

HYBRID METHODS OF ORGANIZING GROUPS FOR A BUSINESS GAME

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ABSTRACT

We investigated the problem of how groups should be organized for a business game by implementing a hybrid method that combines self- and computer-assignment. This method rests on a scoring system that derives group performance scores from individual performance scores. In our scheme, individual performance is the outcome of individual consumption of the products produced by the companies of the game. We describe our scheme, show how scores are derived, and examine three hybrid-method variants. Data obtained from a 202-undergraduate, one-semester administration of a business game that incorporates the three variants show that initial differences in group sizes arising from different variants narrow as the game proceeds, but persist to the end of the exercise; and that differences among the variants are not substantial enough to give rise to statistically significant differences in the pattern of increases in mean scores over the duration of the exercise. The data also suggests that players may perform best when, at the start of the exercise, the size of their group exactly matches the size they prefer.

INTRODUCTION

Although the technology of computerized business games has advanced substantially since the genre was invented in the 1950s (Wolfe, 1993), the social structure of many of these games has largely remained the same. Commonly, the game is a competition among groups, each group consisting of three to five players who collectively assume the role of a company's president (Teach, 1993; Wolfe & Rogé, 1997). The players may choose to assign each other differentiated roles, but the game itself neither requires nor enforces role differentiation. Inasmuch as a collective chief executive is rare in the everyday world, the social structure of these games is a distorted representation of its everyday-world counterpart.

The social structure of people in the everyday world of work is differentiated and hierarchical. Within everyday world structures, people are free to join and free to leave. People, whether executives at work or students at play, manifest different levels of engagement. Some are free riders, others are easy riders, and still others are hard chargers, to use Wolfe and McCoy's (2011) typology and terminology. Free and easy riders may be admonished and hard chargers may be praised, but admonition is not always effective, praise is not always appreci-

ated, and neither free riders nor easy riders nor hard chargers may be correctly identified.

A person's ability to deal with variations in engagement levels may be best tested in an environment where individuals are free to join and free to leave. Yet, this kind of freedom is generally absent when the game is administered as a competition among groups, because the departure of group members in such a setting is difficult to handle equitably, especially because the party that is in the minority is often faulted but not necessarily always wrong.

We contend that a gamed social structure that recognizes the importance of the individual and gives individuals the freedom to join and to leave groups requires a scoring system based fundamentally on individual performance rather than on group performance. This is the obverse of the usual implementation, in which group scores are fundamental, with individual scores derived from group scores by a method of allocation that may involve peer ratings by group members (Hall & Ko, 2006; Malik & Strang, 1998; Morse, 2002, 2003; Payne & Whittaker, 2005; Poon, 2002). In the discussion that follows, we show that a scoring system based fundamentally on individual performance is feasible. We describe the system that we have implemented, point out variations of the system, set forth research questions with respect to the variations, and present data on results of the present study, which is based on two earlier studies (Thavikulwat & Chang, 2010, 2012).

SCORING SYSTEM

Perhaps the simplest way to implement an individual-performance scoring system for a business game is to base the system on profit. In this scheme, each player would own a holding company that would invest in the operational companies of the game. The profitability of the holding company would then constitute each player's performance score. This profit-based scheme could be added on the existing structure of many business games, without necessitating a complete rewriting of the program codes.

The scheme we have implemented, however, is consumption based. In our scheme, profit is not the measure of performance. Rather, profit is one of several paths to the measure of performance. The measure of performance is consumption, and consumption is measured by the extent it is effective in extending the player's life cycle in the game, considering that each player may advance through multiple life cycles in a single ad-

ministration of the game. Under this scheme, higher consumption is more effective than lower consumption and steady consumption is more effective than erratic consumption. Profits, when distributed to players in the form of dividends or captured in the price of shares that are sold, enable players to raise their level of consumption. Salaries received from the players' employment with the companies they manage have a similar effect. Essentially, players receive income that they use to buy the virtual products produced by their simulated companies. Some products have higher consumption utility values (CUVs) than other products, so players are incentivized to shop for the highest value at the lowest price. Moreover, because players can receive income from different parties through different roles, no player is compelled to join with any party, whether that party consists of the shareholders of a company or of its management. Thus, a consumption-based scheme such as ours allows players more freedom than a profit-based scheme.

CONSUMPTION-BASE SCHEME

In our consumption-based scheme, players receive a score for each period of the game. Their overall score for the exercise is the sum of the scores they receive each period, accumulated over the duration of the exercise. In each period, each player gains CUVs as a consequence of the product-purchasing policies they set and the product-purchasing decisions they make. Thus, if Product A's CUV is 1 and Product B's CUV is 4, the player who purchases four As and two Bs in a period gains $4 \times 1 + 2 \times 4 = 12$ CUVs for the period. Metaphorically, a CUV is a unit of happiness. The more CUVs a player gains in a period, the happier they are in that period.

The CUVs gained in each period extend the player's lifespan within each life cycle. The relationship between CUVs

and lifespan extension is concave exponential, exhibiting diminishing returns to increasing consumption of the period.

