Title

Statistical Discourse Analysis of Group Problem Solving

Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 30(30)

ISSN

1069-7977

Author

Chiu, Ming Ming

Publication Date

2008

Peer reviewed

Statistical Discourse Analysis of Group Problem Solving: Evaluations, Wrong Ideas, Rudeness, Justifications, and Micro-creativity

Ming Ming Chiu (mingmingchiu@gmail.com)
Department of Educational Psychology, 314 Ho Tim Building, CUHK, Shatin, NT, Hong Kong

Abstract

This study examines how group processes affected micro-creativity. I videotaped eighty high school students as they solved an algebra problem in groups of four. Statistical discourse analysis of 2,951 turns of talk showed that correct contributions (CC, a measure of micro-creativity) occurred more often after a group member justified an idea, correctly evaluated an idea, politely disagreed or expressed a wrong, new idea (+36%, +25%, +24%, +4%). CCs occurred less often after a group member disagreed rudely or agreed (–4%, –5%). Correct evaluations had the longest lasting effects, across three speaker turns of talk. Statistically-identified, watershed breakpoints separated time periods of high and low micro-creativity. The effects of agreements and correct evaluations differed across these time periods, and the effects of justifications and questions differed across groups.

Keywords: Creativity; education; group processes; problem solving; hierarchical linear modeling; time-series

Past research on the development of original ideas that are useful or influential (*creativity*) largely focused on individuals (Sternberg & Lubart, 1999). However, the explosion of information and specializations will increasingly require teams with diverse skills and knowledge to create innovations (*group creativity*; Sawyer, 2004). Still, researchers have not systematically examined how group processes affect creative moments (*group micro-creativity*). This study takes a step forward by analyzing the micro-creativity of twenty groups of students as they solve an algebra problem. By understanding how group processes affect micro-creativity, we can help groups work together more creatively.

In this paper, creativity refers to the "small c" creativity of ordinary people in daily life, not the "big C" creativity that substantially affects society (Sternberg & Lubart, 1999). Micro-creativity at a moment in time is measured via a correct, new idea (*correct contribution*, CC; see Sternberg & Lubart, 1999 for other creativity measures). A CC's "new" component is relative to the group members' experiences, and its "correct" component is within the intersection of the problem situation and the relevant mathematics (e.g., algebra).

This study contributes to the research literature in four ways. First, I showed when CCs occur, whether they occur uniformly through a problem-solving session or more frequently in some time periods than in others. Second, this study showed how the micro-time context created by prior speakers' actions (CCs, justifications, etc.) and interactions affected the likelihood of creating a CC. Third, I tested whether the above effects differed across groups or across time periods. Lastly, I tested these hypotheses with a new statistical discourse analysis tool, dynamic multilevel analysis (Chiu & Khoo, 2005).

Group Processes and Micro-Creativity

New ideas and argumentation might aid CC creation (Paulus & Brown, 2003). However, concerns over face or status can hinder their creation (Brown & Levinson, 1987).

Four Hypotheses

H1. New ideas (correct or incorrect) help create CCs.
H2. Argumentation (evaluations, disagreements, questions, justifications) facilitates CC creation.
H3. Rude disagreements and false agreements hinder creation of CCs, while polite disagreements aid the creation of CCs.
H4. Greater status differences reduce CCs.

Group Processes that Aid Micro-Creativity

New Ideas Groups that create many ideas, representations, or solution proposals are more likely to find a correct or optimal solution (Paulus & Brown, 2003). Group members can also build on idiosyncratic ideas to create CCs through processes such as sparked ideas, jigsaw pieces, and creative misinterpretations (Paulus & Brown, 2003; Chiu, 1997). One person's comments (e.g., a key word) might spark another person to activate related concepts and propose a CC. Like fitting jigsaw pieces together, group members also can put together different pieces to create a CC. Lastly, a person might also misinterpret another person's incorrect idea to create a CC. Thus, even wrong, new ideas can lead to CCs.

