

## Effect of peer instruction on the likelihood for choosing the correct response to a physiology question

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**Relling AE, Giuliodori MJ.** Effect of peer instruction on the likelihood for choosing the correct response to a physiology question. *Adv Physiol Educ* 39: 167–171, 2015; doi:10.1152/advan.00092.2014.—The aims of the present study were to measure the effects of individual answer (correct vs. incorrect), individual answer of group members (no vs. some vs. all correct), self-confidence about the responses (low vs. mid vs. high), sex (female vs. male students), and group size (2–4 students) on the odds for change and for correctness after peer instruction in a veterinary physiology course ( $n = 101$  students). Data were assessed by multivariable logistic regression analysis. The likelihood for change after peer instruction increased when the confidence on an individual answer was low ( $P < 0.01$ ), when the answer was incorrect ( $P < 0.01$ ), and when group members had different responses ( $P < 0.01$ ). The likelihood for correctness after peer instruction increased when the confidence in group answers was high ( $P < 0.01$ ), when the individual answer was correct ( $P < 0.01$ ), and when at least one of the group members had the correct response ( $P < 0.01$ ). After peer discussion, more changes were from incorrect to correct responses than vice versa (72% vs. 28%,  $P < 0.01$ ). Changes to correct answers occurred after discussion with peers having both the correct individual response (76% of times) and also the incorrect individual answer (24% of times). In conclusion, the benefits of peer instruction are due to students having correct answers generally prevail in discussions. Also, students who all have incorrect answers can get the correct answer through debate and discussion.

student feedback; odds for change; odds for correctness; peer instruction

IT HAS BEEN RECOMMENDED to teach science in the way it is practiced (3). That means instructional activities must resemble the nature of investigative activities (29). In this sense, science is practiced by research groups trying to solve real problems all around the globe; thus, collaboration and problem solving are key components of the scientific world (4). Thus, knowledge should be constructed by active processing of information and also by interacting with classmates and the instructor in science classes (9). In addition, it has been suggested that, as the generation of new scientific knowledge is huge, trying to deliver it all can be counterproductive (2). As our world is changing at a faster pace than ever, our students will face challenges that did not exist in the past generation. Thus, the change needed today in science instruction relates to providing our students with the skills and competencies they need to face the demands of a changing workplace (21). Most faculty members get their teaching positions after earning research doctorates without receiving any formal training in the practice

of teaching. This is why most scientists teach the way they were taught, i.e., lecture based (21). Other reasons for not including collaborative learning activities in their courses are that teachers have too much content to cover, that high-performing students are the decision makers in peer discussions, that low-performing students would benefit undeservingly in the process, and that low-performing students could deter high-performing students. Another reason could be the difficulty of changing the way we teach (26).

Peer instruction, a teaching method consisting of lectures interspersed with conceptual questions engaging students in problem solving and collaborative activities, has proved to be effective in physics courses for over a decade (8, 12). The effectiveness of peer instruction has long been related to knowledge transmission from students with the correct answers and right reasons to their peers during discussions (17). It has recently been reported that this positive effect is not only due to that knowledge transmission but also to coconstruction of new knowledge (27) and that the combined effect of feedback provided by students and by instructors is better than the single effect of feedback given by either students or instructors alone (28). In addition, some promising results have also been reported in physiology courses (6, 15, 23). Thus, this instruction technique could help instructors to smooth the worrying transition from didactic lectures to the highly recommended and more demanding active learning activities. In this context, gaining insights into the peer discussions leading to coconstruction of knowledge may support the incorporation of collaborative learning activities in science classes. Therefore, the aim of the present study was to measure the effects of individual answers (correct vs. incorrect), individual answers of group members (no vs. some vs. all correct), self-confidence about the responses (low vs. mid vs. high), sex (female vs. male students), and group size (2–4 students) on the odds for change and for correctness after peer instruction.

### METHODS

The present study was approved by the Internal Review Board of the Faculty of Veterinary Sciences of the National University of La Plata.

**Student population.** One hundred and one students, aged 21.7 (SD 3.5) yr, with a proportion of female students of 0.67, attending at a veterinary physiology course (Fisiología no 03G1-42300, Facultad de Ciencias Veterinarias, Universidad Nacional de La Plata, La Plata, Argentina) were enrolled in this study.

