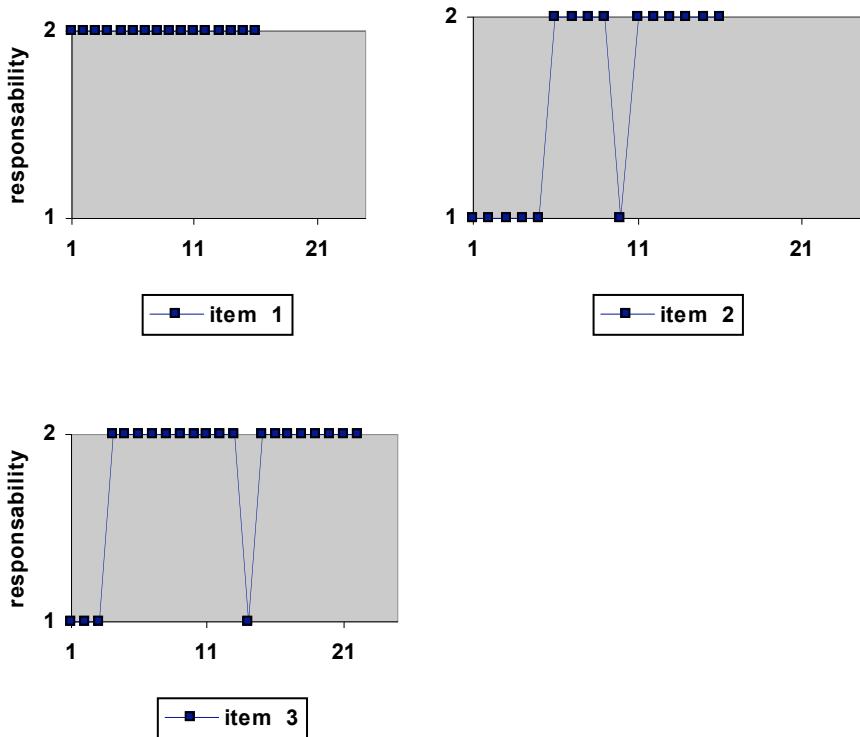
**Figure 5. Shared or not shared responsibility of the three item resolution of stage 3 of interaction by the dyad 2**
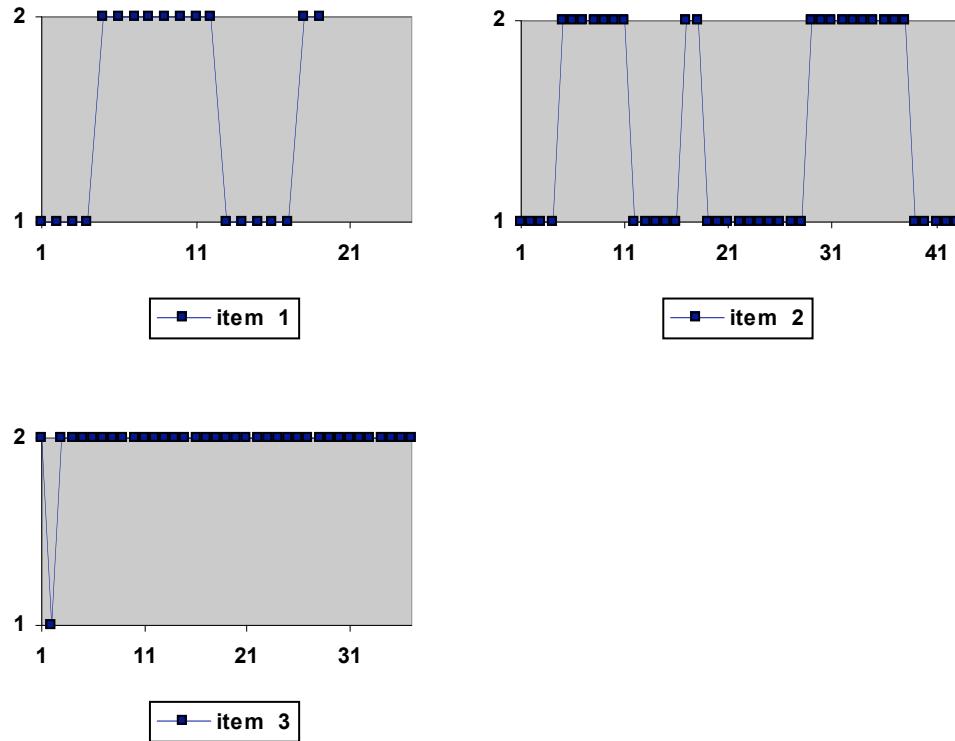
Figure 6: Shared or not shared responsibility of the three item resolution of stage 3 of interaction by the dyad 3