Group members' different views can help identify flaws and refine wrong ideas. (Orlitzky & Hirokawa, 2001). By creating more ideas (including wrong ideas) and evaluating them correctly, groups can create CCs. Hence, group members need not only build on correct ideas (See hypothesis H1.)

Argumentation Successful group problem solving often involves argumentation, a social process by which people explain and justify their own views to convince both themselves and others (Kuhn, Shaw & Felton, 1997). During argumentation, group members evaluate one another's ideas, recognize problems, and justify their views.

According to the *functional theory of group decision-making*, group members at least implicitly evaluate the previous speaker's action and problem solving approach (Orlitzky & Hirokawa, 2001). For example, Jay says "five times six is eleven." Kay can agree ("right"), use a neutral action ("louder, can't hear you"), disagree ("no, you're wrong"), or change the topic ("I'm hungry"). While agreements support the current problem-solving trajectory, disagreements and changes of topic (ignoring the previous action) try to change it (Chiu, 2000).

Evaluations can be right or wrong in mathematics. As correct evaluations support correct ideas ("yes, five times six is thirty,") or identify flaws ("No! Five times six is not eleven,"), they can help create a shared knowledge base among group members for building new CCs. In contrast, incorrect evaluations reject CCs ("wrong, five times six is NOT thirty,") or accept wrong ideas ("right, five times six is seven,"), embedding flaws in their shared knowledge that can propagate into wrong, new ideas (Chiu, 2000).

When group members recognize problems or difficulties (perturbations), they can disagree or ask questions (Piaget, 1985). Disagreements indicate obstacles to be overcome ("no, five times six isn't eleven"). Thus, disagreements can show the need for CCs and identify flaws to avoid, thereby motivating and aiding micro-creativity.

Meanwhile, a question ("what's five times eight?") can indicate an individual or group gap in understanding. For an individual gap question, other group members who know the answer can help her (e.g., Kay says "forty"). Thus, individual gap questions encourage review of old ideas rather than the creation of CCs. In contrast, no one knows the answer to a group gap question, which motivates the need for a CC and points to a way to create it. Thus, perturbations can motivate and inform micro-creativity.

After perturbations provoke new ideas, group members often justify them. Chiu and Khoo (2003) showed that group members often anticipated criticisms of new ideas and preemptively justified them by linking them to data, using a warrant, or backing a warrant. Likewise, after a person disagrees with a proposal, the original proposer might justify it. Then, others can offer and justify their views (Piaget, 1985). When Jay asks an individual gap question, other members can respond with explanations and justifications (Piaget, 1985). As justifications support the validity of an idea, they can help create CCs.

Group Processes that Hinder Micro-Creativity

Research on politeness suggests that disagreeing politely might aid creation of CCs but disagreeing rudely might hinder creation of CCs. When arguments spill over from the cognitive arena into the social arena, groups members might protect their public self-images (*face*) rather than further the problem solving (Brown & Levinson, 1987). Status differences can exacerbate these face concerns.

Face and Rudeness Each evaluation affects both the problem solving and the previous speaker's face. Evaluations range from polite to rude: agreement, neutral, change of topic, and disagreement (Chiu, 2000). Consider Jay's utterance, "five times six is eleven." If Kay agrees with Jay ("right"), she supports him, promotes his face, and enhances their social relationship (Brown & Levinson, 1987). Thus, members might agree and repeat shared information to create common ground and solidarity.

In contrast, other actions do not support face. Neutral actions include discourse management or meta-discourse actions (e.g., "louder, can't hear you"). Although changes of topic ("I'm hungry") can be neutral, they can be rude if the previous speaker (Jay) expects a response. For example, if Jay asks, "three times four is seven?" and Kay says "I'm hungry," she either ignores him or does not listen to him, both of which are rude. Lastly, disagreements (e.g., "no, you're wrong") can threaten face by lowering public perception of the previous speaker's (Jay's) competence (Brown & Levinson, 1987).