**Procedures.** On the first day of class, every student was assigned a personal identification number (PIN) to keep the student's anonymity and to be able to trace back student interactions. Numbers were correlatives from 1 to 101. Students were told to record their PIN on the in-class quiz form and also to record the PIN from their peer(s) of discussion. Students were instructed to form groups of two to four

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students by self-selection. In addition, students had to record their sex on the in-class form. The class was lecture based, and the peer instruction technique was used for seven classes involving cardiovascular, respiratory, and renal physiology, as previously described (15). Briefly, four to six minipresentations were interspersed in 90-min classes where in-class quizzes were used to record answers and confidence levels on answers (scale: 1 = “very sure,” 2 = “not so sure,” and 3 = “just guessing”) at both individual and group levels. Questions included on in-class quizzes were qualitative problems asking for a prediction (increase/decrease/no change) about the response of a system to a perturbation (15, 18, 19). The time allowed for answering every question of the in-class quizzes varied from 1 to 4 min.

Criteria for inclusion in the analysis were as follows: quizzes should have recorded PINs from the student completing the quiz and from the peer(s) of discussion (up to 3 peers were accepted) and at least three questions fully answered (response plus confidence). A total of 365 quizzes were included in the study (118 quizzes from groups of 2 students, 159 quizzes from groups of 3 students, and 88 quizzes from groups of 4 students). A total of 59 quizzes were not included (30 quizzes from groups of 5 students, 18 quizzes from groups of 6 students, and 11 quizzes without PINs).

**Statistical analysis.** A completely randomized design was used where the student was considered as the experimental unit. The effect of peer instruction on both the odds for change (yes vs. no) and odds for correctness (correct vs. incorrect) were assessed with logistic regression models (1). The logistic models included the fixed effects of individual answer (correct vs. incorrect), individual confidence level (very sure vs. not so sure vs. just guessing), individual answers of group members (all correct vs. some correct vs. no correct), group size (2 vs. 3 vs. 4 members/group), and sex (female vs. male students). The logistic model assessing the odds for correctness also included the fixed effect of group confidence level (very sure vs. not so sure vs. just guessing). Fixed effects with  $P > 0.05$  were removed from the logistic models (1). All results are presented as percentages, and significance was set at  $P < 0.05$ .

## RESULTS

Fifty-one percent (1122 of 2212) of individual answers were correct, and 25% (559 of 2212) of individual responses were changed after peer discussion. Of the 2212 individual answers, 41 did not include a confidence level. The odds for changing an

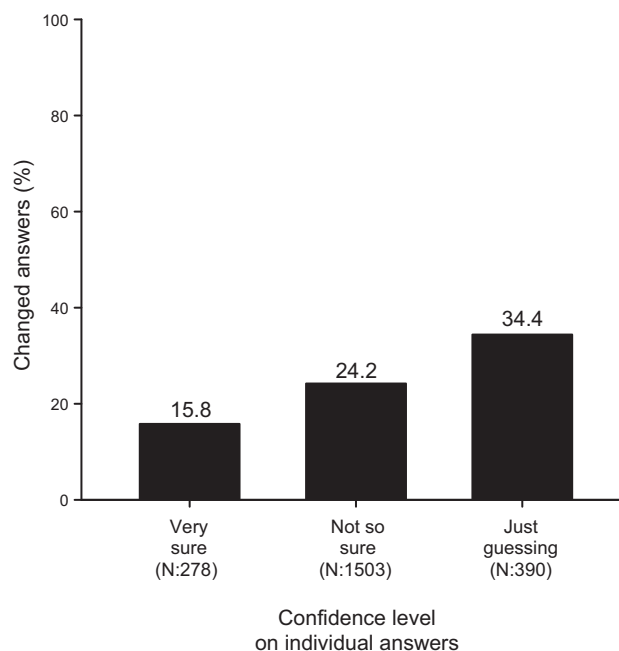


Fig. 1. Percentage of changed answers after peer instruction depending on the confidence level on individual answers in a veterinary physiology course ( $n = 101$  students).