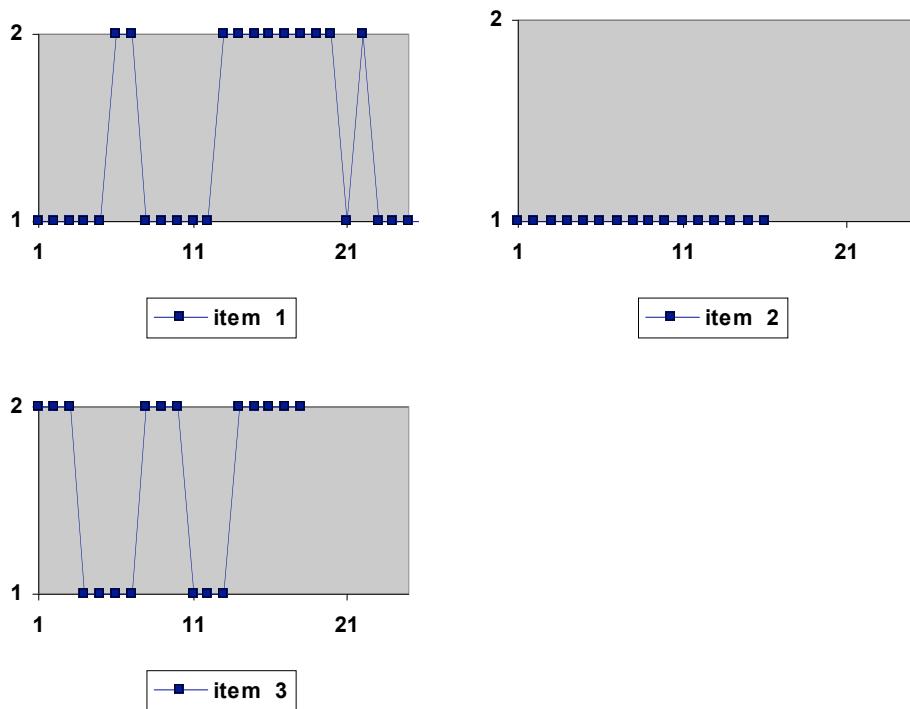
Figure 7: Shared or not shared responsibility of the three item resolution of stage 3 of interaction by the dyad 4
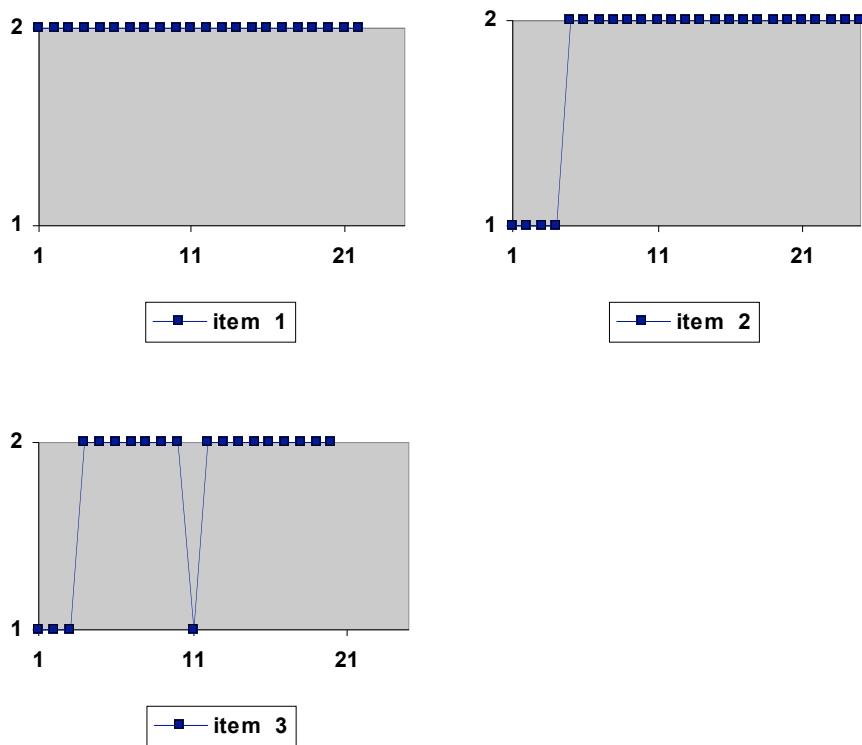
Figure 8: Shared or not shared responsibility of the