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Cooperation and Competition in Large Classrooms – Appendix

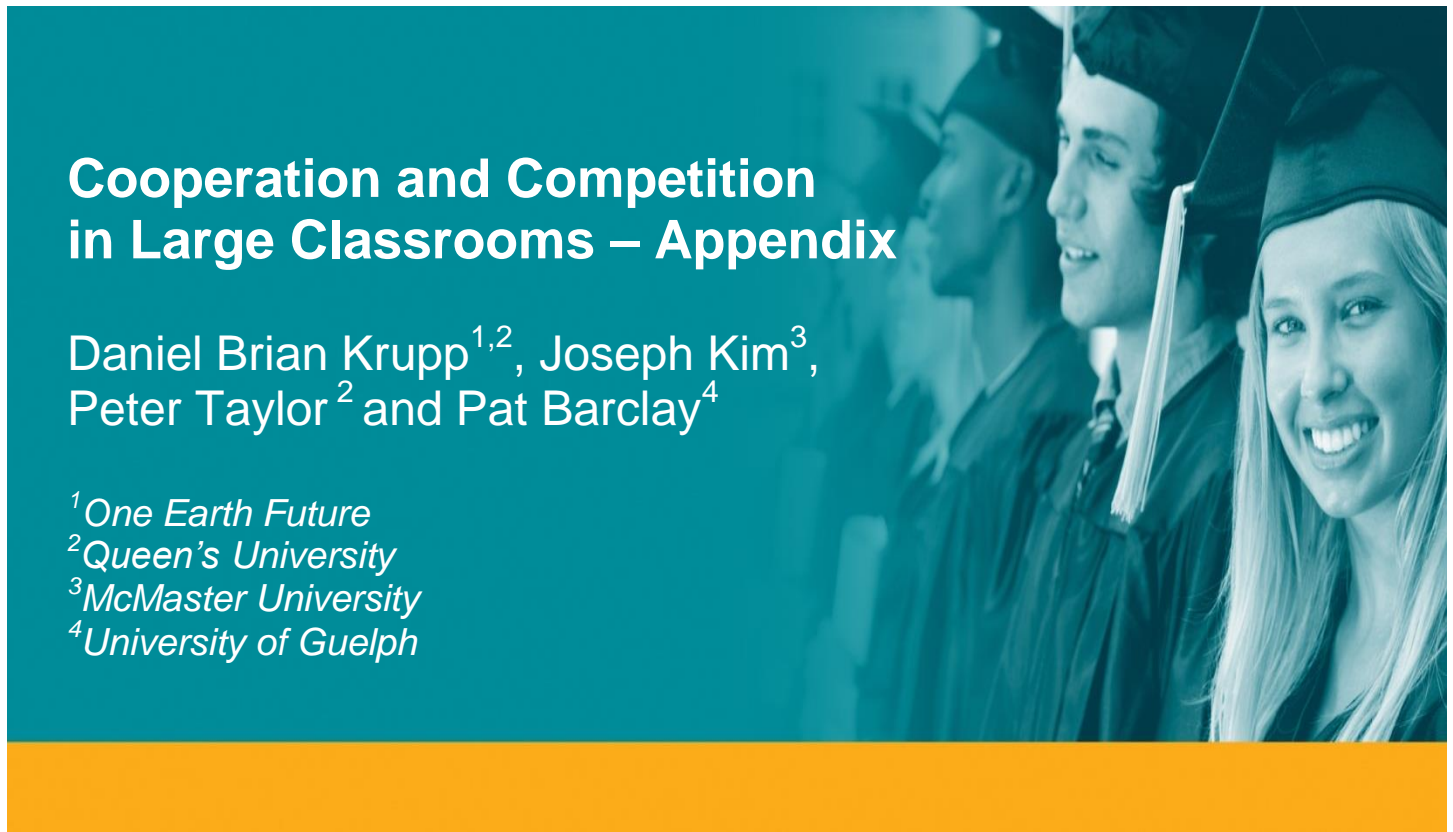
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Appendix 1: Example Instruction Script Given to Students

The following is an example of the script delivered to students in the various testing phases. The purpose of the script was to maintain consistency across TAs in information presentation. This example is drawn from the global competition condition from S3.