Specifically, we define a standard level of consumption (x^*) in CUVs for the population and set a standard consumption satiation level (s^*) corresponding to x^* , such that s^* exhibits diminishing returns to consumption at the exponential rate of γ , and such that s^* falls between 0 and 1 (Equation 1). Reordering the terms of Equation 1, we derive γ from s^* and x^* to arrive at Equation 2. We then apply Equation 3, which has the same form as Equation 1, to derive for each player the player's satiation level (s) given the player's CUV (x) of the period.

$$s^* = 1 - \frac{1}{e^{\gamma x^*}} \tag{1}$$

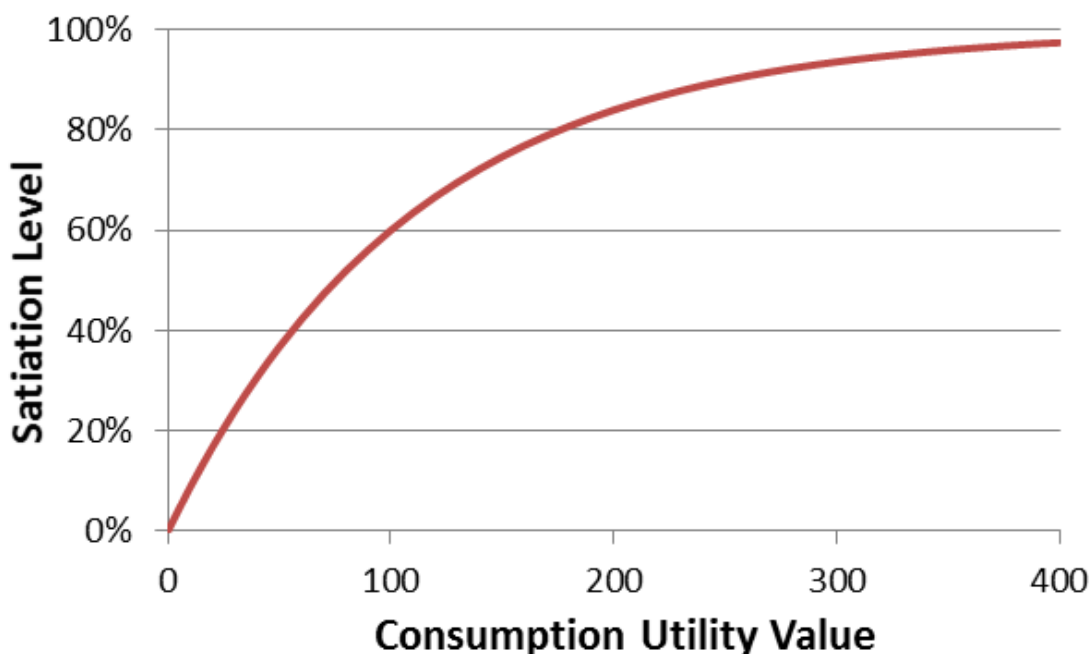
$$\gamma = -\frac{\ln(1-s^*)}{x^*} \tag{2}$$

$$s = 1 - \frac{1}{e^{\gamma x}} \tag{3}$$

If both x^* and s^* are fixed for the duration of the exercise at $x^* = 100$ CUVs and $s^* = .60$, then $\gamma = .0092$ and the relationship between CUVs and satiation levels is as shown in Figure 1. Metaphorically, x^* can be thought of as the society's poverty level, so this setting can be explained as implying that the poverty level is 60% of satiation, which ranges between 0% and 100%.

To link satiation to life extension, we define a maximum lifespan (H) for each player and an at-risk span (K) such that for each period of life that the player lives, the player loses $K(1 - s)$ periods of life. Thus, the player who consumes at the constant rate of s has an expected lifespan (E) defined by Equation 4, which reduces to Equation 5.

FIGURE 1
EFFECT OF CONSUMPTION UTILITY VALUES ON SATIATION LEVEL



$$E = H - EK(1 - s) \quad (4)$$

$$E = \frac{H}{1+K(1-s)} \quad (5)$$

Accordingly, the assured, $s = 0$, lifespan of a player at the start of a life cycle is $H / (1 + K)$. After n periods of constant s -level consumption have elapsed, the assured remaining lifespan (L_n) of the player is found by applying Equation 6. The life extension (Y) that a player gains from consumption in a single period is the difference between L_{n+1} at $s_n = s$ and L_{n+1} at $s_n = 0$ (Equation 7). We consider each period's life extension to be the player's individual performance score of the period, so the player's overall individual performance score (Y_T) for an exercise with a duration of n periods is the player's summative score across all periods (Equation 8).

$$L_n = \frac{H - n - nK(1-s)}{1+K} \quad (6)$$

$$Y = \frac{H - (n+1) - nK(1-s) - K(1-s)}{1+K} - \frac{H - (n+1) - nK(1-s) - K(1-0)}{1+K} = \frac{sK}{1+K} \quad (7)$$

$$Y_T = \sum_{i=1}^n Y_i = \sum_{i=1}^n \frac{s_{i-1}K}{1+K} \quad (8)$$

If H and K are fixed for the duration of the exercise at $H = 100$ periods and $K = 1$ period, then each player's assured lifespan at the start of each life cycle ($n = 0$) is 50 periods (Equation 6) and .5 is the highest attainable individual performance score of a period (Equation 7, when $s = 1$). These game settings can be presented to players plainly, as follows:

In this game, you will advance through several life cycles. You begin each life cycle with an assured lifespan of 50 periods. As you consume products by buying them from companies that produce them, your lifespan will be extended. The more you consume, the more your lifespan will be extended, but by no more than half a period for every period that you live. The incremental effect of consumption on life extension diminishes as more is consumed in each period, so consuming the first item of a product extends life more than the second item, which extends life more than the third item, and so forth. Products differ in their effectiveness in extending life, as measured in CUVs. Consuming an item of a product with a higher CUV extends life more effectively than consuming an item of a product with a lower CUV. Nevertheless, CUVs are additive, so consuming four one-CUV items has the same effect as consuming one four-CUV item. Your individual score in the game is the cumulative number of periods that you have extended your life, by your consumption, over the duration of the exercise.

