Abstraction and Transfer in Collaborative Learning

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Abstract: The study conducted with 51 nurse students produced three results. First, the students who studied in pairs built more abstract representations of clinical cases than those working individually. Second, the fact of building a more abstract representation did not lead to higher scores in a transfer task. Third, the students who were trained with examples taken from varied contexts got higher scores in a transfer task than those working with examples from the same context. The partial contradiction between these results questions the relationship between abstraction and transfer. It may also indicate that the abstract representations built as a side-effect of grounding mechanisms were not internalized into personal representations.

Introduction

This research was inspired by a former study of Schwartz (1995) which showed that pairs construct together a more abstract representation than those built individually by any member of the pair. This study was conducted with secondary school students. For instance, while reasoning on the motion of linked gears, individuals tended to rely on gesturing concretely the moves of the gears while pairs induced a numerical parity rule (if gear 1 rotates clockwise, odd pairs will rotate anticlockwise and even pairs clockwise). In another task, while reasoning on the habitat requirements of organisms, individuals tended to draw a concrete representation, i.e. a picture, while pairs produced more often an abstract representation such as matrices. In order to construct a shared representation of the problem (Roschelle, 1992), peers have to progressively abandon their personal detailed representations in favor of representations that can serve as common grounds. "Because the representation bridges multiple perspective of the problem structure, it tended to be an abstraction" (Schwartz, 1995, p. 321). From a distributed cognition viewpoint, one could rephrase this observation by stating that grounding (Clark & Brennan, 1991) leads to some inductive process at the group level (at least when grounding is rather symmetrical).

These results are very important because abstraction is one of the challenges for educational designers. Therefore, we aimed to confirm that social interactions augment the probability that learners develop abstract representation. Schwartz' results also trigger a second expectation concerning the educational effects of peer interactions. If pairs draw more abstract representations, we could expect that they are also better in transferring acquired knowledge to new situations. The relationship between abstraction and transfer is a controversial and complex debate. The scientific issue is to know if building an abstract representation is a necessary step for mapping the knowledge acquired in the source context to the solution to be built in the target context (Gick & Holyoak, 1983). It can be argued that cognitive scientists have overestimated the explicitness or the degree of abstraction of such representations and thereby opened the door to the critiques of situated cognition theories. We do not address directly this argument at the theoretical level but investigate instead from an instructional design perspective: What ever the 'natural' transfer mechanisms are, if we succeed to have pairs building more abstract representations than individuals, would they also be better in transfer?

While the explanation of the pair abstraction effect relies to inter-individual induction, research on transfer has rather focused on intra-individual induction. There seems to be a rather consensual view that transfer has higher chances to occur if, during the training, the subjects have encountered or applied the same knowledge structure in a variety of contexts (Tardiff; 1996; Del'Guidice, 1998; Gick & Holyoak, 1983). Using examples taken from multiple contexts provides opportunities to dissociate superficial features – bound to a context- from the deeper context-independent features. Therefore, we chosen to

complete our investigation of abstraction in pairs with a study of the effect of examples diversity on transfer.

Transfer relies upon the isomorphism between the context where knowledge is acquired and the context where it has to be applied. Authors refer to near transfer when the two source and target contexts only differ by superficial features; while far transfer is used for cases where the isomorphism is can only be found at deeper features. Obviously, the degree of isomorphism is a continuous variable and it is a simplification to dichotomize in 'far transfer' and 'near transfer'. Nevertheless, our measures of transfer discriminate near-, medium- and far-transfer items.

Research Questions

This study raises three questions.

Do pairs build more abstract representations than individuals? This question aims to confirm Schwartz' findings presented above. We talk here about the physical representations made on paper and not the subjects' mental representations.

Given that abstraction is one of the hypothetical mechanisms for transfer, are pairs better than individuals in transferring their knowledge?

How will the collaboration process interfere with other ways for promoting transfer, namely diversifying the context of training examples?

Method

Experimental Plan

These questions lead to a 2 x 2 experimental plan. The first independent variable is the grouping, i.e. subjects working individually ('solo' condition) versus subjects working in pairs ('duo' condition). The second independent variable is the heterogeneity of the context from which are selected the training examples: for one group, all cases studies were selected in a hospital context ('mono' condition), while the other group received examples from various contexts ('multi' condition). The dependent variables are described later on.