When a person disagrees (e.g., Kay), the target person (Jay) ideally tries to understand the criticism and use it productively to create a CC. However, the threat to Jay's face may ignite his impulse to retaliate emotionally (*face attack*, "no, you're wrong!" Chiu & Khoo, 2003). Thus, rude disagreements threaten face, escalate interpersonal conflict, and often hinder creation and evaluation of CCs. In this hostile environment, group members might withhold CCs or correct evaluations rather than risk losing face (Chiu, 2000). In the worst case, a spiral of rude disagreements can end the collaboration.

To avoid threatening Jay's face, Kay might go to the opposite extreme and publicly agree. By doing so, Kay enhances her social relationship with Jay at the expense of their problem solving. Such false agreements allow errors to persist and potential CCs to remain unspoken. Also, group members might avoid disagreements due to pressure to achieve premature consensus (Janis, 1989).

Avoiding the extremes of rude disagreement and false agreement, Kay can disagree politely to reduce the threat to Jay's face and maintain problem solving integrity (Chiu & Khoo, 2003). Instead of "no, you're wrong," Kay can disagree politely, "If five is multiplied by six, we don't get seven." The polite disagreement both reduces blame and creates common ground. First, Kay uses the hypothetical "if" to distance the idea from reality. Second, she does not assign blame (no "you"). Third, Kay uses the passive voice, "is multiplied," to hide causal agency and responsibility. Lastly, she uses the passive circumstantial verb "get" to implicate agency in external conditions.

Kay's polite disagreement creates common ground by repetition and shared positioning. By repeating Jay's computation, "five is multiplied by six . . . eleven," Kay suggests that she shares his understanding. Also, Kay uses shared positioning, specifically the first person plural pronoun "we," to claim common cause with Jay.

Kay's polite disagreement supports her relationship with Jay, so he is less likely to retaliate. Instead, Jay is more likely to try to understand Kay's criticism, recognize the flaw, and correct it with a CC (Chiu & Khoo, 2003). Indeed during a disagreement, polite redress is the accepted norm among peers, as its absence is noticeably and unacceptable (Holtgraves, 1997). In short, polite disagreements support both the social relationship and micro-creativity.

Status Status differences can reduce CCs and distort evaluations of CCs through status struggles (Bales, 2001) or through the greater influence of high status members (Cohen, 1994). Cohen (1994) defined status as “an agreed-on rank order where it is generally felt to be better to be high than low rank” (p. 23). As a higher status person often receives more group resources and attention, people often compete for higher status (status struggles), especially if no status hierarchy has been established (Bales, 2001). During status struggles, intentional rude disagreements (*face attacks*; e.g., "everyone knows that five times six is thirty, not eleven") can enhance one's own face at the expense of a competitor's face (Chiu & Khoo, 2003). As noted earlier, rude disagreements can hinder creation of CCs.

After a status hierarchy has been established, status affects the expectations of each group member (Cohen, 1994). In *expectation states* theory, status is linked to the expectation of competencies for the current activity (Cohen, 1994). High status is conferred on group members who are expected to contribute positively to a desired outcome. These expectations create different opportunities to perform and receive rewards. Members can selectively invite and defer to high status members' opinions while discouraging, undervaluing, or outright ignoring lower status members' ideas, thereby distorting evaluations to agree excessively with high status people’s ideas and disagree excessively with low status people’s ideas. By doing so, members enact their expectations of high status members dominating the interaction and increase the ratio of flaws to correct ideas in the group’s shared knowledge base. High status people's influence can also increase over time. High status people speak early and often (Hackman & Johnson, 2000). As group members value and prefer supporting previously discussed, shared information rather than introducing new information, high status people's domination increases in severity over time (Stasser & Birchmeier, 2003).

Greater status differences can exacerbate status effects or raise the incentives for status struggles, both of which might reduce CCs. For group problem solving, the primary status characteristic is often past task achievement, but group members might also use diffuse status characteristics (such as social status) to make assumptions about one another’s competence.