GROUP PERFORMANCE SCORE

For a group of m members, the group performance score (Z) for each period is the mean of the individual performance scores of the group's members for the period (\bar{Y}) adjusted by m

and an administratively set group credit discount rate (δ) ranging between 0 and 1 (Equation 9). Thus, $\delta = 0$ means that group size does not affect the group performance score, and $\delta = 1$ means that the group performance score is zero irrespective of the number of group members. Each player's overall group performance score (Z_T) is the sum of that player's group performance scores cumulated over all the periods of the exercise (Equation 10). Finally, each player's overall grand performance score (G_T) is the sum of that player's overall individual and group performance scores (Equation 11).

$$Z = \frac{\sum_{j=1}^m Y_j}{m} (1 - \delta^m) = \bar{Y}(1 - \delta^m) \quad (9)$$

$$Z_T = \sum_{i=1}^n Z_i \quad (10)$$

$$G_t = Y_T + Z_T \quad (11)$$

ALGORITHM FOR SWITCHING GROUPS

If players are to be free to join and leave groups, a player wishing to leave a group should not be administratively constrained by the desire that other group members might have to retain the player, and a player choosing to join a group should not be allowed to join if the other group members either do not want the additional member or would be immediately disadvantaged by adding the new member. These considerations guided the development of our group-switching algorithm.

To allow players to exit a group at will, our algorithm enables any player to start a one-member group. To allow group members to prevent a player from joining, our algorithm requires every player to specify a preferred group size. The size of each group is then limited to the smallest preferred size specified by the group's members. To assure that the acceptance of a new member would not immediately disadvantage current group members, our algorithm does not permit a player to join if the player's acceptance into the group would lower Z .

The last consideration requires that the minimum acceptable individual performance score (\hat{Y}) of the player who wishes to join an existing group to be the score that leaves Z unchanged when a new member joins (Equation 12). Re-ordering the terms of Equation 12, we arrive at Equations 13. Merging Equation 9 into Equation 13, eliminating Z , we arrive at Equation 14, which shows clearly the dependence of the relative minimum acceptable individual score (\hat{Y} / \bar{Y}) on m .

The relationship between \hat{Y} / \bar{Y} and m for three values of δ is graphed in Figure 2. When $\delta = .5$, a lower-performing player who wishes to join a higher-performing player in forming a two-person group (ex-ante group size of 1) must have an individual performance score no less than one-third (.33) that of the higher-performing player, whereas the same player wishing to join two players in forming a three-person group (ex-ante group size of 2) must have an individual performance score no less than four-seventh (.57) that of the mean individual performance score of the two players. Thus, joining a smaller group is easier

than joining a larger group, *ceteris paribus*.

STARTING CONDITION

A final concern is the starting condition of the players. We see three possibilities: single player (SP), single group (SG), and preferred size (PS).

With SP, every player is initially assigned to a single-person group. Under this condition, every player is incentivized to raise the player’s group performance score by joining with other players, preferably other players whose individual performance scores are higher than the player’s own. The smaller the δ , the earlier the incentive for increasing group size falls as group size increases (Figure 2). Hence, the incentive for forming a small group is highest when δ is small, whereas the incentive for forming a large group is highest when δ is large.

With SG, all players are initially assigned to one group. Under this condition, only players with high individual performance scores are incentivized to exit the starting group so as to form a new group.

With PS, each player is initially assigned to a group with the same number of members as the player’s preferred group size, to the extent possible given the number of players and their group-size preferences. When all assignments are perfect, so that every player is in a group of exactly the size that the player prefers, players have the least incentive to exit their starting group and the greatest difficulty finding a group that they can advantageously join, because any group-size preference that they might have is satisfied by their starting group and any oth-

er group that they may wish to join is not initially open to accepting an additional member. To join another group, the prospective member must induce every member of that group to raise that member’s preferred group size, because our algorithm does not allow a new member into the group if the addition would raise the group’s size above the preferred-group-size setting of the member whose setting is the lowest.

