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TEACHERS' TOPIC

An Educational Board Game to Assist PharmD Students in Learning Autonomic Nervous System Pharmacology

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Objective. To examine whether playing a board game can assist PharmD students in learning autonomic nervous system (ANS) pharmacology.
Design. Of 72 students enrolled in a required second-year pharmacology course, 22 students volunteered to play the board game, which was followed by an in-class examination consisting of 42 ANS questions (ANSQs) and 8 control questions (CTLQs). Participants were given a pretest and a posttest to assess immediate educational improvement. Participants' scores for pretest, posttest, in-class examination, and ANSQs were compared. Also, scores for examination, ANSQs, and CTLQs were compared between board game participants (PART) and nonparticipating classmates (NPART).
Assessment. Board game participants scored progressively higher between the pretest, posttest, examination, and ANSQs. Additionally, PART scores were higher than NPART scores for examination and ANSQs. Difference between PART and NPART CTLQ scores was not significant.
Conclusion. A board game can assist PharmD students in learning ANS pharmacology.
Keywords: autonomic nervous system pharmacology, educational game, board game, game, active learning

INTRODUCTION

Autonomic nervous system pharmacology can be a difficult concept for students at the University of Charleston School of Pharmacy (UCSOP). The topic immediately follows principles of pharmacology lectures (eg, receptor theory, dose-response curves) at the beginning of the first semester of the second year. One reason for the difficulty in learning the topic may be that ANS pharmacology lectures are the first set of pharmacology lectures to include individual drugs. Students must apply the concepts of pharmacologic activity to a list of drugs. However, from the instructor's experience, the main reason for the difficulty seems to be that the students are often unable to see the ANS as a whole system, beyond the interactions of the drug at the individual receptor. Pharmacology is taught as 2 consecutive 4-hour courses at the school.

During this study, ANS pharmacology was taught in 8 hours of lecture over 4 days, with the addition of 2 hours on one day for ANS pharmacology of the eye. The main text for the course was Katzung's *Basic and Clinical Pharmacology*.[1] The textbook illustrations of generic adrenergic and cholinergic nerve terminals are appropriate for learning the actions of the drug at the presynaptic nerve terminal or postsynaptic drug target and the physiology that leads to stimulation and regulation of neurotransmission at the disembodied synapse. However, the figures do not fully illustrate the complete neural network of the preganglionic-postganglionic-target cell system, nor the downstream effects of drugs that bind upstream in that network. Because of this conceptual gap, the authors created a board game to assist students in learning the effects of drugs in the ANS as a whole.

Educational games are often incorporated into the curriculum.[2-10] Not only can games make learning more enjoyable, but they can also encourage in-class participation and improve students' attitudes toward learning the material. The type of game and the methods of analysis seem dependent on the type of content and the end educational goal of the game. For example, Batscha incorporated the use of PowerPoint into a game for a nursing school classroom.[2] Students reported it was a "great review." Shiroma and colleagues used a game to teach psychopharmacology to medical students.[3] No mean improvement resulted between pretest and posttest scores. However, students indicated that they enjoyed playing the game and that the game increased their knowledge

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of psychopharmacology. Odenweller and colleagues developed 2 GI physiology card games that were played by high school, graduate, and medical students.[4] The goal of their study was to replace simple memorization with active learning and application of concepts. Students commented that they felt the study goals were carried out and reported liking that the games emphasized material they had already learned with a different method.

Games are used for teaching pharmacy students, as well. For Patel, the goal was to increase student participation in small group case studies.[5] Patel allowed students to take responsibility for their learning objectives by having students choose the game format, which included board games, popular television games, sports games, and children's games. A team of students then designed the game that would provide the discussion format for the in-class case of the day. As a result, students' participation scores increased. Students were surveyed at the end of the course, and they indicated that they felt the games in the study fostered learning and knowledge reinforcement. The effect of playing the game on examination scores was not assessed, as that was not the goal of the study. For Barclay and colleagues, the goal was to measure the effect of educational card games on assessment scores by learning style.[6] Two card games on pharmacotherapeutic topics were created and played by pharmacy students. Their findings indicated a significant increase in students' posttest scores after playing the games, regardless of learning style, although the effect was stronger on cardiology scores among students with a kinetic learning style. The games were played during a 6-week advanced pharmacy practice experience (APPE), which did not include examination scores in their grade.