Method

Eighty students from four 9th grade algebra classes in an urban, US high school participated in this study. On a state-wide exam, the school scored between the 40th to 50th percentiles in mathematics. These students had not received any group training and had not worked together.

All 80 students answered two social status questions, "Who are 3 classmates you would most like to hang out with? Name 3 classmates who are the easiest for you to talk with outside of school work." Then, these students worked in groups of four, with no same gender or same race groups. There were 40 girls and 40 boys; their races were 12 Asian, 27 Black, 28 Hispanic, and 13 White.

The teacher introduced her students to algebraic equations with multiple variables with this problem:

> "You won a cruise from New York to London, but you arrive 5 hours late. So, the ship left without you. To catch the ship, you rent a helicopter. The ship travels at 22 miles an hour. The helicopter moves at 90 miles an hour. How long will it take you to catch the ship?"

The students had not yet learned any procedures for solving this problem in class. Of the many solutions for this problem, one is equating the distance for each vehicle, cruise ship and helicopter (22 mph x [Time + 5 hours] = 90 mph x Time), to yield 1.618 hours or 1 hour 37 minutes.

The students had pens, paper, and calculators and were videotaped as they worked for 30 minutes. Two research assistants (RAs) transcribed and coded the videotape.

This study included individual, group, and speaker turn variables. Students identified themselves as *girls* or boys and as *Asian*, *Black*, *Latino* or White. *Mathematics grade* refers to students' mid-year algebra grades. *Peer friendship* was the mean number of times a student's name appeared on classmates' answers to the two social status questions. Group variables included the *group means* and *variances* of these variables. The RAs coded each group's final answer as right or wrong (1 or 0; *solution score*).

The RAs divided the videotape transcripts into sequences of words or actions (e.g., writing "3 x 40") by the same person, (*speaker turns*). Unlike flat classifications with only one or two codes for each speaker turn (e.g., Bales, 2001), two research assistants coded each turn and its relations to other turns along five dimensions: evaluation of the previous action (*agree*, *ignore*, *rudely disagree*, politely disagree), knowledge content (new idea [*contribution*], old idea [*repetition*], null problem content), validity (*correct*, *wrong*, null problem content), *justification*, and invitational form (*command, question*, statement), (Chiu, 2000). A CC is a new idea that is consistent with both the problem situation and algebra. With limited knowledge about the group members’ experiences, the RAs coded a turn as a contribution if it was not in the problem statement or textbook, and was not discussed earlier during the lesson. Krippendorff's (2004) α tested inter-coder reliability.

Statistical analysis of group processes at the speaker turn level is problematic, as time-series data from multiple groups often violates the independence assumption. Also, the effects of the explanatory variables on the outcome variable can differ across groups (group heterogeneity) or change over time (non-stationarity).

This study uses a new method, *dynamic multi-level analysis* (DMA, Chiu & Khoo, 2005) to solve all of these difficulties by: (a) identifying distinct time periods, (b) testing for differences across groups and time periods, (c) using multilevel analyses of the binary outcome variable, (d) testing for residual serial correlation, and (e) identifying direct and indirect effects.

To identify the breakpoints for each group, I used a modified version of the Maddala and Kim (1998) model selection method based on information criteria. Assuming a given number of breakpoints (first 0 breaks, then 1 break, then 2 breaks, etc.), all possible locations of those breakpoints in each group's time series data were tested. After the Bayesian information criterion (BIC) was computed for each model of breakpoints, the optimal model with the lowest BIC was identified, and the breakpoints in that model identified the different time periods.