Hypotheses

Hypothesis 1: When asked to write or draw a representation of the case, pairs draw more abstract representations than individuals.

Hypothesis 2: Subjects who studied in pairs obtain a higher score in the transfer task than those who studied individually.

Hypothesis 3: Varying systematically the context where examples are taken from leads to higher scores in transfer tests.

Hypothesis 4: The effect of context variation is higher for pairs than for individuals.

Participants

The experiments have been conducted with 51 first year students in a nurse school in Fribourg (Switzerland). The age ranged between 18 and 20 years. There were 44 women and 7 men. The students were French speaking and the whole experiment was run in French. The experiments were run in their usual teaching rooms. The subjects were distributed in four conditions.

Group Solo-Mono: Subjects work individually on a set of cases taken from the hospital context (N=11)

Group Solo-Multi : Subjects work individually on a set of cases taken from various contexts (N=12)

Group Duo-Mono: Subjects work in pairs on a set of cases taken from the hospital context (N=7 pairs)

Group Duo-Multi: Subjects work in pairs on a set of cases taken from various contexts (N=7 pairs)

The subjects were distributed in groups according to their score on the pre-test in order to have groups with equivalent prior knowledge (cf. procedure section)

Material

The learning material was about the psychological concepts of loss and mourning. Since these two topics are involved in many professional situations, they are taught along their 4 years of nurse training. The final goal is to give nurses the ability to cope with difficult situations (e.g. the death of a child). The learning activities developped in this experiment constitute only a conceptual introduction to these concepts.

Procedure

Pré-test (20 min): All students passed individually a test for measuring their domain knowledge. The test included two open questions on mourning. Their average level was rather good since the subjects had an introductory psychology course on these topics a few weeks before. Students were sorted in four knowledge levels according to the quality of their answers. In order to equilibrate the amount of pre-existing knowledge, students where then distributed over the four experimental conditions in a way that the ratio of subjects from each knowledge level was almost identical in each group.

Task 1 (1 hour): Two weeks later, the experiment began. The first task was rather open. All students (solos or duos) received a case study of a mourning process. The case began with a mother loosing her daughter in a car accident. The case description was two pages long and included a lot of information. The task instructions were deliberately left very general: "*Identify and organize in a schema (make groups, links, build a hierarchy), on this page, the different features of the mourning situation described hereafter.*" The two groups working in solo mode were in one room and the two groups working in duo went to a different room.

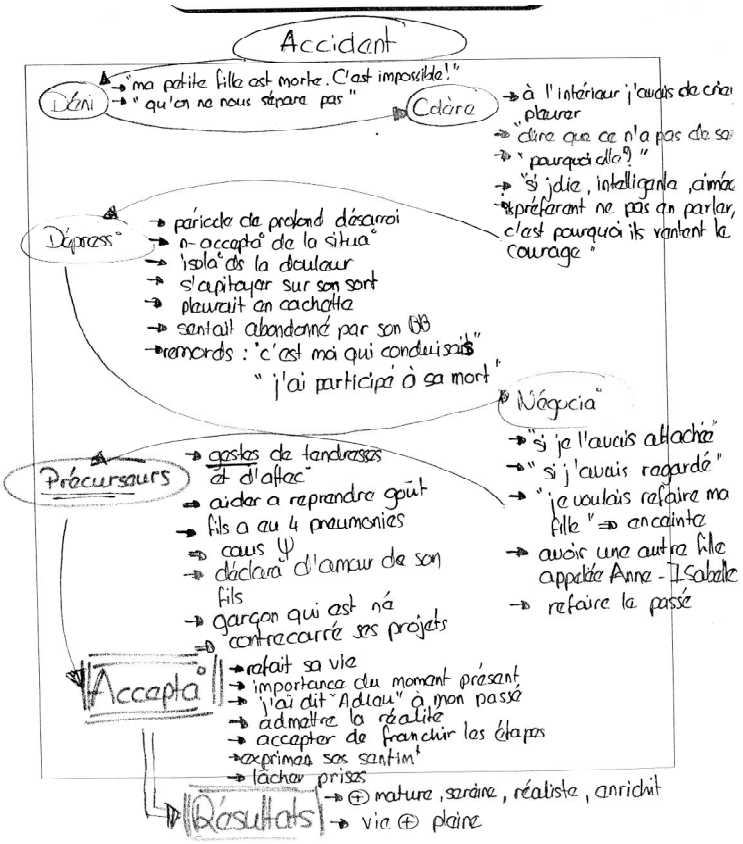

Figure 1: Example of representation built by a pair (in French)