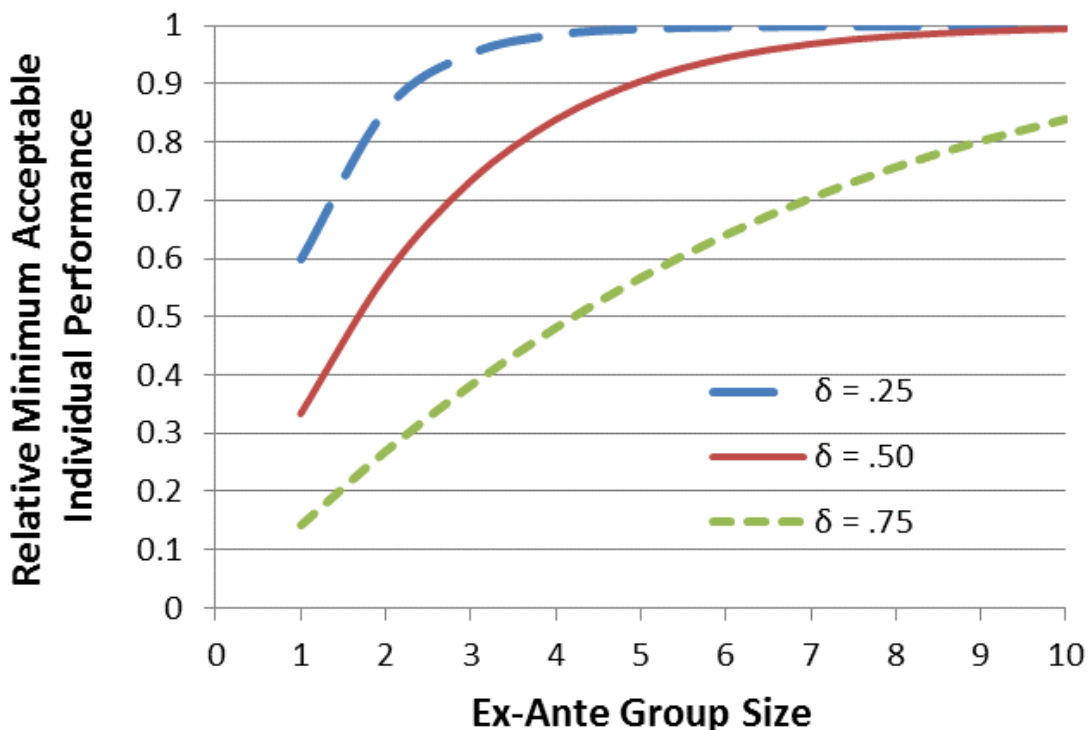
RESEARCH QUESTIONS

Our method of organizing players into groups for a business game is a hybrid of self-assignment and computer-assignment. Players are administratively assigned to a group as they register, and then immediately allowed to re-assign themselves through the group-switching algorithm that we coded into the computer program that supports the game. Players may switch groups at any time over the entire duration of the exercise. A player’s group performance score of each period is based on the player’s group membership at the end of the period.

We seek to determine the extent to which the starting condition of our hybrid method makes a substantial difference in players’ experiences and scores over the duration of the exercise. The basic difference is that of group size, but possible differences in performance scores also are of interest.

At start up, group size is necessarily smallest under SP and largest under SG. This fact gives rise to our first question.

FIGURE 2
EFFECT OF GROUP CREDIT DISCOUNT RATE (Δ) ON THE RELATIONSHIP
BETWEEN RELATIVE MINIMUM ACCEPTABLE INDIVIDUAL PERFORMANCE
AND EX-ANTE GROUP SIZE



Question 1: *For how many periods of play will the initial differences in group sizes last?*

A measure of pedagogical interest is individual performance. The PS condition is more immediately encouraging of collective efforts than either the SP or SG conditions, because under PS group sizes are generally closest to the sizes that the members prefer. Group membership can raise individual performance when players help each other or lower individual performance when players distract each other. This concern leads to our second question.

Question 2: *What is the pattern of increases in mean individual performance scores under each condition?*

A difference of interest to students is credit toward grades. In our application, credit towards grades is drawn from the grand performance score, which is the sum of the individual and group performance scores. This consideration leads to our third question.

Question 3: *What is the pattern of increases in mean grand performance scores under each condition?*

METHOD

We applied our hybrid method of organizing groups to 202 undergraduate business students enrolled in two different courses offered by two different universities, one in Hong Kong (HK) and the other in the United States (US). The HK students comprised one large section of a senior-level class on strategic management; the US students comprised three approximately equal-sized sections of a junior-level class on international business. All jointly participated in the same one-semester, Internet-based (Pillutla, 2003) game, GEO.

The HK students started and ended the semester about two weeks earlier than the US students, so the HK students registered into the game and were removed from the game two weeks earlier than their US counterparts. Inasmuch as the pace of the game accelerated over its one-semester duration, from two weeks for the first period to eight hours for the last, the HK students experienced the game over fewer periods, from its beginning at period 0 through period 140; whereas the US students experienced the game over more periods, from period 1 through period 160.

We set the parameters of the program that supports the game to the values of Table 1 and configured the game to assign the players to one of three conditions (SP, SG, and PS) on a

**TABLE 1
PARAMETRIC SETTINGS**

Parameter	Description	Values
x^*	Standard level of consumption	100 CUVs
s^*	Standard consumption satiation level	.6
H	Maximum lifespan	100 periods
K	At-risk span	1 period
δ	Group credit discount rate	.5

**TABLE 2
INITIAL BREAKDOWN OF PARTICIPANTS BY COUNTRY, CONDITION, AND GROUP SIZE**

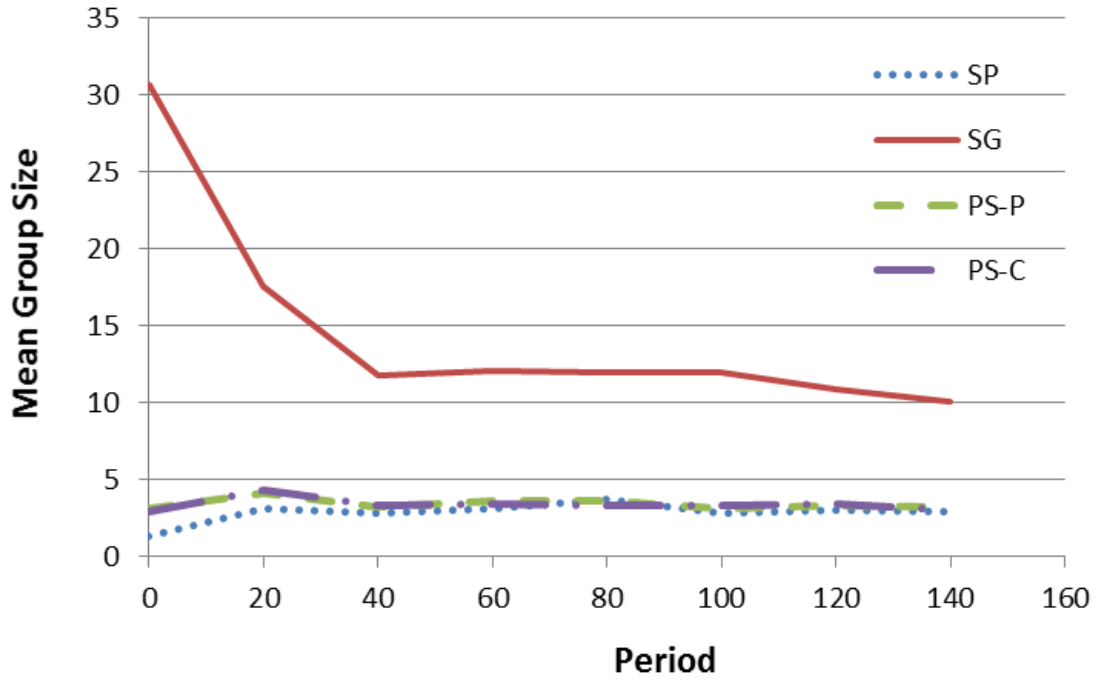
Country	Condition	Group Size							
		1	2	3	4	6	10	11	33
HK ¹	SP	31	3			2			
	SG		1			2			33
	PS-C	2	4	3	4	1			
	PS-P	4		9	8	1			
US ²	SP	28	3						
	SG						10	22	
	PS-C	8	7	6	4				
	PS-P	3		3					