A *multi-level Logit* variance components model (Goldstein, 1995) tests if the outcome variable, CC, significantly varied across groups or across time periods. If both varied significantly, a 3-level model was needed: speaker turns (level 1) within time periods (level 2) within groups (level 3). Then, I ran the following multilevel analysis with predictive quasi-likelihood estimation (Goldstein, 1995).

$$\pi_{ijk} = F(\beta_{000} + f_{0jk} + g_{00k} + \beta_{00s}\mathbf{S}_{00k} + \beta_{00t}\mathbf{T}_{00k} + \beta_{ujk}\mathbf{U}_{ijk} + \beta_{vjk}\mathbf{V}_{(i-1)jk} + \beta_{vjk}\mathbf{V}_{(i-2)jk} + \beta_{vjk}\mathbf{V}_{(i-3)jk} + \beta_{vjk}\mathbf{V}_{(i-4)jk})$$

The probability (π_{ijk}) that a CC occurs at turn i of time period j in group k is a Logit link function (F) of the variation parameters (f_{0jk}, g_{00k}) and the vectors of predictors. Meanwhile, f_{0jk} and g_{00k} indicate the deviations of time period j and group k from the overall mean β_{000}.

First, I added a vector (**S**) of s classroom identification control variables. Wald tests identified significant explanatory variables (more reliably than likelihood ratio tests; Goldstein, 1995). I tested the regression coefficients for significant differences across groups and across time periods. I removed non-significant variables.

Then, I added t group-level variables: correct group solution, mean of group members' mathematics grades, mean of group members' social statuses, variance of mathematics grades, variance of social statuses, racial variance, gender variance (**T**). This tests the status effects (H4) hypothesis. Then, I added interactions among pairs of significant variables in **T**. Next, I added u current speaker variables: gender, race, mathematics grade, social status, correct evaluation, agree, politely disagree, rudely disagree, justify, question and command (**U**).

I entered lag variables for the previous speakers, first at lag 1 (indicating the previous turn, denoted -1), then at lag 2 (denoted -2), then at lag 3, and so on until none of the variables in the last lag were significant (lag 4 in this case; a vector autoregression or VAR, Kennedy, 2004). I added v previous speaker variables (–1) at the speaker turn level: gender (–1), race (–1), mathematics grade (–1), social status (–1), correct evaluation (–1), agree (–1), politely disagree (–1), rudely disagree (–1), CC (–1), wrong contribution (–1), correct old idea (–1), justify (–1), question (–1), and command (–1) (**V**). These variables tested the new ideas, argumentation, and rudeness hypotheses (H1, H2, H3). Then, I added the lags –2, –3, and –4 of the **V** variables were added. Ljung-Box (1979) Q-statistics tested for serial correlation (up to order 4) in the residuals.

The path analysis estimated the direct and indirect effects (Kennedy, 2004). To aid interpretation, I converted each predictors' total effects to odds ratios, reported as the percentage increase or decrease (+ X% or – X%) in the likelihood of a CC (Kennedy, 2004).

I used an alpha level of .05 for all statistical tests. Benjamini, Krieger, and Yekutieli's (2006) two-stage linear step-up procedure controlled the false discovery rate (FDR). Lastly, I estimated the predictive accuracy of the final model (Kennedy, 2004).

Results

Earlier analyses of this data showed that groups with proportionately more CCs were more likely to correctly solve the problem (*successful groups*; Chiu & Khoo, in press). Meanwhile, exploration of the breakpoints identified by DMA suggests three types (on-task ↔ off-task transitions, insights, and critical errors). Krippendorf's alpha for evaluations of previous actions, knowledge content, correctness, and invitational form were 0.93, 0.98, 0.99, and 0.91 respectively.

The explanatory model showed that group properties did not affect the likelihood of a CC. CC creation was not linked to greater racial diversity, gender diversity, or status differences (showing no support for H4). See Figure 1.

In contrast, recent speaker actions affected the likelihood of a CC. Wrong, new ideas yielded more CCs (+9%; see Figure 1), showing partial support for H1. After a wrong idea, group members were less likely to agree (–18%) and more likely to disagree rudely (+6%). Thus, they often detected and corrected errors to create a CC (e.g., "should be two hours, not five hours"). However, a CC did not raise the likelihood of a subsequent CC. Thus, these groups had few chain reactions of CCs.