individual answer after peer instruction were affected by both the confidence and correctness of individual answers and also by the correctness of individual answers of group members ( $P < 0.01$ ; Table 1). Just guessing answers and not so sure answers had 2.54 and 1.85 higher odds, respectively, of being changed after peer instruction than very sure responses ( $P < 0.01$ ; Fig. 1 and Table 1). Individual incorrect answers had over threefold higher odds of being changed after peer instruction than correct responses ( $P < 0.01$ ; Fig. 2 and Table 1). Of the 2212 individual answers, 28 group answers did not include either confidence level or individual answers of group members. No correct and some correct answer groups had  $>2$ -fold

Table 1. Logistic model of the odds for changing answers after peer instruction in a veterinary physiology course

	Changed Answers		P value
	% (n/N) <sup>a</sup>	OR (95% CI) <sup>b</sup>	
Confidence <sup>d</sup>			<0.01
Just guessing	34.4 (134/390)	2.54 (1.63–3.99)	
Not so sure	24.2 (364/1503)	1.85 (1.24–2.75)	
Very sure	15.8 (44/278)	Referent <sup>c</sup>	
Initial answer <sup>e</sup>			<0.01
Incorrect	36.7 (400/1090)	3.35 (2.58–4.37)	
Correct	14.2 (159/1122)	Referent <sup>c</sup>	
Groups <sup>f</sup>			<0.01
No correct	18.0 (97/539)	2.36 (1.25–4.48)	
Some correct	41.1 (445/1082)	14.70 (8.26–26.15)	
All correct	2.5 (14/563)	Referent <sup>c</sup>	

$n = 101$  students. <sup>a</sup>% (n/N), percentage (number/total); <sup>b</sup>OR (95% CI), odds ratio (95% confidence interval); <sup>c</sup>referent, level of the predictor variable compared against the other levels; <sup>d</sup>confidence, confidence on individual answers; <sup>e</sup>initial answer, individual answers; <sup>f</sup>groups, individual answers of group members. Sex and group size were excluded because they had no effect ( $P > 0.10$ ).

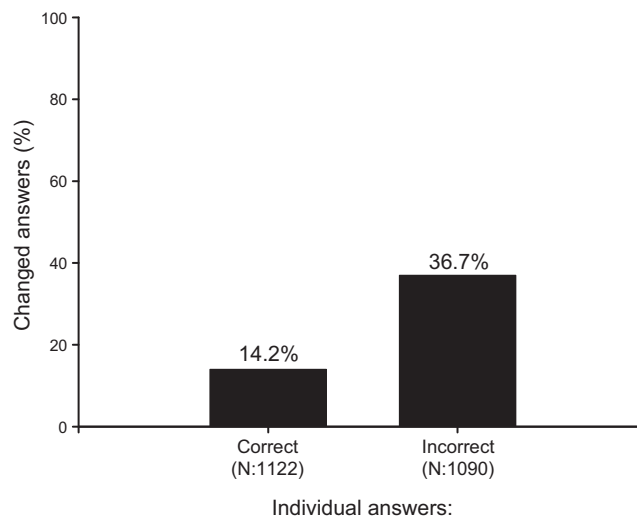


Fig. 2. Percentage of changed answers after peer instruction depending on the correctness of individual answers in a veterinary physiology course ( $n = 101$  students).

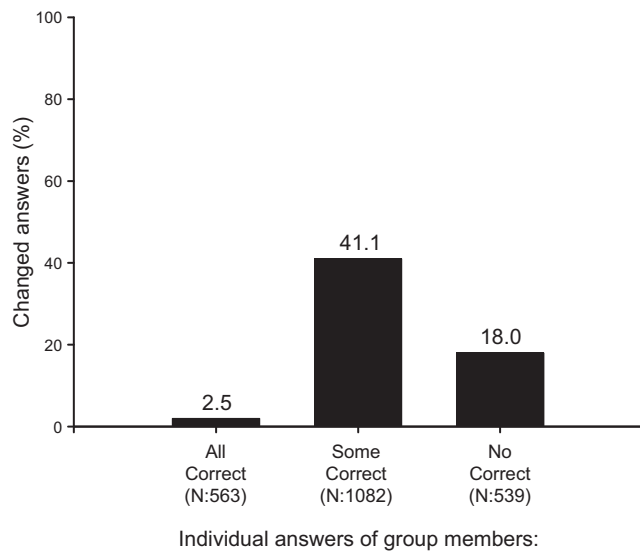


Fig. 3. Percentage of changed answers after peer instruction depending on the correctness of individual answers of group members in a veterinary physiology course ( $n = 101$  students).

and >14-fold higher odds, respectively, of changing their responses after peer instruction than all correct answer groups ( $P < 0.01$ ; Fig. 3 and Table 1). Conversely, sex ( $P = 0.26$ ) and group size ( $P = 0.35$ ) had no effect on the odds for changing individual answers.