¹ $\chi^2(15) = 173, p = .000.$

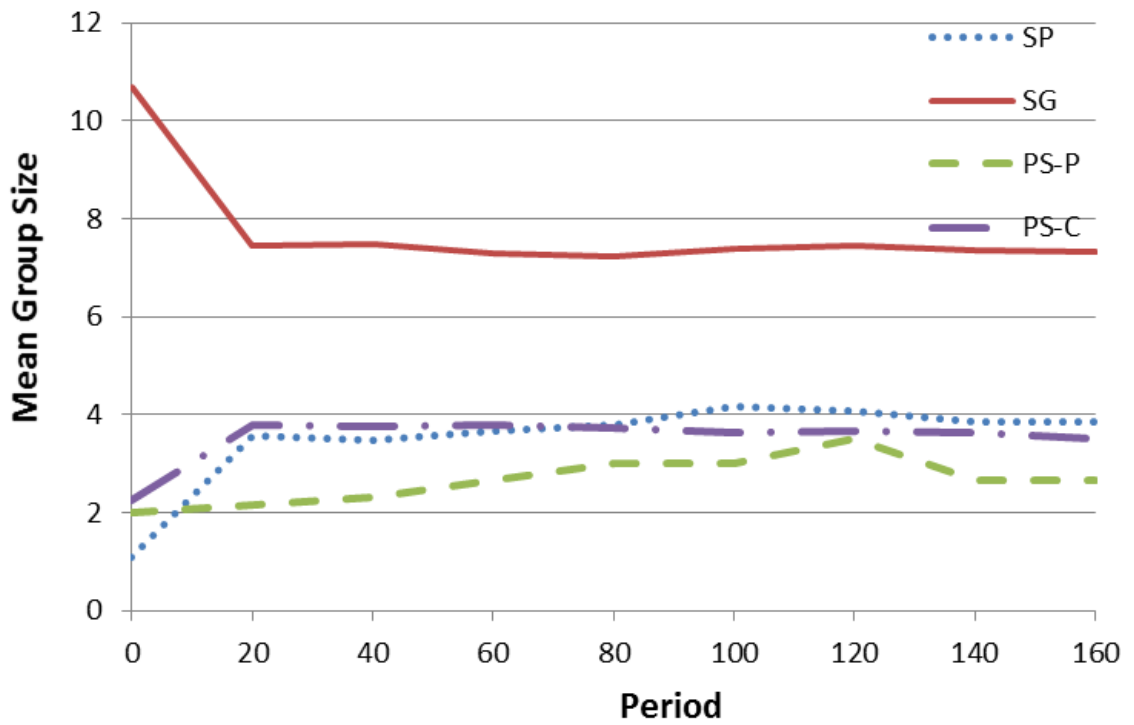
² $\chi^2(15) = 138, p = .000$

FIGURE 3
MEAN GROUP SIZES BY COUNTRY AND CONDITIONS

A (HK)



B (US)



rotating basis as they registered. Regardless of assigned condition, every player was required to specify a preferred group size within the range of 1 to 12 at registration. Every player assigned to the SP condition was placed in a single-person group, every player assigned to the SG condition was placed in the same section-specific group, and every player assigned to the PS condition was placed into the same group as other PS-assigned players who had specified the same preferred group size, except that (a) all PS-assigned players who specified preferred group sizes exceeding 6 were placed in the same group as those who had specified the preferred size of 6 and (b) each registering player was placed in a new group if placing the player in an existing group would cause the size of the existing group to exceed the group members' specified preferred size.

For the purpose of this study, players assigned to the PS condition are divided into two sub-conditions: PS-P, when the match between their actual group size and their preferred group size was perfect; and PS-C, when the match between their actual group size and their preferred group size was compromised, that is, not perfect.

Following computer assignment, participants could switch groups without regard to assignment condition, so group membership remained fluid until the game advanced into the next period, at which point the program computed group credits and archived the state of the game at that period before changing the state to that of the following period.

RESULTS

Table 2 shows the initial distribution of participants and groups by country and condition. The initial distribution is a composite, derived from the state of the game at the end of the period in which each participant registered. The composite is formed from 106 HK students who registered in period 0, 94 US students who registered in period 1, one HK student who registered in period 2, one US student who registered in period 3, and one HK student who registered in period 17. One US student, who dropped the class in period 2, is removed from the

study.

Figure 3 shows group sizes from the initial state to the final state (period 140 for HK players and period 160 for US players), plotted at 20-period intervals. The graphs answer the first research question: For how many periods of play will the initial differences in group sizes last?

The results of HK players are similar to those of US players. For HK players, the initial differences in group sizes are substantially narrowed by period 40. The differences in group size between SG and other conditions persist past period 40 to the end of the exercise at period 140, $F(3, 104) = 23, p = .000$. For US players, the initial differences in group sizes are substantially narrowed earlier, by period 20. Like the HK players, the differences in group sizes between SG and other conditions persist to the end of the exercise at period 160, $F(3, 90) = 23, p = .000$.

