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ABSTRACT

In a study of peer collaboration among children, the case is made for treating the dyad, rather than the individual, as the unit of analysis. Subjects included 154 children aged 5 to 9 years from a broad range of social classes. Children worked in 14 problems (representing 6 types of problems) predicting the movement of a balance beam. Children were either not paired with a partner or paired with a partner of equal, lower, or greater ability to perform the task. Results were examined for an individual member of the dyad or for the dyad as a unit. When the individual was treated as the unit of analysis, data indicated that children paired with a partner of greater ability tended to improve on their pretest scores, while those with a partner of lower ability tended to regress in their thinking. However, the scores disguised whether the more competent child raised his or her partner to the higher level, or the less competent partner was more convincing and caused the more competent partner to regress. Factors that uncover the true pattern of results are products of the dyadic interaction: the types of rules and reasoning employed, and the intersubjective understanding attained. To make sense of these findings, the dyad must be the unit of analysis. Four tables present study data. A 23-item list of references is included. (SLD)

Peer collaboration:

The case for treating the dyad as the unit of analysis

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Introduction

Scholars have become increasingly interested in the effects of social influence on cognition over the course of the last decade. The theoretical impetus is a good deal older, however, and may be found in the writings of Vygotsky, Baldwin, Dewey, Mead, Bandura, and even in some of the early writings of Piaget (Tudge & Winterhoff, 1991). The direction of effects is not considered to be unidirectional in any of these theoretical positions--that is, that the individual is not solely influenced by the surrounding social world but also exerts an influence on it. This position is to be found in clearest form in Vygotsky's writings; Vygotsky embodies the most "transactional" notion--that there is an interpenetration of individual and social/cultural world that blurs any distinction between the two: "A normal child's socialization is usually fused with the process of his maturation. Both lines of development--natural and cultural--coincide and merge one into the other. Both series of changes converge, mutually penetrating each other to form, in essence, a single series of formative socio-biological influences on the personality" (Vygotsky, 1983, p. 22). Piaget, despite spending most of his life describing the ways in which individual development occurs, also viewed the child's interaction with the external world (whether physical or social) as dialectical in nature (Piaget, 1959, 1977, 1983). The same is true of Bandura; although his empirical research (and that of his students) focuses almost entirely on the ways in which the social world influences individual development, his theoretical construct of "triadic reciprocal determinism" clearly stresses the bi-directional nature of influence (Bandura, 1986).

If we are to do justice to these theoretical demands of bi-directionality or to the transactional nature of development, the question arises as to the unit of analysis to be used. One method is to acknowledge, for theoretical reasons, that influences are two-way in nature, but to choose to focus on one member of an interacting dyad, triad, or system. This technique certainly has the advantage of allowing easy statistical analysis; our most prized statistical techniques require independence of the units of analysis. Another strategy is to focus upon each member of a dyad in turn, examining the sequences of behavior or speech. This technique has the advantage of treating the dyad as an interacting unit, although each pair member continues to be viewed as conceptually distinct, with the unit of analysis again being the individual. Sequential analysis may be the most appropriate statistical tool to use in this case.

An alternative approach is to treat the dyad as the unit of analysis. This fulfills theoretical requirements (particularly following Vygotsky), but opens the question of how to code the dyad as a whole. Relatively less helpful techniques are simply to sum or average the scores of each interacting partner, or to use correlational techniques. The problem with the summing or averaging techniques is that there is no way of differentiating between partners who, on a 5-point scale, are coded as 1 and 5 in one case, 3 and 3 in another. The problem with correlations is that there is a danger of not distinguishing between dyads whose members both score one in one case, both five in another.

Researchers interested in the impact of collaboration on cognitive development have typically focused attention upon the least competent partner (typically a child). Thus scholars influenced by Vygotsky have examined the effects of teachers or mothers on children who are trying to solve a problem (Newman, Cole, & Griffin, 1989; Tharp & Gallimore, 1988; Valsiner, 1984; Wertsch & Hickmann, 1987), or have compared the impact on children of working with an adult or with an older child (Ellis & Rogoff, 1982; Gauvain & Rogoff, 1989; Radziszewska & Rogoff, 1988). Similarly, neo-Piagetian researchers have concentrated on the non-conserving member of conserver/non-conserver pairs (Ames & Murray, 1982; Doise & Mugny, 1984; Perret-Clermont, 1980). The performance of this "target" child may then be subsequently analyzed and reported. This practice fulfills statistical requirements of independence of the units of analysis, and is justified when one is solely interested in an adult's impact on a child or a tutor's influence on a tutee.