When group members evaluated correctly or justified ideas, the likelihood of CCs increased, partially supporting H2. If any of the three previous speakers evaluated correctly (–1, –2, –3), the current speaker was more likely to create a CC (+2%, +5%, and +3%, respectively). Furthermore, a group member who evaluated correctly often helped subsequent speakers evaluate correctly, both in the next turn (+12%) and in the following turn (+14%). Also, group members who evaluated correctly helped other group members justify their ideas (+3%), create fewer wrong ideas (–3%) and agree more often (+2%).

When group members justified ideas, the likelihood of a CC rose substantially in unsuccessful groups (+29%) and rose even higher in successful groups (+70%), possibly because they used different types of justifications. Successful group members often justified their ideas with

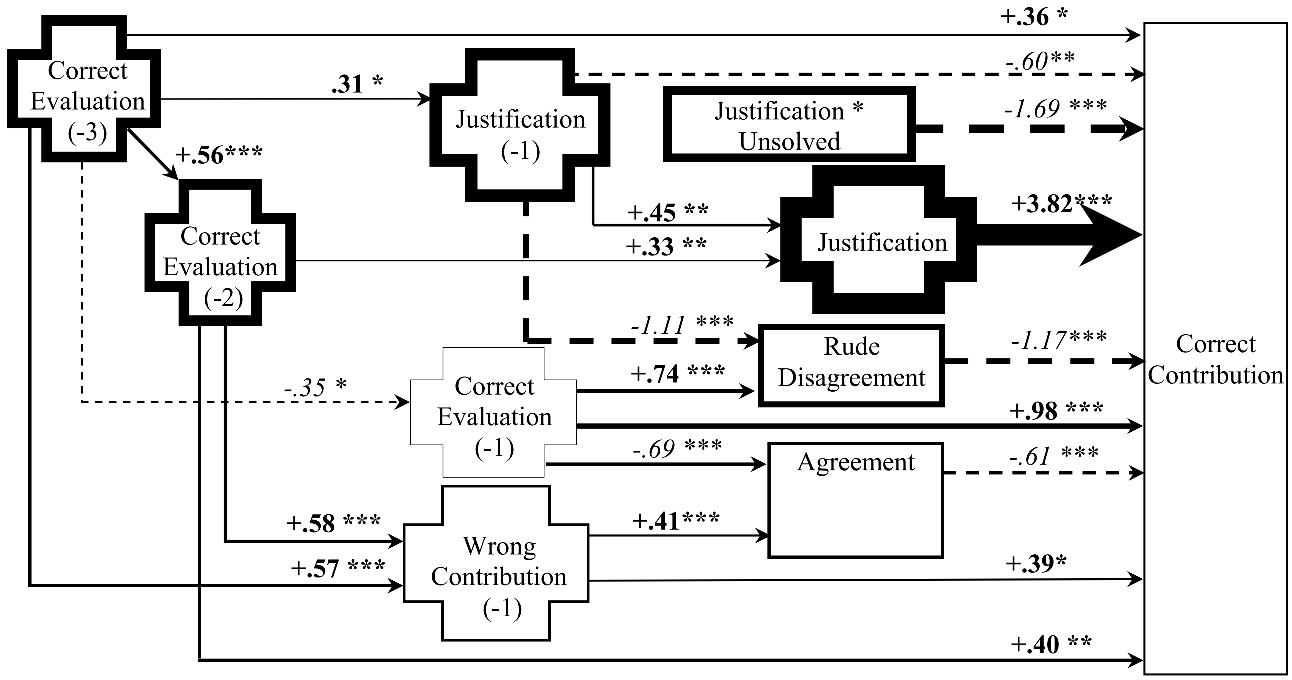

Figure 1: Path analysis of a correct contribution (correct, new idea; CC) with significant, standardized parameters. Crosses (✚) and rectangles (▫) show positive and negative total effects, respectively. Solid arrows and dashed arrows show positive negative, direct effects, respectively. Wider lines indicate larger effects.