Figure 4 shows increases in mean individual performance scores from the initial state to the final state, plotted at 20-period intervals. These graphs answer the second research question: What is the pattern of increases in mean individual performance scores under each condition?

The shapes of the curves are different between HK players and US players. For HK players, the curves are all distinctly concave, peaking between periods 80 and 100, suggesting that HK players were less attentive to the game in the later periods. For US players, the curves are approximately linear, and except for the PS-P condition, no peak is evident, suggesting that US players were generally attentive to the game throughout its duration. The HK players are seniors who must successfully complete a final-year project unrelated to the game, so work on the project diverts their attention from the game, which explains the concave shape of their performance curves.

The apparently superior performance of players in the PS-P condition past period 60 is the same for HK players as for US players, but the cumulative differences are not statistically significant for either HK players or US players. The mean increase in individual performance scores between periods 60 and the end of the exercise (period 140 for HK students and period 160 for US students) are shown in Table 3. The strikingly higher

TABLE 3
INCREASE IN MEAN INDIVIDUAL PERFORMANCE FROM PERIOD 60 TO THE END OF THE EXERCISE

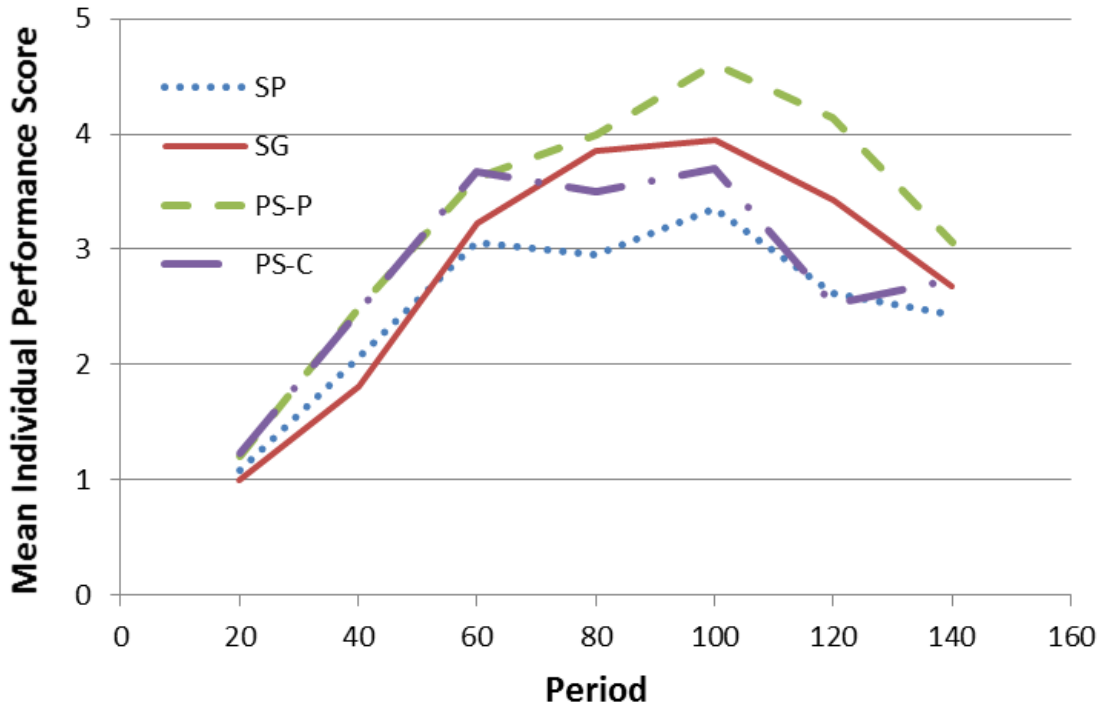
Country	Condition	Mean	SD
HK ¹	SP	11.35	10.52
	SG	13.91	11.21
	PS-C	12.46	12.42
	PS-P	15.80	13.11
US ²	SP	13.73	10.62
	SG	17.48	15.00
	PS-C	12.79	13.29
	PS-P	22.11	9.50