However, in collaboration between peers the expected direction of effects may be less clear and the processes whereby collaboration influences development may be disguised when analysis focuses upon only one member. In this case, the only valid unit of analysis may be the dyad itself--one that "possesses all the basic characteristics of the whole" (Vygotsky, 1987, p. 46). The work of Forman and her collaborators (Forman, 1987, in press; Forman & Cazden, 1985; Forman & McPhail, in press) is a notable exception to the prevailing tendency in the developmental literature to focus solely upon one member of a dyad; her extensive research with young children and adolescents has treated the dyad as the unit. Forman has relied on transcript, rather than statistical, analysis to examine collaboration in action.

Methodology

Sample. Participants consisted of 154 children aged from 5-9, from a broad range of social classes.

Task. Siegler's (1976) mathematical balance beam task was used. The children worked on 14 different problems, exemplifying 6 types of problem, in which they had to predict the movement of the beam given various configurations of weights and distances from the fulcrum. The pattern of predictions across the 14 problems determined which of 5 different rules (levels of thinking) the children used.

Procedure.

1. Individual pretest
2. Treatment (one week after pretest):
   a) no partner;
   b) equal partner, in which each child was paired with a partner (same age, same gender) who was eqully competent; i.e., who had used the same rule at the time of the pretest;
   c) lower partner condition, in which each child was paired with a partner (same age, same gender) who was more competent; i.e., who had used a higher rule at the time of the pretest;
   d) higher partner condition, in which each child was paired with a partner (same age, same gender) who was less competent; i.e., who had used a lower rule at the time of the pretest.

Disagreements in prediction during the paired session were followed by pair discussion until resolution. At no time was any feedback given.

3. 1st individual posttest (one week after treatment).
4. 2nd individual posttest (one month after treatment).

Results

In this paper, I shall compare two alternative ways of dealing with dyads collaborating to solve mathematical problems. First, I shall portray the results as typically presented, treating the individual as the unit of analysis. To retain independence of the units, one member of each dyad was randomly dropped from the analyses. Across the entire sample the results were clear (see Table 1): lower partners (children paired with a partner who had used a higher rule) on average improved at both posttests. However, the higher partners, on average, regressed in their thinking and the regression was as stable a phenomenon as the improvement. The effect of treatment condition was consistently highly significant ($p < .002$) and cannot be attributed to regression to the mean--irrespective of how high or low their initial scores were lower partners, on average, improved whereas the higher partners, on average, regressed.

The second way of dealing with the dyad is to treat the dyad itself as the unit of analysis. Treating the dyad in this fashion revealed a very different picture from the one portrayed above. The results will be presented initially in terms of the outcomes that are possible for any dyad: both could improve on their pretest scores, one could improve while the other retains the same rule, etc. Nine such outcomes are possible, but in this data set all but two of the 56 dyads fell into one or other of the following five outcome patterns; both declined, the less competent member retained the pretest rule while the more competent member declined, both retained the same rule, the more competent member retained the same rule while the less competent member improved, and both improved.

As is shown in Table 2, members of equal rule dyads were most likely to continue to use the same rule during the treatment and at both posttests, although many equal rule children declined. Children in these dyads, in fact, performed similarly to children who worked without a partner. This pattern of findings suggests that working with a partner who thinks about the problem in the same way as oneself is not likely to lead to development. The pattern of results for the members of unequal rule dyads was very different, however, with virtually all children falling into a bimodal distribution in which either the more competent partner persuaded the less competent partner of the correctness of his or her thinking or the opposite happened, and the less competent partner was more persuasive. The pattern of rule use at the time of the treatment was, in most cases, still in place at each of the two posttests.

The bimodality of results for the unequal rule dyads can only be explained by attending to the processes of interaction themselves. Three factors are of particular importance: (a) the types of dyads (as judged by the particular rules used by dyad members); (b) the reasoning to which children were exposed in the course of the paired session; and (c) the intersubjective understanding gained during the course of the paired session.