three item resolution of stage 3 of interaction by the dyad 5
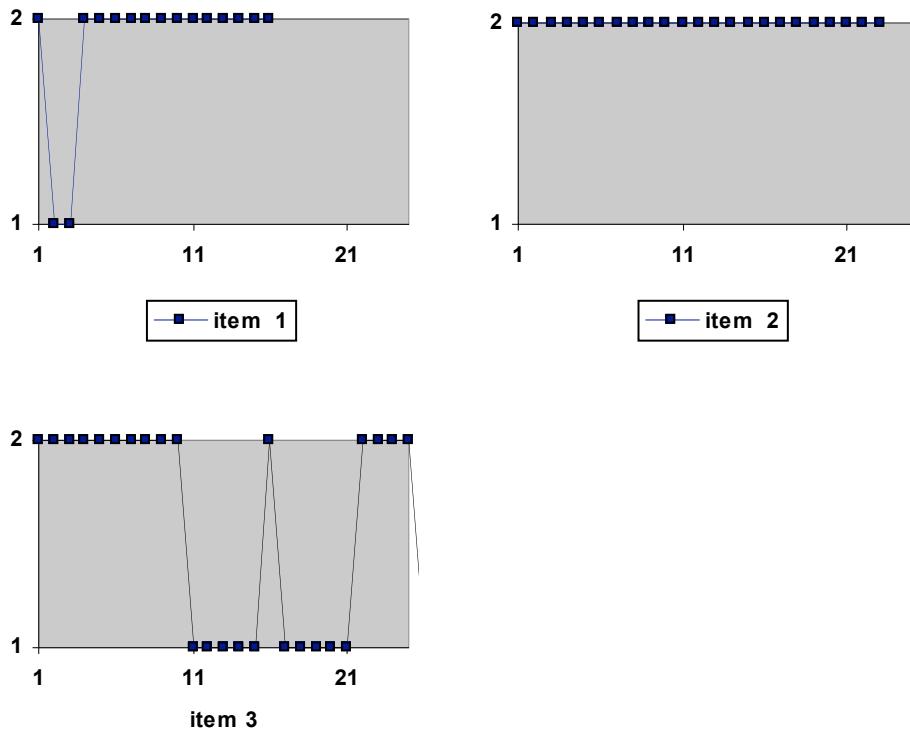
Figure 9: Shared or not shared responsibility of the three item resolution of stage 3 of interaction by the dyad 6
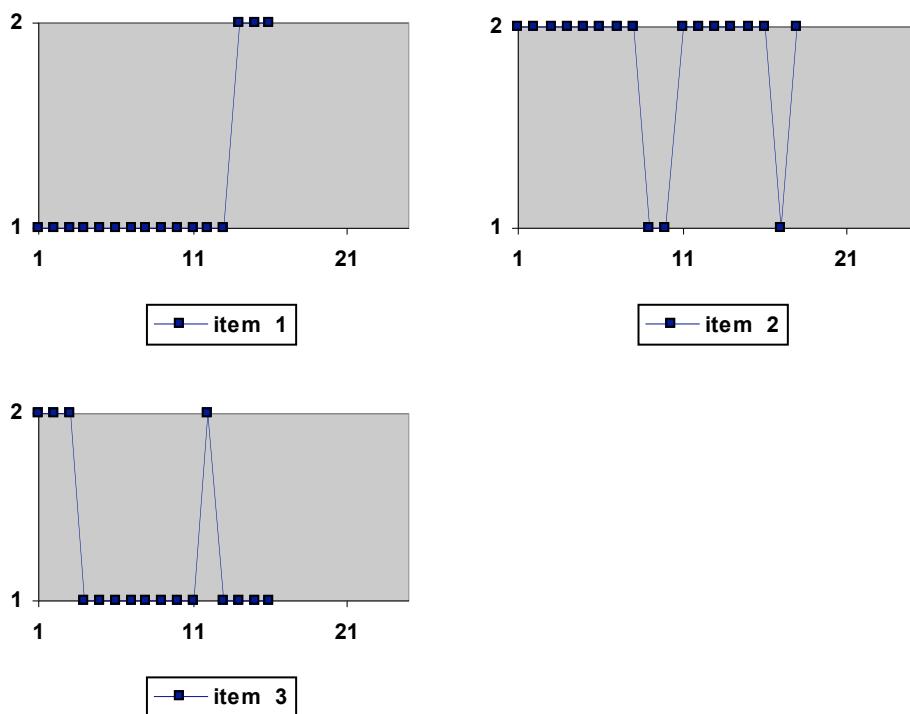