Each week, you have an online quiz that, as part of your grade, you are asked to complete. For quizzes 4 to 12, we have implemented an additional “bonus” credit system whereby we will reduce the weight of your Final Exam by up to 3%, over and above any credits you receive from your participation in research. Thus, if you earn sufficient credit in both research participation (5% weight) and the weekly quiz scheme (3% weight), it is possible to reduce the weight of the Final Exam from 60% to 52%.

Here is how it will work *for the next three weeks*:

Averaged over the next three quizzes (quizzes 4 to 6, inclusive), if your *entire tutorial group’s average mark is in the top 25% of average marks across all tutorials over the same quizzes, each of you will receive a 1% credit counting towards the weight of the Final Exam. Thus, if your entire tutorial group earns an average score that is better than 75% of the other tutorial groups, averaged over quizzes 4 to 6, you will earn 1% credit.*

Before quiz 7, we will provide a new set of instructions so that you can earn additional bonus credit.

Appendix 2: Modified Course Experience Questionnaire

CEQ Part I

Please complete the following questions by circling your answer.

1. How many of your classmates **did you help** to study for or complete this quiz?

0 1 2 3 4 (or more)

2. How many of your classmates **helped you** to study for or complete this quiz?

0 1 2 3 4 (or more)

3. Did you use your course materials while completing the quiz?

Yes No

CEQ Part II

Please tell us about your experience in this course by **circling the number** that best describes your response to the following questions.

	Strongly agree					Strongly disagree				
I feel part of a group of students committed to learning.	1	2	3	4	5					
I am able to explore academic interests with staff and students.	1	2	3	4	5					
I have learned to explore ideas confidently with other people.	1	2	3	4	5					
The other students value my ideas and suggestions.	1	2	3	4	5					
My tutorial group feels like a community.	1	2	3	4	5					

Appendix 3: Statistical Analyses

The summary results are reported in the Results section of the main document. Here, we present the full mixed-factorial, nested ANOVAs and, when appropriate, matched pair *t*-tests for each of the four semesters. The independent variables were Condition (within-subjects: three levels in S1, S3 and S4; two levels in S2), Order (between-subjects: three levels in S1, two levels in S2, and six levels in S3 and S4) and TA (between-subjects: as many levels as there were TAs in the study in a given semester). Note that “TA[Order]” refers to the TA variable being nested within the Order variable, as discussed in the Results section, and that all *F* approximations and associated *p* values are based on Wilks’ lambda.

For S3 and S4, data from Parts I and II of the CEQ were collected. We averaged each of the three items from Part I over the weeks from the same condition and analyzed them separately. Higher response scores on these measures represent more help given, more help received, and more frequent use of course materials for the tests, respectively. With respect to Part II of the CEQ, we summed responses to create total scores for each student in each condition. Responses on Part II of the CEQ were reverse-scored and could range from 0, indicating a strongly negative assessment of the learning community, to 25, indicating a strongly positive assessment of the learning community.

It is possible that the competition condition has effects in the first phase of the study only, when participants have not become acclimated to the manipulation. Thus, following the analyses of the full, mixed-factorial design, we report the results of nested, between-subjects ANOVAs, examining the possible effects of Condition and TA nested within Condition (“TA[Condition]”) on test performance in the first phase of each semester.

Semester 1

There were no significant main effects of Order ($F_{2,2178} = 0.91, p = .404$), TA[Order] ($F_{35,2178} = 1.41, p = .056$) or Condition ($F_{2,2177} = 1.18, p = .308$) on test scores. There was a significant interaction between Condition and Order ($F_{4,4354} = 254.43, p < .001$), but not between Condition and TA[Order] ($F_{70,4354} = 1.01, p = .445$).