Rose's study used a board game to help first-year pharmacy students learn the processes of metabolic pathways.[7] Posttest scores improved for game-related questions, but also improved for questions not related to the game in the same assessment. Rose used the nongame-related questions as a control to provide evidence that the game method of learning was more successful than the standard lecture method that was used for the nongame-related material. All students in the course played the game during class time, but the pretest and posttest were voluntary and scores were anonymously linked by matching codes. Thus, no assessment was made for improvement in course grades as a result of playing the game.

Other studies used board games and measured learning via comparison of pretest and posttest scores. Valente and colleagues used a board game to teach the mechanisms of antimicrobial actions.[8] Girardi and colleagues created a "T-and B-Cell Ontogeny" board game.[9] In both studies, students who played the game had positive impressions of the game and showed improvement between pretest and posttest scores. However, control questions were not used in these studies.

In all of these studies, most surveyed students agreed that the games were beneficial in their learning process, indicating that using the game method resulted in a positive change in their attitudes toward learning the material. Some studies also indicated an improvement in participation scores. Thus, using games as a teaching method not only makes learning in the classroom more enjoyable, but also stimulates students' interest in the subject. In addition, some studies attempted to measure the effects of educational games on learning by comparing pretest and posttest scores of students who played the game vs students who did not play the game. However, these games did not use course examination grades to assess whether the game methods improved learning course material. The pretests and posttests in these studies were voluntary and anonymous. As such, students' motivation and effort in answering the questions correctly may have caused their scores to be lower than what they would have achieved on a required in-class examination on the same material. Because examination grades are used to determine successful completion of degree programs in professional schools, they would more accurately determine whether the game method improved learning the professional course material.

Persky and colleagues did attempt to measure the learning effect of games by assessing change in course examination scores.[10] They incorporated "Poker," "Pharmacy Scene Investigation (PSI)," and "Clue" games into teaching second-year pharmacy students basic and clinical pharmacokinetics over 2 semesters. The poker game was played in the fall semester course, and the other 2 games were played in the spring semester course. Course final examination scores were assessed. However, all students in each of the 2 semesters played the games, so examination scores for these students were compared to the examination scores of students from the previous year's class who did not play the games. Final examination scores were improved over the previous year's scores for the second-semester course in which the PSI and Clue games were played, but not for the first semester course in which the Poker game was played. While this method may have been a more accurate measure of learning, comparing students from different years did not adjust for differences in learning styles and abilities between the 2 classes. Nor did this method indicate the effect of each game on learning because the final examinations included material for the entire semester, not all of which was covered by any one game.

We used a board game to teach ANS pharmacology to second-year pharmacy students. To allow for different learning styles, participation was voluntary. Also, the game was played outside of class to allow for comparison between students receiving only traditional in-class didactic lectures and those receiving the additional method of the educational game. As in the studies discussed earlier, a comparison was made of board game participants' pretest and posttest scores. However, in an attempt to more accurately measure the effect of the game method of teaching, course examination grades were also compared between students who played the game and students in the same class who chose only the standard lecture method of teaching. Additionally, our study used control questions on material that was not covered in the game but appeared on the same examination. To our knowledge, this is the first study to use any type of game to teach ANS pharmacology.

DESIGN

An extensive literature search was carried out using the terms educational games, game-based learning, games as teaching methods, educational card games, educational pharmacy games, educational board games, and autonomic nervous system game. Databases used included PubMed, Medline Complete, Google Scholar, and CINAHL Plus. To our knowledge, this is the first study of the use of a board game to assist students in learning ANS pharmacology.