Figure 10: Shared or not shared responsibility of the three item resolution of stage 3 of interaction by the dyad 7
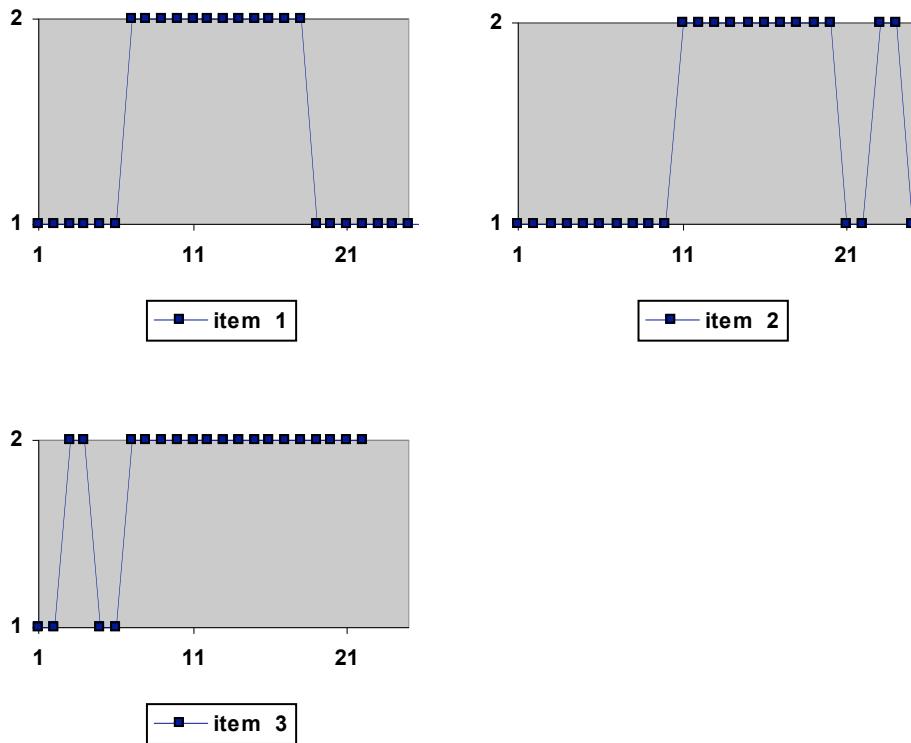
Figure 11. Shared or not shared responsibility of the three item resolution of stage 3 of interaction by the dyad 8
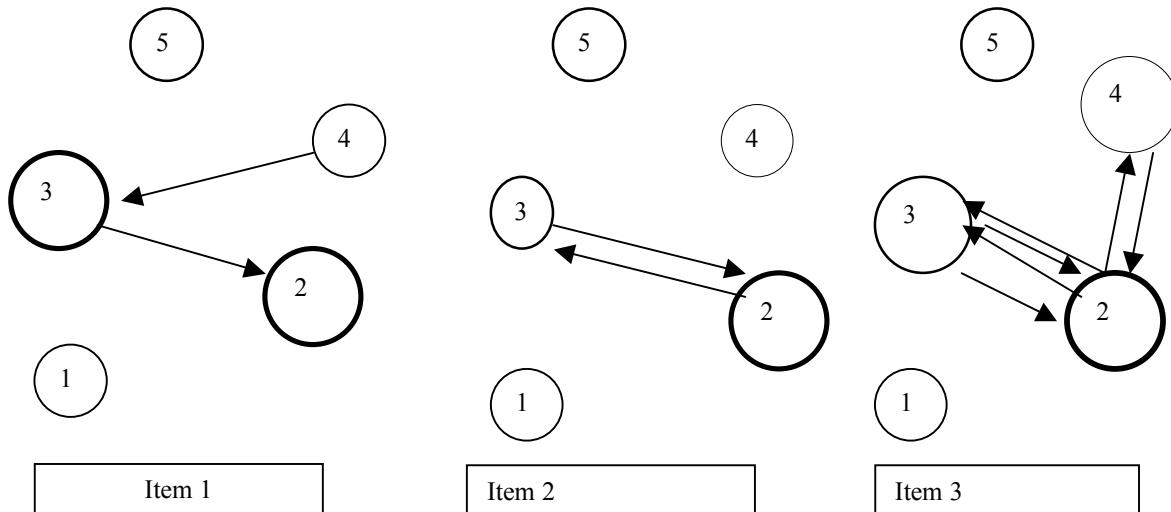