Task 2 (1 hour): The second task was run just after the first one, in the same afternoon, with a break for changing rooms. The students received a grid that they had to fill for describing each mourning

case. The empty grid specified the 3 phases of the mourning process (choc, depression, recovery) and 5 or 6 subprocesses for each phases. For the two groups in the 'mono-context' condition, the 6 cases concerned the hospital context. For the two groups in the 'multi-context' condition, the 6 cases included situations where the pain is related to any loss (e.g. loosing one's job). The two groups in the mono-context condition where in one room (both solos and duos) and the two groups working in the multi-context condition went to a different room.

Post-Test (two hours) The post-test was passed by students individually, 11 days after the second task. The task was to analyze five situations. The instructions were to "*identify the key elements, structure them, establish links, make a synthesis and extract underlying principles*". Each situation was described by a one or two pages long text and included a more specific question. Three out of the 5 questions measured respectively near, medium and far transfer. These different questions aimed to see if the independent variables have a different effect on far and distant transfer. However, since the far transfer question was taken at the end of the test and since subjects complained about the time limitation, differences between near and far transfer might not reflect transfer difference but the time issue. Hence, we will not discriminate far and near transfer items in the following.

Since we wanted to observe spontaneous transfer, we carefully designed the post-test in a way that students do not identify it as the follow-up of the previous phases of the experiment. The questionnaire was given to the students by another professor that those involved in the preliminary phases and in a different course. It was introduced to the students as a way to collect information about their analytical skills before the second year. A few weeks later, the experimenters presented to study results to the students. They reported that they were not aware of the link between the experiment and this final task.

Dependent Variables

For measuring the subjects knowledge in the pre-test, task 2 and the post-test, the two experimenters built a grid of the items to be found in the texts, schemas and grids produced by individuals and pairs. The correlation between their ratings was above 0.95 in the 3 cases (Bravais-Pearson).

A more sophisticated dependent variable was the degree of abstraction of the schemata drawn in task 1. The degree of abstraction was elaborated by counting the occurrence of certain items:

> We counted the number of explicit references to the phases of mourning: denial, anger, negotiation, depression and acceptance. What is counted is not the fact that students use one of these exact terms, synonymous were accepted
>
> The degree of abstraction was higher if there is no direct transcription of the concrete terms used in the case description.
>
> The degree of abstraction was higher when students emphasized graphically the key elements, thereby emphasizing the conceptual structure of the case.
>
> The degree of abstraction was higher when students related the key elements by links or arrows.

Although this rating was complex, the correlation between judges was 0.96.(Bravais-Pearson). Diverging judgments where then discussed in order to reach consensus.

Results

Hypothesis 1.

The schema drawn by the pairs were significantly more abstract than those drawn by individuals ($F=4.89$, $df=1$, $p< .05$). The average abstraction mark was 9.43 for pairs ($SD = 4.23$) and 6.39 for individuals ($SD= 5.57$). The maximal value of the abstraction mark was 15. It is interesting to point out that our study confirm Schwartz' results in a very different experimental setting. We did not compute an interaction effect with the second independent variable since the degree of abstraction was measured on the first task while the variety of cases only concern the second task. The experiment confirms that effect observed by Schwartz (1995) but does not provide a qualitative account of the mechanisms that leads to this higher level of abstraction.

Hypothesis 2.

The pairs do not perform better than individuals at the transfer items of the post-test (t=-.029, dl = 49, p = .77).. The average score is 0.092 for pairs (SD = 0.004) and 0.087 for individuals (SD = 0.004). The second hypothesis is hence rejected. It is also rejected if we consider individually any transfer item of the post-test, i.e. the near-, medium- or far-transfer items.

Hypothesis 3.

The subjects who were trained with examples from varied contexts get significantly higher scores on the transfer items in the post-test (F=8.807; df=1; P < .01). The average performance on transfer was 0.077 (SD = .033) for the mono-context group and 0.103 (SD = 0.038) for the multi-context group. We may hence infer that varying the context of examples increase the transfer mechanisms, although we must notice that transfer scores were quite low in all conditions.