Before conducting this research, the project was approved as exempt by the University of Charleston's Institutional Review Board (IRB). Scores from all students enrolled in the class were included in the exemption. Although only supplying a description of the study to the students was required, informed consent was obtained from the participants at the beginning of their game session. The description emphasized that playing the game was voluntary and that scores for the test given before and after playing the game would not be included in the calculation of course grades. While the pretests and posttests were not anonymous, only the faculty member who taught the lectures and administered the in-class examination had access to the tests. Any data to which the co-authors had access were coded and de-identified.

The intended purpose of playing the game was for students to understand the function of the ANS system as a whole and how drugs produce their effects, at receptor and system levels. The game included the pathway components and drugs that were presented in class lectures. Readers who want to use this game as an interactive learning tool in their own classrooms could use the board as a template for customizing the pathway components and drugs to their own lecture content. In the ANS board game, the game consisted of the board, dice, game pieces, vertebrae cards, pathway component cards, and drug cards.

The board (Figure 1) was created by drawing all of the components in PowerPoint, printing them on a color printer, pasting them onto a poster board, and drawing the connecting axons with a marker to make the complete system. The original board was printed in color with green circles and blue squares. The board image was converted to black and white for publication. The ganglionic and target cell synapses of both the typical sympathetic and parasympathetic pathways were drawn to include grey circles, containing the components of the cellular pathways, and black squares, containing the end product or result of the actions of the components in the preceding grey circles. For example, the first black square is labeled ACh for acetylcholine. To make ACh, the choline hemitransporter (grey circle, labeled CHT) must take up choline (another grey circle). Choline-acetyltransferase (grey circle, labeled ChAT) combines choline with acetylCoA (another grey circle) to make ACh, which is in the black square, indicating the end of the reaction and the location to which the player will move next in the game.

The game pieces were flat glass floral beads in a variety of colors. All of the game cards were printed onto colored card stock, with each deck printed on a different color. The vertebrae cards were labeled with the abbreviation of a vertebra, as in C2, T12, L3, S4, etc., to correspond with one of the 4 starting tiles on the game board, which were labeled: Cranial 1-7, Thoracic 1-12, Lumbar 1-5, and Sacral 1-5. The drug cards contained one drug per card. Drugs included in the deck were those discussed in lecture and that affect the ANS at various locations, including presynaptic preganglionic membrane, postsynaptic postganglionic membrane, in the cytoplasm of the postganglionic presynaptic nerve terminal, etc. The component cards corresponded to the pathway components contained in grey circles on the board.

PharmD students who were enrolled in a required 2nd-year pharmacology course were recruited to play the board game through announcements during lecture. The class met Tuesdays and Fridays for 2 hours each day. The general topic of ANS pharmacology was covered in 8 hours over 4 class days. The time was divided between ANS physiology and neurotransmission, modification of the system through autoreceptors, feedback and reflex signaling, cholinergic drugs, and adrenergic drugs. Another class day (2 hours) covered ANS pharmacology of the eye. In total, ANS pharmacology was taught for 10 hours in 5 days over 2.5 weeks. Students were given opportunities to play the game during the 11 days between the end of the general ANS lectures and the examination.