Within Order 1 (phase 1, asocial; phase 2, local; phase 3, global), global score ($M = 7.50$) was significantly greater than both asocial score ($M = 6.27; t_{909} = 22.19, p < .001$) and local score ($M = 7.06; t_{909} = 8.04, p < .001$). Local score was also significantly greater than asocial score ($t_{909} = 14.53, p < .001$). Within Order 2 (phase 1, local; phase 2, global; phase 3, asocial), global score ($M = 7.13$) was significantly smaller than asocial score ($M = 7.57; t_{761} = 7.69, p < .001$), but significantly greater than local score ($M = 6.34; t_{761} = 13.06, p < .001$). Moreover, local score was also significantly smaller than asocial score ($t_{761} = 21.02, p < .001$). Finally, within Order 3 (phase 1, global; phase 2, asocial; phase 3, local), global score ($M = 6.32$) was significantly smaller than both asocial score ($M = 6.96; t_{543} = 8.89, p < .001$) and local score ($M = 7.48; t_{543} = 16.31, p < .001$). Moreover, local score was significantly greater than asocial score ($t_{543} = 7.16, p < .001$).

Semester 2

There were no significant main effects of Order ($F_{1,1603} = 3.60, p = .058$), TA[Order] ($F_{27,1603} = 1.04, p = .409$) or Condition ($F_{1,1603} = 0.26, p = .609$) on test scores. There was a significant interaction between Condition and Order ($F_{1,1603} = 287.38, p < .001$), but not between Condition and TA[Order] ($F_{27,1603} = 0.94, p = .556$). Within Order 1 (phase 1, global; phase 2, local), global score ($M = 7.17$) was significantly greater than local score ($M = 6.66; t_{756} = 11.76, p < .001$). Within Order 2 (phase 1, local; phase 2, global), global score ($M = 6.53$) was significantly smaller than local score ($M = 7.08; t_{874} = 13.73, p < .001$).

Semester 3

Test scores. There were no significant main effects of Order ($F_{5,2326} = 1.55, p = .172$), TA[Order] ($F_{33,2326} = 1.08, p = .351$) or Condition ($F_{2,2325} = 1.48, p = .227$) on test scores. There was a significant interaction between Condition and Order ($F_{10,4650} = 21.77, p < .001$), but not between Condition and TA[Order] ($F_{66,4650} = 0.97, p = .075$).

Within Order 1 (phase 1, asocial; phase 2, local; phase 3, global), global score ($M = 7.23$) was significantly greater than both asocial score ($M = 6.90; t_{531} = 5.50, p < .001$) and local score ($M = 6.90; t_{531} = 5.51, p < .001$). However, local score did not differ significantly from asocial score ($t_{531} = 0.09, p = .929$). Within Order 2 (phase 1, asocial; phase 2, global; phase 3, local), global score ($M = 6.81$) was significantly smaller than local score ($M = 7.32; t_{214} = 5.52, p < .001$), but did not differ significantly from asocial score ($M = 6.89; t_{214} = 0.94, p = .348$). Moreover, local score was significantly greater than asocial score ($t_{214} = 4.51, p < .001$). Within Order 3 (phase 1, local; phase 2, asocial; phase 3, global), global score ($M = 7.39$) was significantly greater than both asocial score ($M = 7.05; t_{358} = 4.74, p < .001$) and local score ($M = 7.05; t_{358} = 4.60, p < .001$). However, local score did not differ significantly from asocial score ($t_{358} = 0.01, p = .995$). Within Order 4 (phase 1, local; phase 2, global; phase 3, asocial), global score ($M = 7.04$) was significantly smaller than asocial score ($M = 7.30; t_{509} = 4.15, p < .001$), but did not differ significantly from local score ($M = 6.99; t_{509} = 0.86, p = .392$). Moreover, local score was significantly smaller than asocial score ($t_{509} = 5.22, p < .001$). Within Order 5 (phase 1, global; phase 2, asocial; phase 3, local), global score ($M = 6.96$) was significantly smaller than local score ($M = 7.38; t_{445} = 6.59, p < .001$), but did not differ significantly from asocial score ($M = 6.99; t_{445} = 0.46, p = .648$). Moreover, local score was significantly greater than asocial score ($t_{445} = 5.86, p < .001$). Within Order 6 (phase 1, global; phase 2, local; phase 3, asocial), global score ($M = 6.93$) was significantly smaller than asocial score ($M = 7.30; t_{302} = 5.24, p < .001$), but did not differ significantly from local score ($M = 6.93; t_{302} = 0.02, p = .983$). Moreover, local score was significantly smaller than asocial score ($t_{302} = 5.32, p < .001$).