Figure12 : Evolution of the modes of interaction in the dyad 1 Clément et Benoît
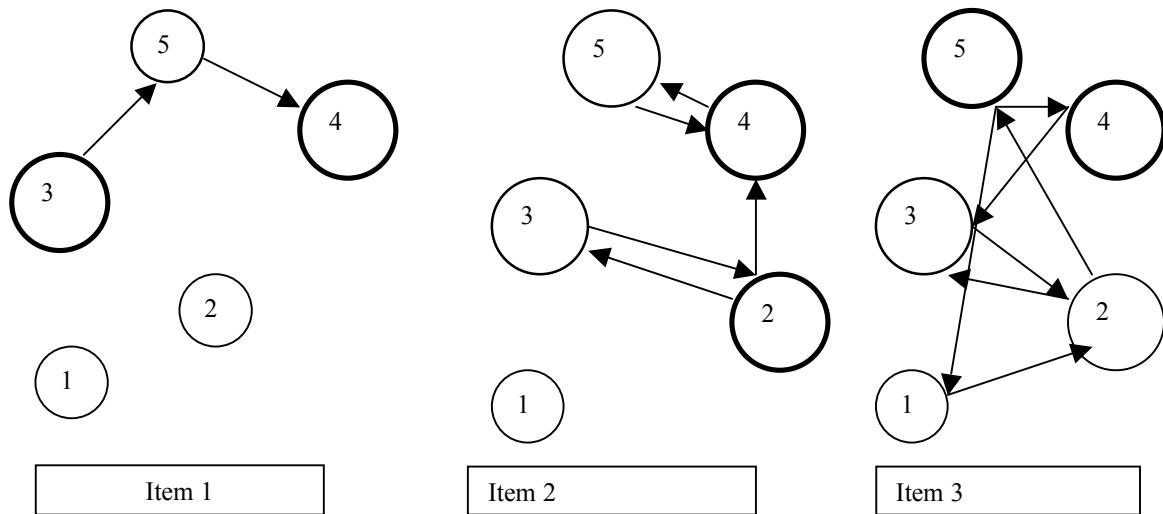
**Figure 13: Evolution of the modes of interaction in the dyad 2 Thibault-Martin**
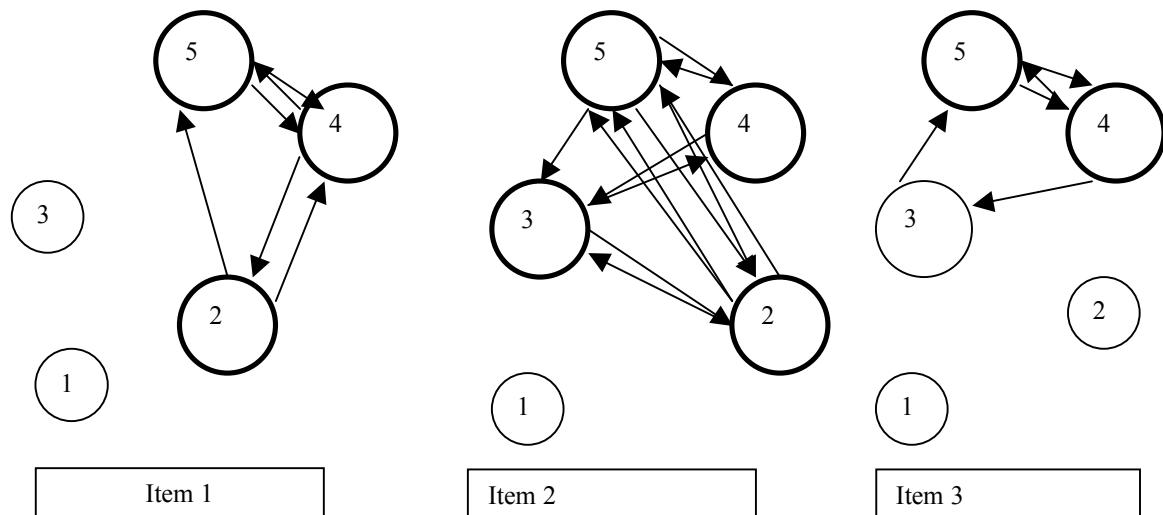