The odds for choosing correct group answers increased with the level of group confidence on responses ( $P < 0.01$ ; Fig. 4 and Table 2). Students with individual correct answers had over twofold higher odds of getting correct group answers than peers with incorrect ones ( $P < 0.01$ ; Fig. 5 and Table 2). The odds were also affected by the pattern of correctness of individual answers of group members since all correct and

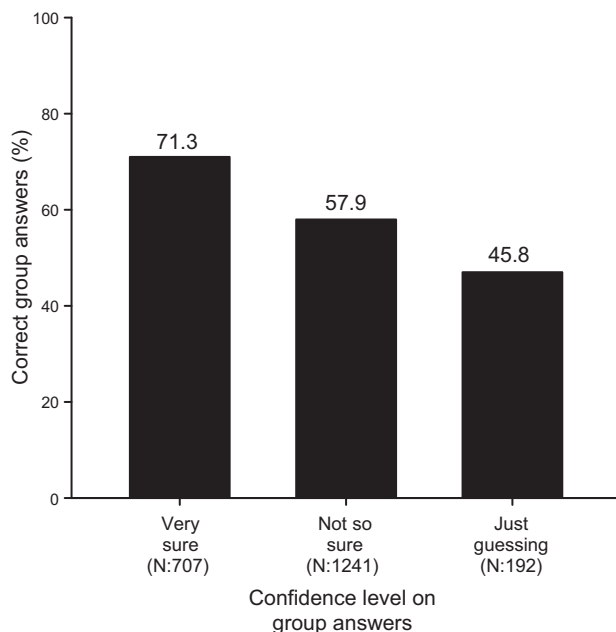


Fig. 4. Percentage of correct answers after peer instruction depending on the confidence level on group answers in a veterinary physiology course ( $n = 101$  students).

Table 2. Logistic model of the odds for getting a correct answer after peer instruction in a veterinary physiology course

	Correct answers		
	% (n/N) <sup>a</sup>	OR (95% CI) <sup>b</sup>	P value
Confidence <sup>d</sup>			<0.01
Very sure	71.3 (504/707)	Referent <sup>c</sup>	
Not so sure	57.9 (718/1241)	0.66 (0.50–0.87)	
Just guessing	45.8 (88/192)	0.39 (0.25–0.61)	
Initial answer <sup>e</sup>			<0.01
Incorrect	36.7 (400/1090)	Referent <sup>c</sup>	
Correct	85.8 (963/1122)	2.35 (1.82–3.03)	
Groups <sup>f</sup>			<0.01
No correct	18.0 (97/539)	Referent <sup>c</sup>	
Some correct	64.6 (699/1082)	5.59 (4.18–7.40)	
All correct	97.5 (549/563)	76.92 (41.67–142.86)	

$n = 101$  students. <sup>a</sup>% (n/N): percentage (number/total); <sup>b</sup>OR (95%CI): odds ratio (95% confidence interval); <sup>c</sup>referent: level of the predictor variable against the other levels are compared; <sup>d</sup>group confidence: confidence level on group answers; <sup>e</sup>initial answer: individual answers; <sup>f</sup>groups: individual answers of group members. Sex, group size, and confidence on individual answers were excluded because they had no effect ( $P > 0.10$ ).

some correct groups had 76.9 and 5.6 higher odds, respectively, of getting correct response after peer instruction than no correct answer groups ( $P < 0.01$ ; Fig. 6 and Table 2). Conversely, sex ( $P = 0.61$ ), group size ( $P = 0.87$ ), and confidence level on individual answers ( $P = 0.71$ ) had no effect.

Changes to correct group answers were 2.8 times higher than changes to incorrect group responses [399 vs. 157 (72% vs. 28%),  $P < 0.01$ ; Fig. 7]. Within changes to correct, 76% (304 of 399 answers) occurred in some correct answer groups and 24% (95 of 399 answers) in no correct answer groups. Within changes to incorrect, 92% (141 of 157 answers) were found in some correct answer groups, 9% (14 of 157 answer) in all correct answer groups, and 1% (2 of 157 answers) in no correct answer groups.