The types of dyads. Two different dyad types can be distinguished among the equal rule group, and four among the unequal rule group, as a function of the nature of the rules used. Two of the rules (Rules 2 and 4) allow children to predict all problems with ease, whereas the remaining three rules (Rules 1, 3, and 5) do not allow such straightforward prediction. (For more details of the rules, see Tudge [1989].) As is seen in Table 3, the only situation in which one or both partners improved consistently was the pairing of a more competent child who used a rule that allowed easy prediction with a less competent child who used a rule that did not allow such straightforward

prediction ("high certain-low uncertain" dyads). In cases in which the situation was reversed ("high uncertain-low certain" dyads), regression of the more competent child was as likely as development of the one who was initially less competent. The same was true for those pairs both of whom used a rule that allowed for ease of prediction ("both certain" dyads), and for those both of whom used a rule that did not allow straightforward prediction ("both uncertain" dyads).

Reasoning heard. To explain why some partners regressed in their thinking while others improved it is necessary to examine the type of reasoning that each dyad member introduced into discussion. Despite the fact that pairs were formed on the basis of the competence that they had displayed at the pretest, it was not always the case that a pair member exhibited his or her pretest reasoning during the paired phase when faced with a partner whose reasoning was at a lower level. Occasionally they simply accepted the reasoning of the less competent child. Not surprisingly, less competent children did not benefit from this collaboration. In contrast, in other paired sessions one or other pair member actually exhibited reasoning at a higher level than either partner had used during the pretest--typically under conditions in which they were trying to work out their disagreements in prediction.

Intersubjectivity attained. Simply hearing reasoning at a higher level than a child had used at the pretest was somewhat predictive of posttest scores; however, the crucial factor was not simply hearing such reasoning but coming to adopt it during the course of the paired session. The shared understanding or intersubjectivity attained during the paired session was highly predictive of posttest scores for both members of the dyad, and washed out the effects of simply hearing higher reasoning.

Reverting to an individual unit of analysis, analysis of covariance (using the pretest score as the covariate) was used to test the extent to which reasoning heard and reasoning adopted was predictive of posttest scores. At the time of the first posttest, both reasoning heard ($F_{2,109} = 3.93$, $p < .05$) and reasoning adopted ($F_{2,109} = 37.19$, $p < .0001$) contributed significantly to the posttest score, controlling for each other and for pretest score. By the time of the second posttest, however, simply hearing reasoning different from that used at the pretest had no significant effect upon the posttest score ($F_{2,108} = 1.51$, $p > .2$), whereas the effects of attaining intersubjective understanding were still clearly associated with posttest score ($F_{2,108} = 21.94$, $p < .0001$).

The impact of adopting a new level of reasoning as a result of collaborating with a partner can most easily be seen in Table 4. Adopting reasoning that was the same as had been used at the pretest only rarely led to a change in rule use at either posttest. Adopting reasoning at either a higher or a lower level during the paired session was highly associated with improvement or decline at both posttests.

Conclusion

When treating the individual as the unit of analysis, the data indicate that children who collaborated with a more competent partner tended to improve on their pretest scores whereas those whose partner was less competent tended to regress in their thinking. Both development and regression were equally stable, the effects still clearly apparent one month later. However, these simple group scores are misleading, serving to disguise the fact that either

the more competent child was able to raise his or her partner to that higher level or that the less competent partner proved more convincing, whereupon the more competent partner regressed. The factors that allow us to make sense of the true pattern of results have to do with differences in the types of unequal rule dyads (the nature of the rules that the dyad members used), whether or not reasoning appropriate to each child's pretest rule was actually brought up during the paired session, and the shared reasoning or intersubjective understanding that was attained by the end of that session. To make sense of these findings, treating the individual as the unit of analysis is clearly inappropriate; the dyad must be considered the unit of analysis.

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Table 1: Treating the individual as the unit of analysis*

Condition	Mean	SD	N
Individuals			
treatment	-0.10	0.89	41
1st posttest	-0.20	0.93	41
2nd posttest	0	0.90	38
Equal rule partners			
treatment	-0.21	0.71	19
1st posttest	-0.26	0.56	19
2nd posttest	-0.37	0.83	19
Lower partners			
treatment	0.84	0.90	19
1st posttest	0.68	0.89	19
2nd posttest	0 68	0.89	19
Higher partners			
treatment	-0.72	1.18	18
1st posttest	-0.72	0.96	18
2nd posttest	-0.65	1.06	17

The effects of treatment condition:
Treatment: $F_{3,87} = 6.56$, $p < .0005$
1st posttest: $F_{3,87} = 5.39$, $p < .002$
2nd posttest: $F_{3,83} = 5.03$, $p < .002$

*Results expressed as a change from pretest score, where 1 signifies an improvement of one rule, -0.5 a decline of half a rule, etc.