"RTD" (rate × time = distance) and other formulas. In contrast, unsuccessful group members often referred to the teacher "because Ms. T said so," which might be less valid or less helpful to other group members. When a group member justified an idea, other group members were less likely to disagree rudely (–5%) and more likely to follow with justifications (+4%).

Polite disagreements increased CC creation (+14%), while rude disagreements reduced it (–4%). Controlling for correct evaluations, excessive agreement also reduced CC creation (–5%). These effects all supported H4. (Other predictors such as questions were not significant.)

The effects of two predictors differed across time periods (agree and correct evaluation [–2]). The effect sizes of agreements varied across time periods from –3% to –21%. Those of correct evaluation (–2) varied across time period from –0.3% to +9%. These significant differences in effect sizes of across time periods suggested that their effects were moderated by unexamined variables that differed across these time contexts. Aside from justifications, agreements, and correct evaluations (–2), all other predictors showed similar effect sizes across groups and time periods, showing no evidence of contextual effects.

This model had an 83% accuracy rate for predicting whether a CC occurred in any given turn. Furthermore, the Q-statistics showed no significant serial correlation.

Discussion

Past studies suggested that diverse views and argumentation can aid creativity, but face or status might hinder it (Paulus & Brown, 2003). This study tested the group micro-creativity versions of these hypotheses using a statistical discourse analysis. Specifically, the likelihood of a correct, new idea (correct contribution or CC) was higher after a (a) wrong, new idea, (b) correct evaluation, (c) justification or (d) a polite disagreement. However, rude disagreement and excessive agreement yielded fewer CCs. The effects of justifications differed across groups, while those of correct evaluations and agreements differed across time periods.

Greater CC creation after wrong ideas, correct evaluations, justifications, and polite disagreements suggest that argumentation often aids micro-creativity. After a wrong idea, group members agreed less often, rudely disagreed more often, and created CCs more often, suggesting that they detected and corrected the flaw in the wrong idea. Thus, wrong, new ideas might have served as kindling for micro-creativity via sparked ideas, jigsaw pieces, or creative misinterpretations (Chiu, 1997).

Correct evaluations had the longest-lasting effects on CC creation. Correct evaluations increased subsequent correct evaluations, justifications, and CC creation over three turns. These results support the view that verifying correct ideas or identifying flaws helps create a shared, valid knowledge base for later group micro-creativity.

Justifications reduced rude disagreements and yielded more justifications and CCs, suggesting that justifications aid rational discourse and micro-creativity. By aiding polite discussions, justifications can highlight the validity of ideas, thereby encouraging further justifications and CC creation.

Argumentation did not always raise micro-creativity, as group members were concerned about face. Although polite disagreements yielded more CCs, rude disagreements and excessive agreements reduced it. These results suggest that students attended to their social relationships and face concerns at the cost of less micro-creativity (Janis, 1989).

Effects differed across groups and time periods. Justifications yielded more CCs in successful groups than in unsuccessful ones. Furthermore, the statistical discourse analysis identified critical breakpoints that separated each group's problem solving session into periods of high and low micro-creativity. Also, the effect sizes of agreement and correct evaluations varied across these time periods.

This study's limitations include its small sample sizes of higher level units (groups, classroom cultures, schools, countries), limited problem content (cf. geometry, biology, history), setting, and limited group histories.

Still, if validated by future studies, these results have the following implications. Theoretically, this study suggests that understanding group micro-creativity requires explicating both time period and local time context influences. Watershed breakpoints (on-task ↔ off-task transitions, insights, critical errors) separated time periods of high and low micro-creativity. The micro-time context of recent actions (wrong ideas, correct evaluations, justifications, agreements, and rude disagreements) also affected micro-creativity.

Methodologically, a statistical discourse analysis (Chiu & Khoo, 2005) identified the watershed breakpoints and aided testing of the micro-creativity hypotheses. With this new statistical tool, scholars can test many hypotheses about sequences of local, causal effects in individuals' and groups' learning and problem solving.