Figure 14: Evolution of the modes of interaction in the dyad 3 Pierre-Anton
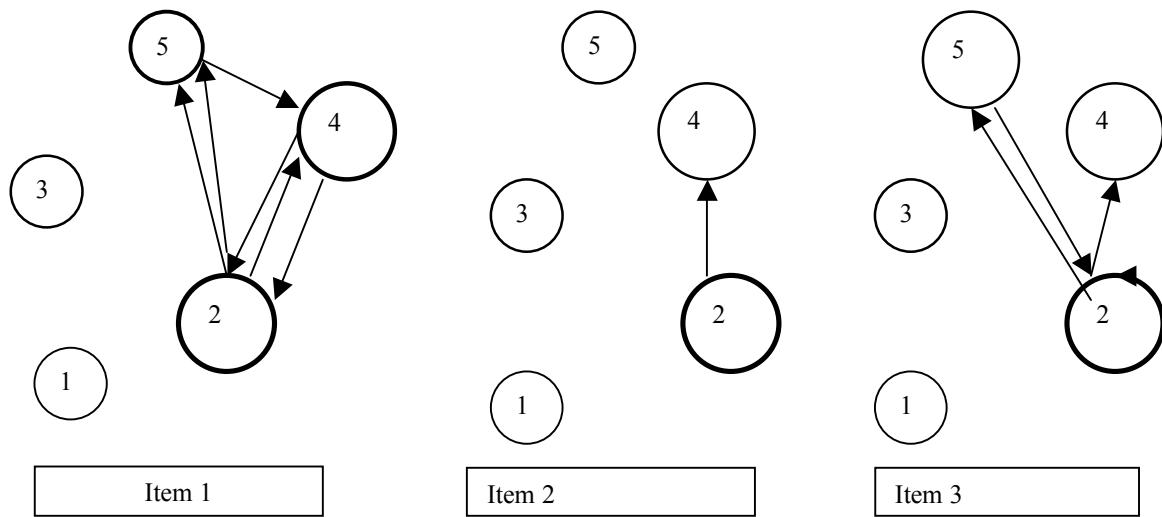
Figure 15 : Evolution of the modes of interaction in the dyad 4 Alessi - Aloys
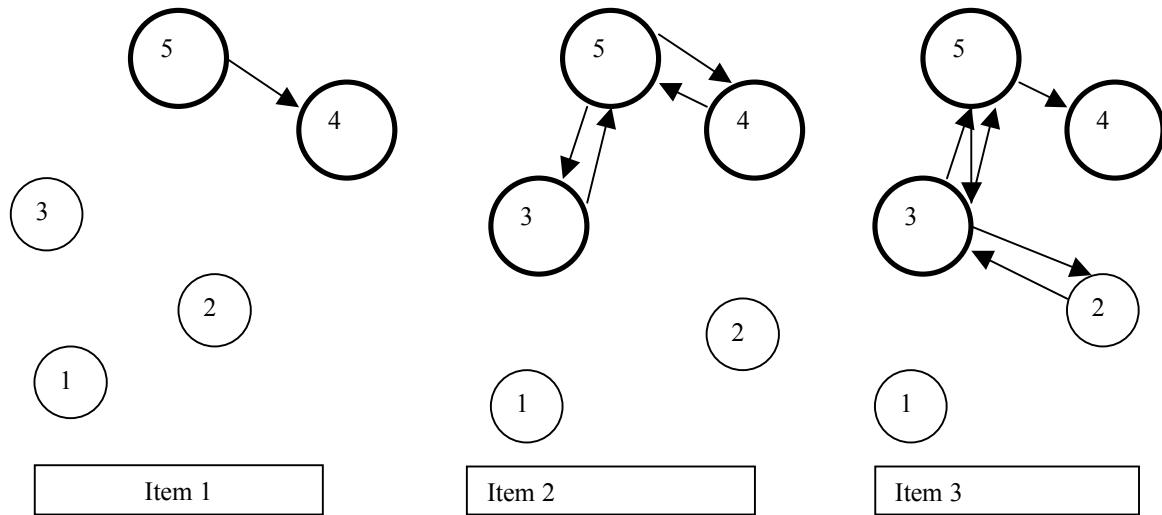
Figure 16: **Evolution of the modes of interaction in the dyad 5 : Henri - Mergim-**