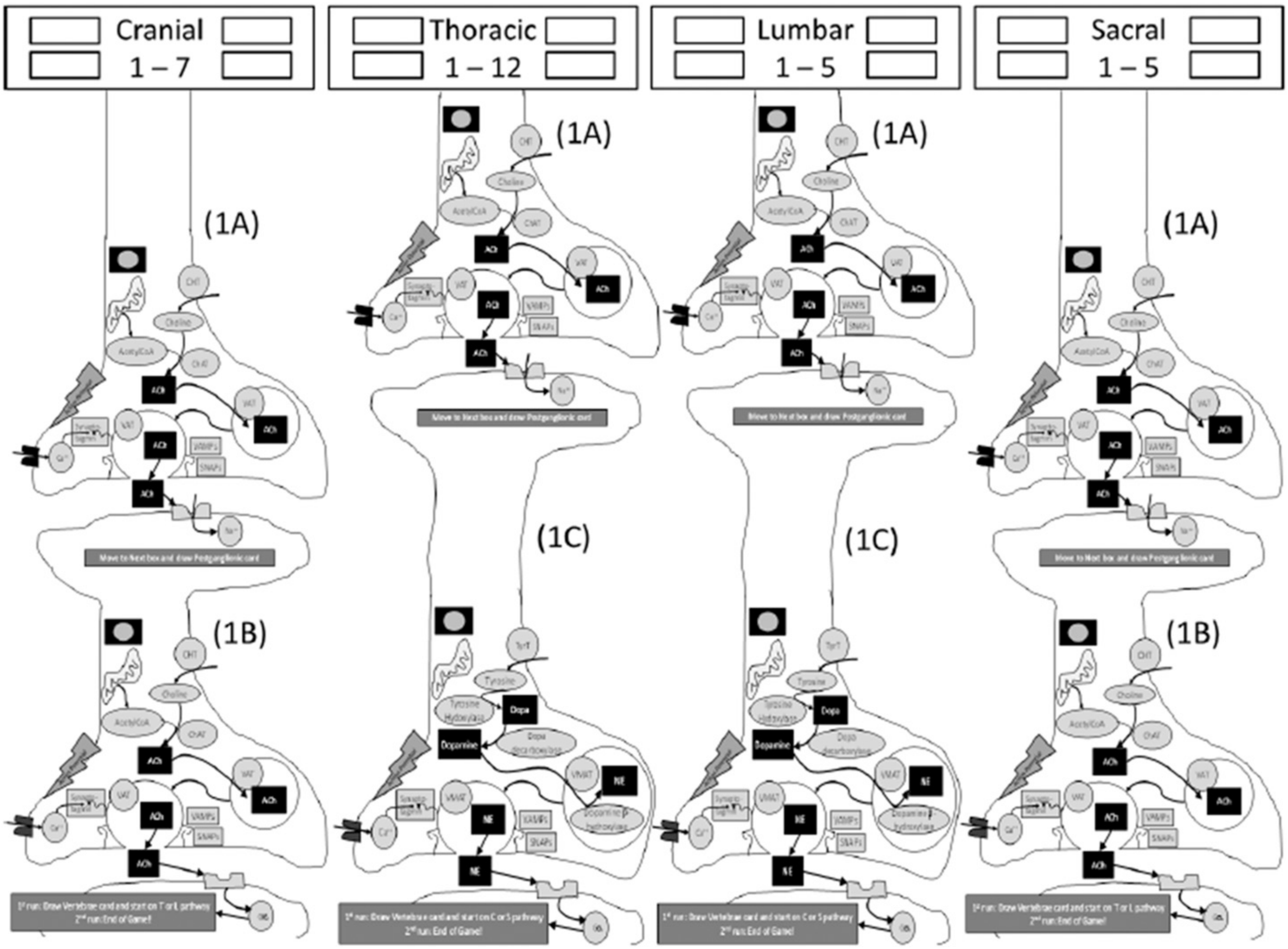

Figure 1. Automatic Nervous System (ANS) Board Game. Image of the game as a whole, showing the layout of the entire board. Each synapse is enlarged in Figures 1A-1C, and the location of each enlargement on the board is indicated in parantheses. The ganglionic and target cell synapses of both the typical sympathetic and parasympathetic pathways were drawn to include the neurotransmission components of the cellular pathways and the end product or result of the components' actions. The game board was designed to reflect that pathways originating from the cranial and sacral regions are typically parasympathetic; thoracic and lumbar pathways are typically sympathetic.