Amount of help given. There were no significant main effects of Order ($F_{5,1384} = 1.11, p = .353$), TA[Order] ($F_{33,1384} = 1.07, p = .355$) or Condition ($F_{2,1383} = 0.16, p = .856$) on amount of help given, and there were no significant interactions between Condition and Order ($F_{10,2766} = 1.50, p = .131$) or between Condition and TA[Order] ($F_{66,2766} = 1.16, p = .174$).

Amount of help received. There were no significant main effects of Order ($F_{5,1384} = 0.77, p = .575$), TA[Order] ($F_{33,1384} = 0.91, p = .623$) or Condition ($F_{2,1383} = 0.29, p = .746$) on amount of help received. There was, however, a significant interaction between Condition and Order ($F_{10,2766} = 1.90, p = .041$), but not between Condition and TA[Order] ($F_{66,2766} = 1.03, p = .410$).

Within Order 1 (phase 1, asocial; phase 2, local; phase 3, global), there were no significant differences among global ($M = 0.29$), local ($M = 0.26$) and asocial responses ($M = 0.31$; all $t_{327} < 1.93$, all $p > .054$). Within Order 2 (phase 1, asocial; phase 2, global; phase 3, local), there were no significant differences among global ($M = 0.27$), local ($M = 0.33$) and asocial responses ($M = 0.34$; all $t_{116} < 1.40$, all $p > .164$). Within Order 3 (phase 1, local; phase 2, asocial; phase 3, global), there were no significant differences among global ($M = 0.24$), local ($M = 0.28$) and asocial responses ($M = 0.30$; all $t_{213} < 1.42$, all $p > .156$). Within Order 4 (phase 1, local; phase 2, global; phase 3, asocial), there were no significant differences among global ($M = 0.25$), local ($M = 0.29$) and asocial responses ($M = 0.27$; all $t_{289} < 1.24$, all $p > .215$). Within Order 5 (phase 1, global; phase 2, asocial; phase 3, local), global responses ($M = 0.35$) were significantly greater than asocial responses ($M = 0.28; t_{283} = 2.13, p = .034$), but there were no significant differences between global and local responses ($M = 0.32; t_{283} = 0.73, p = .467$) or between local and asocial responses ($t_{283} = 1.29, p = .197$). Within Order 6 (phase 1, global; phase 2, local; phase 3, asocial), global responses ($M = 0.31$) were significantly greater than local responses ($M = 0.22; t_{189} = 2.46, p = .015$), but there were no significant differences between global and

asocial responses ($M = 0.27$; $t_{189} = 0.78$, $p = .436$) or between local and asocial responses ($t_{189} = 1.44$, $p = .152$).

Course materials used. There were no significant main effects of Order ($F_{5,1384} = 1.22$, $p = .298$), TA[Order] ($F_{33,1384} = 1.00$, $p = .465$) or Condition ($F_{2,1383} = 1.81$, $p = .164$) on whether course materials were used. There was, however, a significant interaction between Condition and Order ($F_{10,2766} = 9.32$, $p < .001$), but not between Condition and TA[Order] ($F_{66,2766} = 0.85$, $p = .801$).