Practically, these results suggest that group members might improve their micro-creativity by encouraging one another to express their ideas, justify them, and evaluate them carefully and politely. To aid free expression of ideas (including wrong ones), group leaders can create a safe and supportive group culture. Within this supportive culture, group members can elicit justifications and slow contemplation to aid correct evaluations and reduce impulsive, rude disagreements. Through these theoretical, methodological, and practical contributions, this study might help group members improve their micro-creativity.

References

Bales, R. F. (2001). *Social Interaction Systems.* New Brunswick, NJ: Transaction Publishers.

Benjamini, Y., Krieger, A. M., & Yekutieli, D. (2006). Adaptive linear step-up procedures that control the false discovery rate. *Biometrika*, *93*, 491-507.

Brown, P, & Levinson, S. C. (1987). *Politeness.* New York: Cambridge University Press.

Chiu, M. M. (1997). *Building on diversity*. Los Angeles: UCLA. (ERIC No. ED 410 325).

Chiu, M. M. (2000). Group problem solving processes: Social interactions and individual turns. *Journal for the Theory of Social Behavior, 30*, 27-50.

Chiu, M. M., & Khoo, L. (2003). Rudeness and status effects during group problem solving. *Journal of Educational Psychology, 95*, 506-523.

Chiu, M. M., & Khoo, L. (2005). A new method for analyzing sequential processes: Dynamic multi-level analysis. *Small Group Research, 36*, 600-631.

Chiu, M. M., & Khoo, L. (in press). Conflict between cooperative and competitive goals during group problem solving. *Human Communication Research*.

Cohen, E. G. (1994). Restructuring the classroom. *Review of Educational Research, 64*, 1-35.

Goldstein, H. (1995). *Multilevel statistical models.* Sydney: Edward Arnold.

Hackman, M. Z., & Johnson, C. E. (2000). *Leadership.* Prospect Heights, IL: Waveland.

Holtgraves, T. (1997). YES, BUT … Positive politeness in conversation arguments. *Journal of Language and Social Psychology, 16*, 222-239.

Janis, I. L. (1989). *Crucial decisions*. New York: Free Press.

Kennedy, P. (2004). *Guide to econometrics*. Cambridge: Blackwell.

Krippendorff, K. (2004). *Content analysis*. Thousand Oaks, CA: Sage.

Kuhn, D., Shaw, V., & Felton, M. (1997). Effects of dyadic interaction on argumentative reasoning. *Cognition and Instruction, 15*, 287-315.

Ljung, G., & Box, G. (1979). On a measure of lack of fit in time series models. *Biometrika, 66,* 265-270.

Maddala, G. S., & Kim, I. M. (1998). *Unit roots, cointegration and structural change.* New York: Cambridge University Press.

McLeod, P. L., Lobel, S. A., & Cox, T. H., Jr. (1996). Ethnic diversity and creativity in small groups. *Small Group Research, 27*, 2, 248-264

Orlitzky, M., & Hirokawa, R. Y. (2001). To err is human, to correct for it divine. *Small Group Research*, *32*, 313-341.

Paulus, P. B., & Brown, V. (2003). Ideational creativity in groups. In P. B. Paulus, & B. A. Nijstad (Eds.), *Group creativity*. New York: Oxford University Press.

Piaget, J. (1985). *The equilibrium of cognitive structures.* Chicago: University of Chicago Press.

Sawyer, K. (2003). *Group creativity*. Mahwah, NJ: Erlbaum.

Scardamalia, M., & Bereiter, C. (in press). Knowledge Building. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences*. Cambridge: Cambridge University Press.

Stasser, G, & Birchmeier, Z. (2003). Group creativity and collective choice. In P. B. Paulus & B. A. Nijstad's (Eds.) *Group Creativity*. Oxford: Oxford University Press.

Sternberg, R. J., & Lubart, T. I. (1999). The concept of creativity. In R. J. Sternberg (Ed.), *Handbook of Creativity*. New York: Cambridge University Press.