Students made appointments with the instructor for game sessions in groups of up to 6 players. All game sessions were held in a conference room outside of class time. While the students were offered the opportunity to play more than once, none did. From undocumented conversations, the students stated that their schedules were full with work for other classes and if time had permitted, they would have played again. Most students played for an hour, most often during their lunch break. Some students played longer and were able to progress further in the game. The longer the students played, the more drugs and reactions they could discuss, which meant that, playing for more than an hour was optimal. This was especially true for each student's first session because the pretest and posttest used about half of the hour-long game session. If students had played again at subsequent game sessions, they would not have been required to take the tests again, giving them more time to play.

While the ANS lectures were primarily didactic, the board game sessions were andragogical, with the purpose of generating discussion among the participants and problem-solving for application of the drugs to the sympathetic and parasympathetic pathways. The board game sessions were offered to students after the start of the ANS lectures, but prior to the in-class examination on the topic.

The faculty member who taught the ANS lectures also coordinated and attended all game and data collection sessions and wrote all questions on the pre/posttest instrument and the examination. The project also provided an opportunity for 2 students to participate and learn about the scholarship aspect of academic pharmacy. One student was in the fourth year of the pharmacy program on academic rotation; the other was an undergraduate prepharmacy/biology student participating in the work-study program. Both students participated in all aspects of the project, including developing the game, gaining approval from the IRB, collecting data, and writing the manuscript. All of the student data to which these 2 students had access were de-identified prior to their involvement. Another pharmacology faculty member also collaborated in the development of the concept and writing of the manuscript.

The pretest included 20 fill-in-the-blank and multiple-choice questions on material covered in the pharmacology lectures on ANS. At the end of the game session, the same test was given to measure knowledge gained through playing the game. The students were not given a time limit for either of the tests, although 2 students did not complete the posttest due to a lack of time before the start of their next class. All game sessions preceded an in-class examination that included 42 questions on the autonomic nervous system (ANSQs) and 8 questions on another topic that were used as control questions (CTLQs). The examination was a required part of the course and the game participants took the examination in the classroom simultaneously with their classmates who did not play the game.

At the start of the game, 5 component cards were dealt to each player. Players began by rolling the dice to determine who goes first. Each player in turn drew a vertebrae card to determine the starting point, which was 1 of 4 tiles, labeled either Cranial 1-7, Thoracic 1-12, Lumbar 1-5, or Sacral 1-5. Each of the 4 tiles had 4 starting points (Figure 1). In order to distribute players evenly across the board, if a previous player had already started on the tile indicated on the vertebrae card, the player had to draw again. Then, play of the game proceeded in repetitions of