Within Order 1 (phase 1, asocial; phase 2, local; phase 3, global), asocial responses ($M = 0.66$) were significantly greater than global responses ($M = 0.59$; $t_{327} = 3.73$, $p < .001$) and local responses ($M = 0.59$; $t_{327} = 4.33$, $p < .001$). However, global and local responses did not differ significantly ($t_{327} = 0.05$, $p = .957$). Within Order 2 (phase 1, asocial; phase 2, global; phase 3, local), asocial responses ($M = 0.66$) were significantly greater than global responses ($M = 0.54$; $t_{116} = 4.36$, $p < .001$) and local responses ($M = 0.60$; $t_{116} = 2.22$, $p = .028$). However, global and local responses did not differ significantly ($t_{116} = 1.94$, $p = .055$). Within Order 3 (phase 1, local; phase 2, asocial; phase 3, global), local responses ($M = 0.69$) were significantly greater than global ($M = 0.62$; $t_{213} = 3.25$, $p = .001$) and asocial responses ($M = 0.60$; $t_{213} = 4.44$, $p < .001$). However, global and asocial responses did not differ significantly ($t_{213} = 1.06$, $p = .292$). Within Order 4 (phase 1, local; phase 2, global; phase 3, asocial), global responses ($M = 0.54$) were significantly smaller than local responses ($M = 0.63$; $t_{289} = 4.43$, $p < .001$) and asocial responses ($M = 0.60$; $t_{289} = 3.08$, $p = .002$). However, local and asocial responses did not differ significantly ($t_{289} = 1.32$, $p = .188$). Within Order 5 (phase 1, global; phase 2, asocial; phase 3, local), global responses ($M = 0.65$) were significantly greater than local responses ($M = 0.58$; $t_{283} = 3.45$, $p = .001$) and asocial responses ($M = 0.58$; $t_{283} = 3.74$, $p < .001$). However, local and asocial responses did not differ significantly ($t_{283} = 0.24$, $p = .811$). Within Order 6 (phase 1, global; phase 2, local; phase 3, asocial), global responses ($M = 0.69$) were significantly greater than local responses ($M = 0.62$; $t_{189} = 3.01$, $p = .003$) and asocial responses ($M = 0.60$; $t_{189} = 3.49$, $p = .001$). However, local and asocial responses did not differ significantly ($t_{189} = 0.86$, $p = .389$).

CEQ Part II. There was a significant main effect of TA[Order] ($F_{33,1384} = 1.96$, $p = .001$), but not of Order ($F_{5,1384} = 1.95$, $p = .083$) or Condition ($F_{2,1383} = 2.26$, $p = .104$), on Part II of the CEQ. There was also a significant interaction between Condition and Order ($F_{10,2766} = 7.70$, $p < .001$) but not between Condition and TA[Order] ($F_{66,2766} = 1.15$, $p = .197$).

Within Order 1 (phase 1, asocial; phase 2, local; phase 3, global), global responses ($M = 12.20$) were significantly greater than local responses ($M = 11.59$; $t_{327} = 2.32$, $p = .021$) and asocial responses ($M = 11.31$; $t_{327} = 3.45$, $p = .001$). However, local and asocial responses did not differ significantly ($t_{327} = 1.19$, $p = .236$). Within Order 2 (phase 1, asocial; phase 2, global; phase 3, local), local responses ($M = 12.39$) were significantly greater than asocial responses ($M = 11.15$; $t_{116} = 2.96$, $p = .003$). However, there were no significant differences between local and global responses ($M = 11.76$; $t_{116} = 1.21$, $p = .229$) or between global and asocial responses ($t_{116} = 1.40$, $p = .164$). Within Order 3 (phase 1, local; phase 2, asocial; phase 3, global), global responses ($M = 13.15$) were significantly greater than local responses ($M = 11.79$; $t_{213} = 3.94$, $p < .001$) and asocial responses ($M = 12.55$; $t_{213} = 2.00$, $p = .047$). Moreover, asocial responses were significantly greater than local responses ($t_{213} = 2.41$, $p = .017$). Within Order 4 (phase 1, local; phase 2, global; phase 3, asocial), local responses ($M = 12.19$) were significantly greater than global responses ($M = 12.64$; $t_{289} = 2.00$, $p = .046$) and asocial responses ($M = 12.77$; $t_{289} = 2.34$, $p = .020$). However, global and asocial responses did not differ significantly ($t_{289} = 0.48$, $p = .629$). Within Order 5 (phase 1, global; phase 2, asocial; phase 3, local), local responses ($M = 13.04$) were significantly greater than global responses ($M = 11.46$; $t_{283} = 4.84$, $p < .001$) and asocial responses ($M = 11.97$; $t_{283} = 3.96$, $p < .001$). However, global and asocial responses did not differ significantly ($t_{283} = 1.76$, $p = .080$). Within Order 6 (phase 1, global; phase 2, local; phase 3, asocial), global responses ($M = 11.35$) were significantly smaller than local responses ($M = 12.01$; $t_{189} = 2.32$, $p = .022$). However, there were no significant differences between global and asocial responses ($M = 11.91$; $t_{189} = 1.53$, $p = .127$) or between local and asocial responses ($t_{189} = 0.32$, $p = .749$).