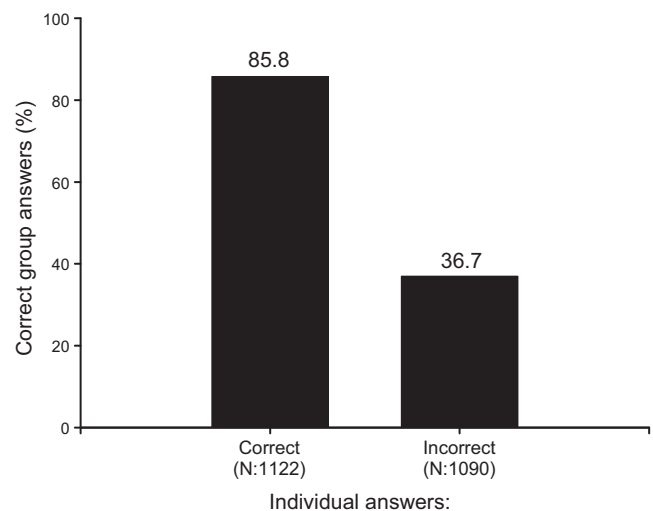


Fig. 5. Percentage of correct answers after peer instruction depending on the correctness of individual answers in a veterinary physiology course ( $n = 101$  students).

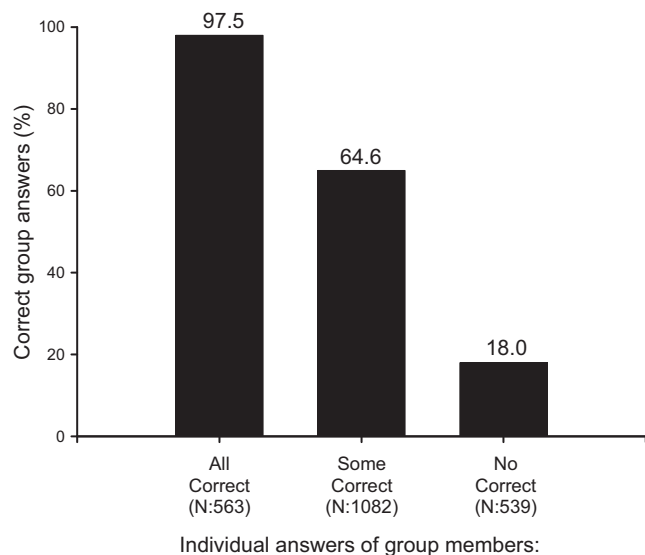


Fig. 6. Percentage of correct answers after peer instruction depending on the correctness of individual answers of group members in a veterinary physiology course ( $n = 101$  students).

## DISCUSSION

The odds, another way of expressing probabilities, is the number of events (i.e., correct answers) divided by the number of no events (i.e., incorrect answers) (1), and the odds ratio is the ratio between the odds of the event in different groups (i.e., odds for correct answers between students working alone and in teams) (10). The odds ratio is a dimensionless index, not influenced by sample size, which measures the biological impact of the factor under study [peer discussion (10)].

The goal of the present study was focused on the peer discussion characteristics that give rise to the effects of peer instruction. A quarter of individual answers were changed after discussion. This finding is in agreement with a previous work in collaborative testing (13). The likelihood for change after peer discussion is much higher in students with individual incorrect answers and in those with low confidence on their answers. These findings are consistent with recent work documenting the effect of peer instruction (8, 15) and collaborative testing (13). In addition, peer instruction has higher impact in some correct answer groups than in the others (no correct and all correct answer groups), maybe as a consequence of the needed discussion for establishing consensus. In addition, during discussions when there is disagreement, as it is the case in the some correct answer groups, those peers with the correct response (and the right reasons) mostly convince their peers to change. Knigh et al. (16) by recording peer instruction activities found cooperative group construction of knowledge in a high proportion ( $\sim 75\%$ ) of the peer discussions. Therefore, this provides support to the idea that the benefits of collaboration are not just the consequence of knowledge transmission (one student saying the correct answer to other group members) but the result of coconstruction of new knowledge by debate and discussion. In this sense, it has been proposed that the production of explanations increase knowledge (5) and that the best way of mastering a subject is by teaching it (18).