Unfortunately, we found also an alternative explanation of this effect. When we consider the answers of the two groups during the 6 training cases (task 2), the average score of the multi-context group (3.51) is significantly higher (t=-2.80, df = 49; p<.01) than the average score of the mono-context group (3.07). This difference appears from the first presented case. Hence, it can hardly be explained as a learning effect across the presented six cases. The sampling process cannot either explain this difference since the subjects were distributed evenly among the groups on the basis of their pre-test performance. Hence, we cannot discard the possibility that the cases used for the multi-context group not only different from those of the mono-context group in terms of context diversity but that they could also be intrinsically more effective for supporting learning.

Hypothesis 4.

Would the pair benefit more from the variety of contexts? We found no interaction effect between the solo/duo variable and the mono/multi-context variable (F=.803; p=.107). Working in pairs had no effect of knowledge transfer both when the examples were taken in the same context or from varied contexts.

Discussion

Our results are mixed. On the one hand, our study confirms that pairs draw more abstract representations than individuals and, even if this new empirical evidence is not a definite confirmation of this effect, it is an interesting step to consolidate Schwartz' findings. Our study also confirms the advantage of varying the context. The most interesting aspect is the apparent conflict between a higher abstraction and no higher transfer. We review now different ways to explain this contradiction, either by methodological weakness of our study, or more conceptual aspects.

Some methodological critiques concern the small size of the sample, as often, but also the way we measured the degree of abstraction. The measure of abstraction was characterized by a high degree of inter-judge correlation, however the construct validity of the measure maybe questioned. The difference between low-abstraction and high-abstraction schemata remains less obvious than in Schwartz' study.

A second methodological critique is that cases of high abstraction occurred both in the solo and in the duo group, although more numerous in the latter, therefore intra-group differences may hide inter-group differences. To verify this explanation, we ran post-hoc comparisons between two contrasted groups, those (solos or duos) who produced the 11 most abstract schemata and those who produced the 11 schemata with the lowest abstraction level. Even these contrasted groups do not differ on the transfer items of the post-test (t=.579, df=20, p=.575): the average transfer score is .10 (SD = .03) for high-abstracters and .095 (SD = .04) for low-abstracters. In other words, this second interpretation does not hold.

A third methodological way to explain the lack of relationship between abstraction and transfer is that abstraction was measured after the end of the first case analysis (task 1) while the transfer performance depended on the cognitive processes engaged also during the next six case analyses (task 2). During these six case studies, students had to fill a grid instead of building a schema. This grid was did not leave room

for pairs to build more abstract representations. Therefore, since the higher abstraction mechanism applied only to a tiny part of the learning time, it could not have a significant impact on the acquired knowledge.

Turning to more conceptual interpretations of our results, a simple deduction would be that abstraction, despite the existence of what Salomon and Perkins (1989) called the high road to transfer, is not the main road to transfer. A second explanation specific to our experiment is that the benefit of collaboration and/or abstraction on transfer is marginal compared to the effect of varying context. This second dimensions of our experimental plan may have hidden the more subtle effects of the first dimensions (solo/duo).

We want to emphasize a third explanation. As mentioned earlier, when we refer to abstraction in this study, we actually mean the degree of abstraction of the physical representations built by the pairs and not the degree of abstraction of their 'mental' representation, whatever forms this 'mental' representation may have. Of course it is not irrational to postulate that the physical representations drawn by our subjects somewhat reflect their metal representations, but we cannot postulate that these are equivalent. The difference between the co-constructed and personal representations might explain our results. It may the case that the specificity of peer interactions is that they lead to produce a more abstract physical representation, because making it visible requires to negotiate mutually acceptable forms, but that this abstract representation is not necessarily internalized and hence has no effect on individual transfer. The duration of task 1 (less than 1 hour) was of course too short to expect internalization. Micro-analytical studies of peer interactions, namely when pairs draw a representation of the task, are necessary to improve our understanding of the emergence and sustainability of these representations.

One way to choose between these explanations would be to study the genesis of collaborative drawings in order to identify specific mechanisms that lead to build abstract drawings and determine if these mechanisms relate to their mental representations. In related experiments, we were surprised to see for instance that team members seldom erased an object drawn by their partners on a whiteboard software. There was no much negotiation-in-drawing. We should compare the drawings built by individuals for themselves versus drawings built individually but aimed towards communication with somebody else. This study relied on simplistic postulates about the relationships between drawings and mental representations that should be revisited by micro-analytic studies of joint drawing activities.

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