¹ $F(3, 104) = .74, p = .53$

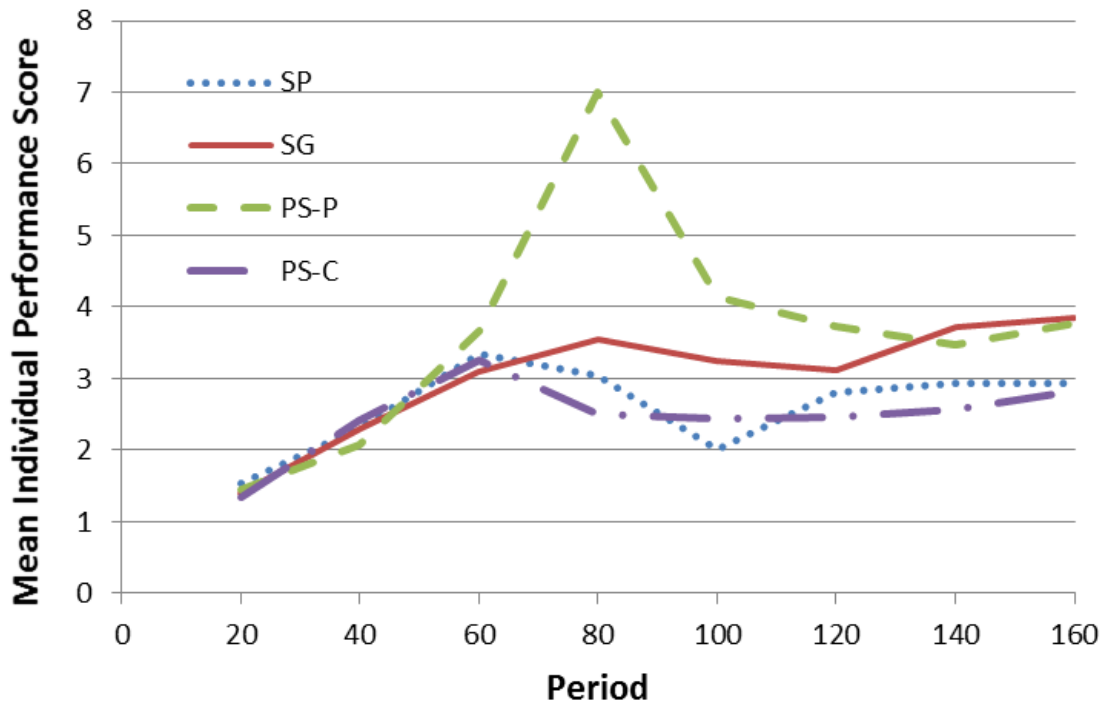
² $F(3, 90) = 1.32, p = .27$

FIGURE 4
MEAN INDIVIDUAL PERFORMANCE SCORES BY COUNTRY AND CONDITIONS

A (HK)



B (US)



increase, however, in the mean individual performance score between period 60 and period 80 of US players in the PS-P condition relative to US players in other conditions (Figure 3) is statistically significant, $F(3, 90) = 4.07, p = .009$.

Figure 5 shows increases in mean grand performance scores from the initial state to the final state, plotted at 20-period intervals. These graphs answer the third research question: What is the pattern of increases in mean grand performance scores under each condition?

Increases in mean grand performance scores display the same pattern as increases in mean individual performance scores. Likewise, the apparently superior performance of players in the PS-P condition past period 60 on grand performance are not statistically significant (Table 4) for either HK players or US players. Likewise also, the strikingly higher increase in the mean grand performance score between period 60 and period 80 of US players in the PS-P condition relative to US players in other conditions is similarly statistically significant, $F(3, 90) = 4.84, p = .004$. Finally, the differences across conditions of HK players' mean grand performance scores between period 20 and period 40 are statistically significant, $F(3, 104) = 2.71, p = 0.049$. In this last case, the mean grand performance scores of the players in the PS-P and PS-C conditions increased by almost identically higher values, 4.67 and 4.63, respectively, while those of the SP and SG conditions increased by almost identically lower values, 3.66 and 3.61, respectively.

DISCUSSION

The results show that the SG condition gives rise to a higher mean group size for the entire duration of the one-semester exercise, and that no starting condition is distinctly superior in its effect on mean players' individual and grand performance scores. The results also suggest the PS-P condition may be more supportive of superior performance than other conditions. The suggestion intrigues, so this study should be replicated to see how well the suggestion fares with a larger set of data.

Even if PS-P is not more supportive of superior performance than other conditions, the PS starting condition does

have the advantage of being a moderate starting condition that is less stressful than SP and more demanding than SG. When $\delta = .5$, for example, SP is a high-stress condition, because every player who is unable to be part of a group of three or more must endure a sizeable group-performance-score disadvantage of at least 25%. On the other hand, SG is a low-stress condition because any player wishing for higher group performance scores must find two or more high-performing players willing to join that player in forming a new group. The uncertainty that the effort will be successful and the likelihood that success will not give rise to substantially higher group performance scores discourages effort.

The major problem with PS is that it does not guarantee that every player will be found in the PS-P sub-condition after all players have registered. The number of players who may be found in the PS-C sub-condition, however, cannot exceed $(S_1 + S_2 - 2)(S_2 - S_1 + 1) / 2$, where S_1 and S_2 are the lower and upper bounds, respectively, on preferred group sizes that players can set. The logic of the formula is that the number of compromised assignments peaks at $(S_1 - 1) + (S_1 + 1 - 1) + (S_1 + 2 - 1) + \dots + (S_2 - 1)$, so the sum of this arithmetic series is the sum of the first and last item of the series, $(S_1 - 1) + (S_2 - 1) = (S_1 + S_2 - 2)$, multiplied by half the length of the series, $(S_2 - S_1 + 1) / 2$. Inasmuch as the maximum number of players who may be found in the PS-P sub-condition does not depend on the number of players, the problem diminishes as the number of players increases.

Starting everyone in an approximately equal-sized (ES) group of between three and four, as Wolfe and Chacko (1983) suggested in their seminal study on group size in business games, may appear to be an equally advantageous starting condition that is simpler than PS. ES apparently avoids the possibility of a gross compromise, wherein the player who specifies the largest preferred size of the allowable range ends up being the sole member of a one-person group, because no other player specified the same preferred size. Even so, simplicity is a negligible advantage when a computer program assigns players to groups, because the PS algorithm is itself not difficult to code, and the disadvantage of a compromised assignment may be self