After peer instruction, more changes go to correct than to incorrect answers (2.8 times, 72% vs. 28%). This finding is in

agreement with previous studies (13, 15). Changes to correct answers after peer discussion are observed in students discussing questions with peers having both correct (76% of times) and incorrect (24% of times) answers. The first finding is in agreement with the fact that students with the correct answers for the right reasons mostly prevail during discussions (17), but the latter is a completely new finding concerning the benefits of peer instruction, given that two to four students with initial incorrect answers can get the correct response through discussion. Smith et al. (27) recently proposed that students not knowing the correct answer could figure it out just by debate and discussion of material. In addition, very similar results working with collaborative testing were found by our research group (13). It has been proposed that what students can do with assistance today, they will be able to do alone in the future, and that students are capable of performing at higher intellectual levels when asked to work in collaboration than when asked to work individually (30).

Students are afraid to answer questions in public when asked by a teacher because they fear being humiliated if they answer incorrectly (12, 22). Conversely, they feel less stressed when questions are posed to the whole class and they are allowed to discuss with peers before interacting with the instructor. This way, students can learn from interacting with peers and from the instructor's constructive feedback. In this sense, it has been reported that a teaching approach where students receive feedback from peers and also from the instructor work better than those approaches where feedback is only given by either peers or the instructor (28). It is reported that answering questions helps students learn from a subsequent lecture (25). In addition, this environment is less stressful and much more constructive for the student-instructor relationship. Furthermore, knowing the correct answers and their reasons is very appreciated by students. In this sense, a cognitive psychology study (24) has stated that corrective feedback is more valuable when it includes the correct answer and the reason. In addition, it is also

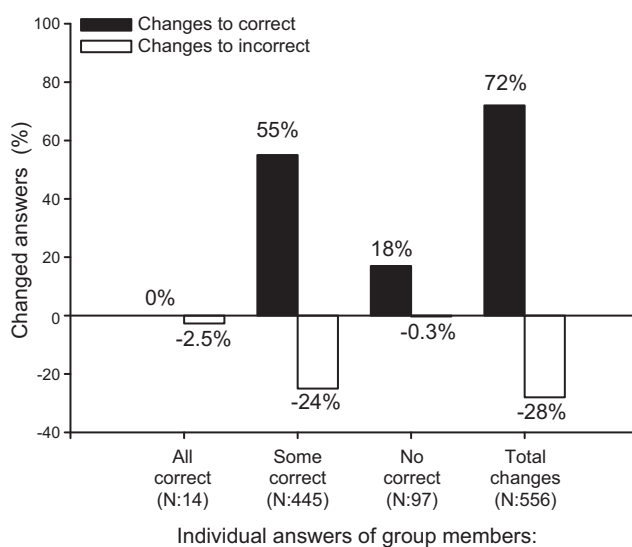


Fig. 7. Percentage of individual answers changed to correct (positive effect) and to incorrect (negative effect) after peer instruction in a veterinary physiology course ( $n = 101$  students). The negative change of 0.3% in the no correct answer group was caused by individuals changing from one incorrect option to a different incorrect option.



beneficial for the instructor because many unseen misconceptions are uncovered during class discussion.

One of the limitations of the present study is that the used design only included extra time for peer review. It did not include extra time for self-review. Therefore, part of the benefits of peer discussion could be due to self-review.

In conclusion, peer instruction is more effective when group members have different answers given that under this situation the student having correct answers prevails most of the time. Also, students working in groups of two to four, all having individual incorrect options, are able to get the correct answer through peer discussion. Finally, the likelihood for getting the correct answer after peer instruction is affected by the correctness of both individual answers and individual answers of group members as well as by group confidence level but not by individual confidence level, group size, and sex.

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#### DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

#### AUTHOR CONTRIBUTIONS

Author contributions: A.E.R. and M.J.G. performed experiments; A.E.R. and M.J.G. analyzed data; A.E.R. and M.J.G. interpreted results of experiments; A.E.R. prepared figures; A.E.R. drafted manuscript; M.J.G. conception and design of research; M.J.G. edited and revised manuscript; M.J.G. approved final version of manuscript.

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