Semester 4

Test scores. There was a significant main effect of TA[Order] ($F_{19,1485} = 1.85, p = .015$), but not of Order ($F_{5,1485} = 0.48, p = .788$) or Condition ($F_{2,1484} = 0.29, p = .746$) on test scores. There was also a significant interaction between Condition and Order ($F_{10,2968} = 35.02, p < .001$) but not between Condition and TA[Order] ($F_{38,2968} = 0.86, p = .711$).

Within Order 1 (phase 1, global; phase 2, local; phase 3, asocial), global score ($M = 6.88$) was significantly smaller than both local score ($M = 7.50; t_{314} = 7.60, p < .001$) and asocial score ($M = 7.39; t_{314} = 5.83, p < .001$). However, local and asocial scores did not differ significantly ($t_{314} = 1.53, p = .126$). Within Order 2 (phase 1, global; phase 2, asocial; phase 3, local), global score ($M = 6.85$) was significantly smaller than both local score ($M = 7.43; t_{270} = 6.39, p < .001$) and asocial score ($M = 7.47; t_{270} = 7.20, p < .001$). However, local and asocial scores did not differ significantly ($t_{270} = 0.62, p = .537$). Within Order 3 (phase 1, local; phase 2, global; phase 3, asocial), local score ($M = 6.81$) was significantly smaller than global score ($M = 7.57; t_{263} = 8.46, p < .001$) and asocial score ($M = 7.44; t_{263} = 6.26, p < .001$). However, global and asocial scores did not differ significantly ($t_{263} = 1.56, p = .121$). Within Order 4 (phase 1, local; phase 2, asocial; phase 3, global), local score ($M = 6.84$) was significantly smaller than global score ($M = 7.29; t_{221} = 4.33, p < .001$) and asocial score ($M = 7.36; t_{221} = 4.99, p < .001$). However, global and asocial scores did not differ significantly ($t_{221} = 0.77, p = .440$). Within Order 5 (phase 1, asocial; phase 2, global; phase 3, local), global score ($M = 7.58$) was significantly greater than local score ($M = 7.39; t_{244} = 2.31, p = .022$) and asocial score ($M = 7.02; t_{244} = 6.03, p < .001$). Moreover, local score was significantly greater than asocial score ($t_{244} = 3.83, p < .001$). Within Order 6 (phase 1, asocial; phase 2, local; phase 3, global), asocial score ($M = 6.68$) was significantly smaller than global score ($M = 7.37; t_{192} = 6.03, p < .001$) and local score ($M = 7.46; t_{192} = 6.08, p < .001$). However, global and local scores did not differ significantly ($t_{192} = 0.99, p = .324$).

Amount of help given. There were no significant main effects of Order ($F_{5,899} = 1.62, p = .151$), TA[Order] ($F_{19,899} = 1.09, p = .355$) or Condition ($F_{2,898} = 1.22, p = .296$) on amount of help given, and there were no significant interactions between Condition and Order ($F_{10,1796} = 1.33, p = .211$) or between Condition and TA[Order] ($F_{38,1796} = 1.00, p = .473$).

Amount of help received. There were no significant main effects of Order ($F_{5,899} = 0.85, p = .515$), TA[Order] ($F_{19,899} = 0.94, p = .539$) or Condition ($F_{2,898} = 1.43, p = .239$) on amount of help received, and there were no significant interactions between Condition and Order ($F_{10,1796} = 1.06, p = .390$) or between Condition and TA[Order] ($F_{38,1796} = 0.87, p = .689$).