TABLE 4
INCREASE IN MEAN GRAND PERFORMANCE SCORES FROM PERIOD 60 TO THE END OF THE EXERCISE

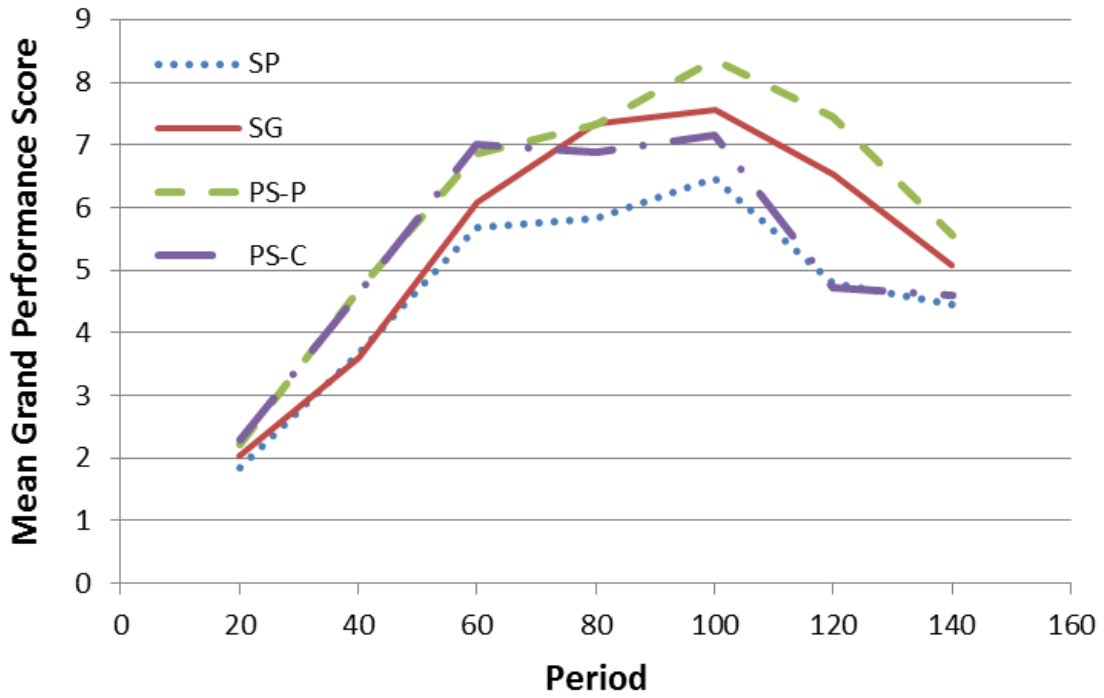
Country	Condition	Mean	SD
HK ¹	SP	21.55	18.59
	SG	26.50	17.25
	PS-C	23.34	20.74
	PS-P	28.68	22.64
US ²	SP	28.24	17.45
	SG	31.49	21.20
	PS-C	24.43	20.50
	PS-P	39.80	15.47

¹ $F(3, 104) = .75, p = .52$

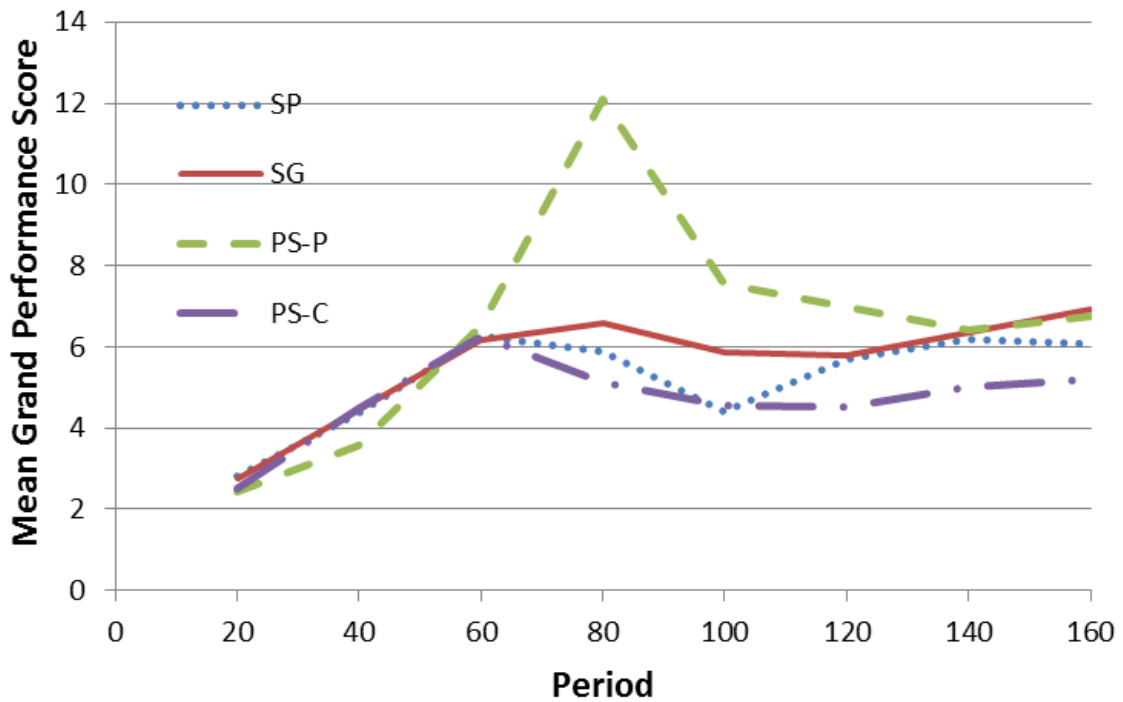
² $F(3, 90) = 1.26, p = .29$

FIGURE 5
MEAN GRAND PERFORMANCE SCORES BY COUNTRY AND CONDITIONS

A (HK)



B (US)



-corrected by players switching groups. Moreover, ES is merely a special case of PS with S_1 set to the lower bound (e.g., 3) and S_2 set to the upper bound (e.g., 4) with a final adjustment after all players have registered to assure that every player is assigned to a group that falls within the bounds.

We conclude by suggesting that how players are formed into groups and how the groups are re-formed as the game proceeds are issues worthy of further study. Research on group formation and re-formation should give rise to insights on how to improve the administration of games as well as other experiential exercises, and may give rise to ideas on how to improve the management of groups in business settings. This line of thinking leads to an interesting question: "Can PS work in the world of work?"

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