Table 2

The effects of dyads having different rules or the same rule*

	Dyad types					
	Treatment		1st posttest		2nd posttest	
Dyadic outcomes[a]	Unequal rule dyads (n=35)	Equal rule dyads (n=19)	Unequal rule dyads (n=34)	Equal rule dyads (n=19)	Unequal rule dyads (n=33)	Equal rule dyads (n=17)
Both partners decline	2.9 (1)	26.3 (5)	2.9 (1)	21.0 (4)	12.1 (4)	17.6 (3)
More competent member declines, less competent stays[b]	37.1 (13)	10.5 (2)	41.2 (14)	15.8 (3)	21.2 (7)	11.8 (2)
Both partners retain same rule	2.9 (1)	47.4 (9)	8.8 (3)	57.9 (11)	12.1 (4)	58.9 (10)
Less competent member improves, more competent stays[c]	48.6 (17)	0 (0)	44.1 (15)	0 (0)	48.5 (16)	5.9 (1)
Both partners improve	8.6 (3)	15.8 (3)	2.9 (1)	5.3 (1)	6.1 (2)	5.9 (1)

Notes

* Results expressed as percentages of the dyadic outcomes for each type of dyad (Ns in parentheses), where Rules 1, 3, and 5 incorporate some degree of uncertainty, and Rule 2 and 4 allow straightforward prediction of all problems.

[a] The 5 most common dyadic outcomes (2 unequal rule dyads compromised).

[b] For same rule dyads, one partner declined, the other continued to use the same rule.

[c] For same rule dyads, one partner improved, the other continued to use the same rule.

Table 3

Dyadic outcomes at the time of the treatment for members of equal rule dyads*

Dyadic outcomes[a]	Equal Rule Dyads		Unequal Rule Dyads			
	Both Certain 2-2 or 4-4 (n=11)	Both Unc 1-1, 3-3 or 5-5 (n=8)	High C-Low Unc Dyads 4-3 or 2-1 (n=6)	High Unc-Low C Dyads 5-4 or 3-2 (n=12)	Diff rules both Unc 5-3 (n=5)	Diff rules both Cert 4-2 (n= 12)
Both partners decline	9.1 (1)	50.0 (4)	0 (0)	0 (0)	20.0 (1)	0 (0)
One partner declines, other stays[b]	9.1 (1)	12.5 (1)	0 (0)	41.7 (5)	20.0 (1)	58.3 (7)
Both partners retain same rule	63.6 (7)	25.0 (2)	0 (0)	8.3 (1)	0 (0)	0 (0)
One partner improves, other stays[c]	0 (0)	0 (0)	83.5 (5)	50.0 (6)	60.0 (3)	25.0 (3)
Both partners improve	18.2 (2)	12.5 (1)	16.7 (1)	0 (0)	0 (0)	16.7 (2)

Notes

* Results expressed as percentages of the dyadic outcomes for each type of dyad (Ns in parentheses), where Rules 1, 3, and 5 incorporate some degree of uncertainty, and Rule 2 and 4 allow straightforward prediction of all problems.

[a] The 5 most common dyadic outcomes (2 unequal rule dyads compromised).
[b] For same rule dyads, one partner declined, the other continued to use the same rule.
[c] For same rule dyads, one partner improved, the other continued to use the same rule.

Table 4

Level of reasoning adopted at treatment by outcomes at both posttests*

	First Posttest			Second Posttest		
Level of reasoning adopted at treatment	Decline	Stay	Improve	Decline	Stay	Improve
Lower level reasoning adopted (N = 31)	80.6 (25)	19.4 (6)	0 (0)	70.9 (22)	22.6 (7)	6.5 (2)
Same level reasoning adopted (N = 56)	7.1 (4)	89.3 (50)	3.6 (2)	7.3 (4)	80.0 (44)	12.7 (7)
Higher level reasoning adopted (N = 23)	0 (0)	21.7 (5)	78.3 (18)	0 (0)	21.7 (5)	78.3 (18)

Notes

* Results expressed as percentages of children declining from pretest rule, using the same rule, or improving from pretest rule, according to whether they adopted lower level, same level, or higher level reasoning during the treatment (paired) session. (Ns are in parentheses, below.)