Course materials used. There were no significant main effects of Order ($F_{5,899} = 0.13, p = .985$), TA[Order] ($F_{19,899} = 0.58, p = .923$) or Condition ($F_{2,898} = 0.07, p = .930$) on frequency of course materials being used. There was, however, a significant interaction between Condition and Order ($F_{10,1796} = 5.63, p < .001$), but not between Condition and TA[Order] ($F_{38,1796} = 0.75, p = .862$).

Within Order 1 (phase 1, global; phase 2, local; phase 3, asocial), global responses ($M = 0.68$) were significantly greater than local responses ($M = 0.59; t_{193} = 3.77, p < .001$) and asocial responses ($M = 0.60; t_{193} = 2.91, p = .004$). However, local and asocial responses did not differ significantly ($t_{193} = 0.60, p = .550$). Within Order 2 (phase 1, global; phase 2, asocial; phase 3, local), global responses ($M = 0.65$) were significantly greater than asocial responses ($M = 0.58; t_{177} = 2.70, p = .008$). However, there were no significant differences between global and local responses ($M = 0.61; t_{177} = 1.57, p = .119$) or between asocial and local responses ($t_{177} = 1.36, p = .177$). Within Order 3 (phase 1, local; phase 2, global; phase 3, asocial), local responses ($M = 0.67$) were significantly greater than global responses ($M = 0.61; t_{159} = 1.92, p = .057$) and asocial responses ($M = 0.58; t_{159} = 2.76, p = .006$). However, global and asocial responses did not differ significantly ($t_{159} = 1.55, p = 0.123$). Within Order 4 (phase 1, local; phase 2, asocial; phase 3, global), local

responses ($M = 0.68$) were significantly greater than global responses ($M = 0.60$; $t_{141} = 2.39$, $p = .018$) and asocial responses ($M = 0.61$; $t_{141} = 2.34$, $p = .021$). However, global and asocial responses did not differ significantly ($t_{141} = 0.17$, $p = 0.865$). Within Order 5 (phase 1, asocial; phase 2, global; phase 3, local), asocial responses ($M = 0.67$) were significantly greater than global responses ($M = 0.59$; $t_{143} = 2.77$, $p = .006$) and local responses ($M = 0.60$; $t_{143} = 2.58$, $p = .011$). However, global and local responses did not differ significantly ($t_{143} = 0.19$, $p = .853$). Within Order 6 (phase 1, asocial; phase 2, local; phase 3, global), asocial responses ($M = 0.68$) were significantly greater than local responses ($M = 0.61$; $t_{105} = 2.15$, $p = .034$). However, there were no significant differences between asocial and global responses ($M = 0.61$; $t_{105} = 1.91$, $p = .059$) or between global and local responses ($t_{105} = 0.00$, $p > .999$).

Test Performance in the First Phase

The omnibus ANOVA was not statistically significant in S1 ($F_{38,2699} = 1.36$, $p = .068$), S2 ($F_{28,1636} = 0.87$, $p = .665$) or S3 ($F_{38,2362} = 0.95$, $p = 0.555$), but was statistically significant in S4 ($F_{24,1498} = 1.78$, $p = .011$). In S4, there was a significant main effect of TA[Condition] ($F_{19,1498} = 1.91$, $p = .010$) but not of Condition ($F_{5,1498} = 0.89$, $p = .488$).

Effects of Help Given and Received

For S3 and S4, we computed the mean test score, mean amount of help given, mean amount of help received and mean CEQ Part II score (S4 only) for each student across the three phases of the study (i.e., from the weeks of tests 4-12 in S3 and tests 4-11 in S4). We then predicted mean test scores in each semester using mean amounts of help given and received. The omnibus model was statistically significant in S3 ($R^2 = .01$, $F_{3,1418} = 4.94$, $p = .002$) but not in S4 ($F_{2,920} = 2.56$, $p = .078$). In S3, mean CEQ Part II scores significantly and positively predicted mean test scores ($\beta = 0.09$, $p = .001$). However, neither mean help given ($\beta = 0.03$, $p = .496$) nor mean help received ($\beta = 0.02$, $p = .626$) significantly predicted mean test scores.



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