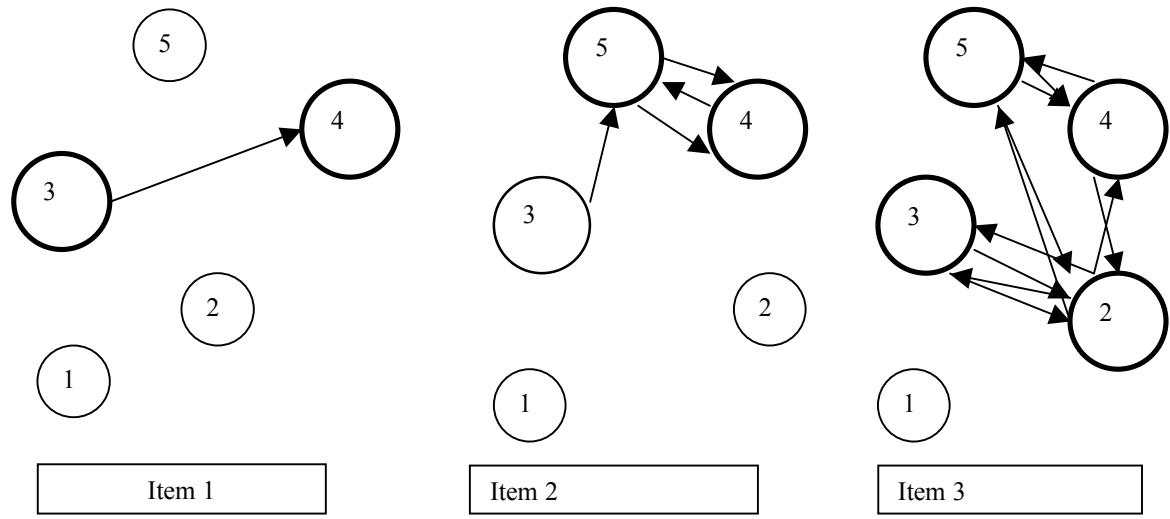
**Figure 17. Evolution of the modes of interaction in the dyad 6 : Rachel – Ioana**
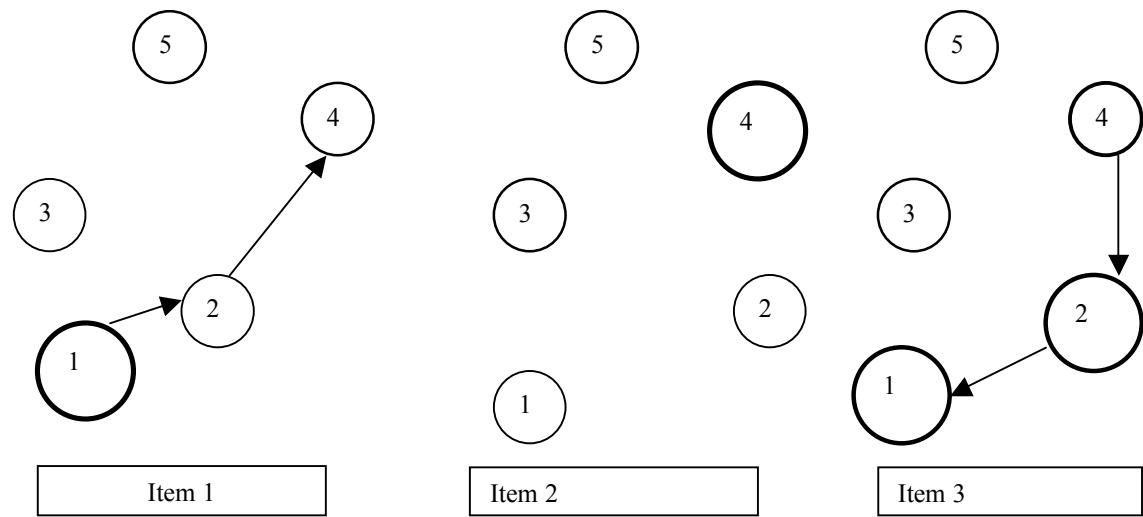
**Figure 18 : Evolution of the modes of interaction in the dyad 7: Marika-Marie**
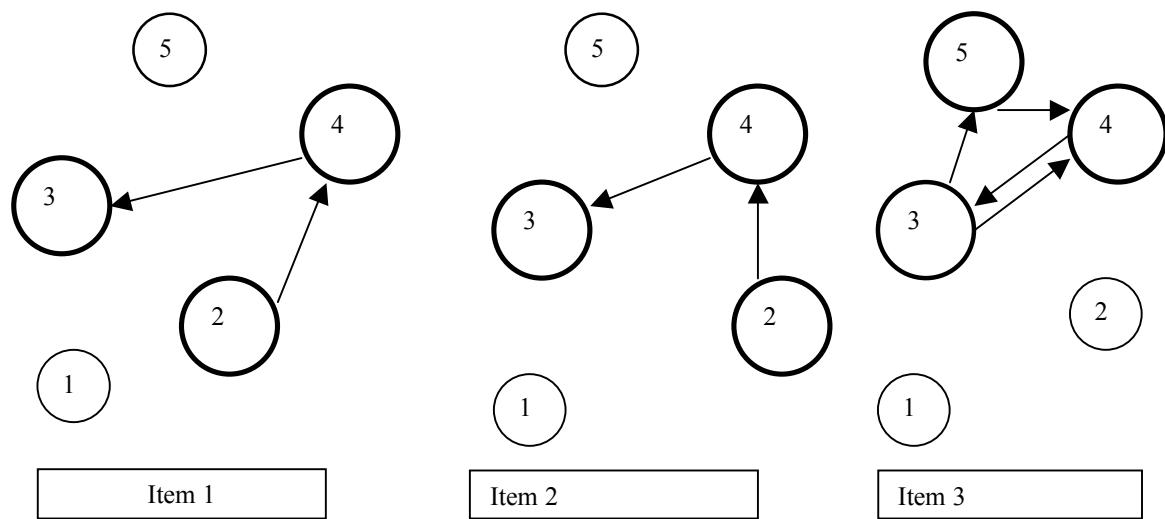
Figure 19. **Evolution of the modes of interaction in the dyad 8: Ismet-Fabrice**
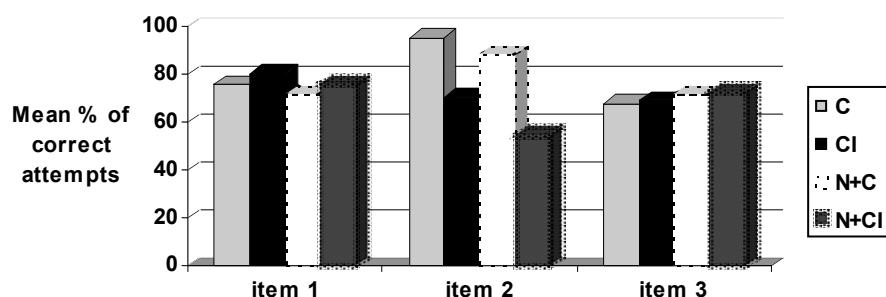

Figure 20. Mean percentage of correct attempts during the interaction (stage 3) according to both conditions and levels of competencies on the task.