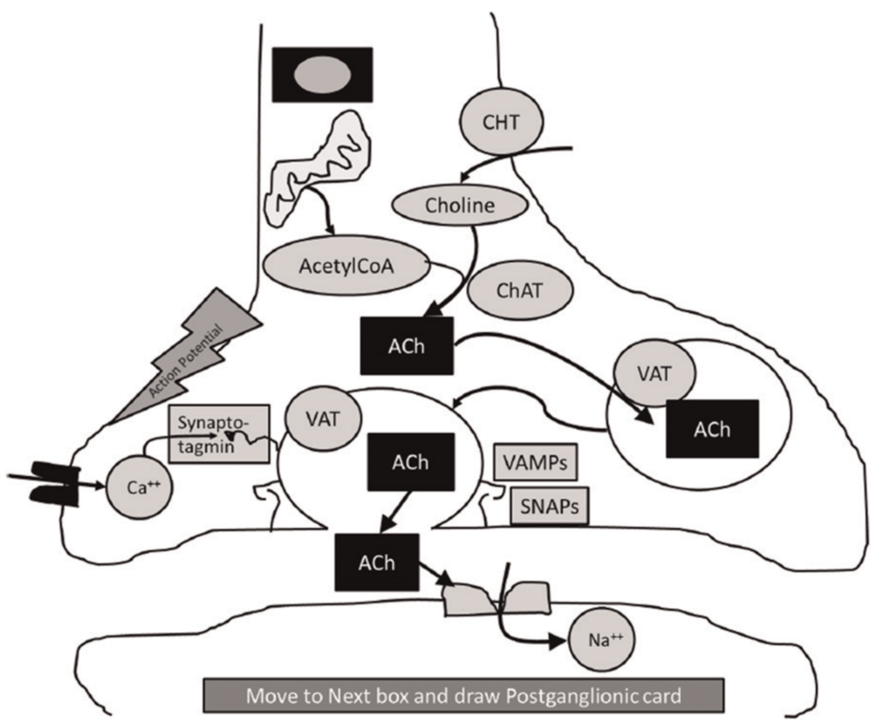

Figure 1A. ANS Board Game Section, Ganglionic Synapse. A close-up of the preganglionic cholinergic nerve terminal and postganglionic cell body from the board game (labeled "1A" in Figure 1). Because all ANS pregangionic nerves are cholinergic, the figure is included in the top half of the cranial, thoracic, lumbar and sacral pathways. The synapse was drawn to include grey circles containing the neurotransmission components of the pathways and black squares containing the end product or result of the actions of the components that are in grey circles. For example, the first black square is labeled ACh for acetylcholine. To make ACh, the choline hemitransporter (grey circle labeled CHT) must taken up choline (another grey circle). Choline-acetytransferase (grey circle labeled ChAT) combines choline with acetylCoA (another grey circle) to make ACh, which is in the black square, indicating the end of the reaction and the location to which the player will move next in the game once all the component cards for that reaction have been collected. CHT, choline hemitransporter; ChAt, choline acetyltransferase; ACh, acetylcholine; VAT, vesicle-associated transporter; Ca^{++}, calcium ions; VAMPs, vesicle-associated membrane proteins; SNAPs, synaptosomal nerve-associated proteins; Na^{++}, sodium ions.

3 rounds: component card draw and play; component card pass and play; and drug card draw and play. The goal of the players was to successfully make their way through one parasympathetic pathway (from tiles in Cranial 1-7 and Sacral 1-5) and one sympathetic pathway (from tiles in Thoracic 1-12 and Lumbar 1-5). Figures 1A, 1B and 1C are enlargements of the sections noted in Figure 1 to show detail. Figure 2 shows a flow chart of the steps for playing the ANS board game.

In the first round of play (component card draw and play), each player drew 1 component card (for a total of 6 cards to start). In turn, players examined their cards to determine if they had the set of components (in grey circles) that would allow them to move along their nerve pathway to the next destination point (black square). If the component cards were played, the player had to discuss with the other players what each component was and how the reaction or process occured in the cell. In this way, all players were reviewing the functions of the ANS. If a player did not have all of the component cards to progress to the next black square, game play passed clockwise to the next player.

The second round of play (component card pass and play) consisted of each player choosing a component card from his/her hand and passing it to the player on the left. In turn, each player used the newly received card to play, if possible, and then passed a discard to the player on the left.

In the third round (drug card draw and play), each player, in turn, drew a drug card and showed it to the other players. Each player had to determine where the drug binds and its mechanism of action. All players openly discussed the drug card as a part of the educational process. Players were allowed to bring their notes and textbooks to the game session to immediately find any missing information or to clarify any disputes. If the drug stimulated neurotransmission at the player's current point in the pathway, the player used the card to move forward, and the card was placed in the discard pile. If the drug stimulated the player's current pathway, but the site of action was downstream from the player's current location, the card was held until another drug card round later in the game when the player reached that point in the pathway. If the drug inhibited neurotransmission, the player could play the card on an opponent who was at the inhibitor's site of action, forcing the opponent to move backward in the opponent's pathway. The opponent receiving the inhibitor card had to redraw the component cards in order to regain the opponent's position.

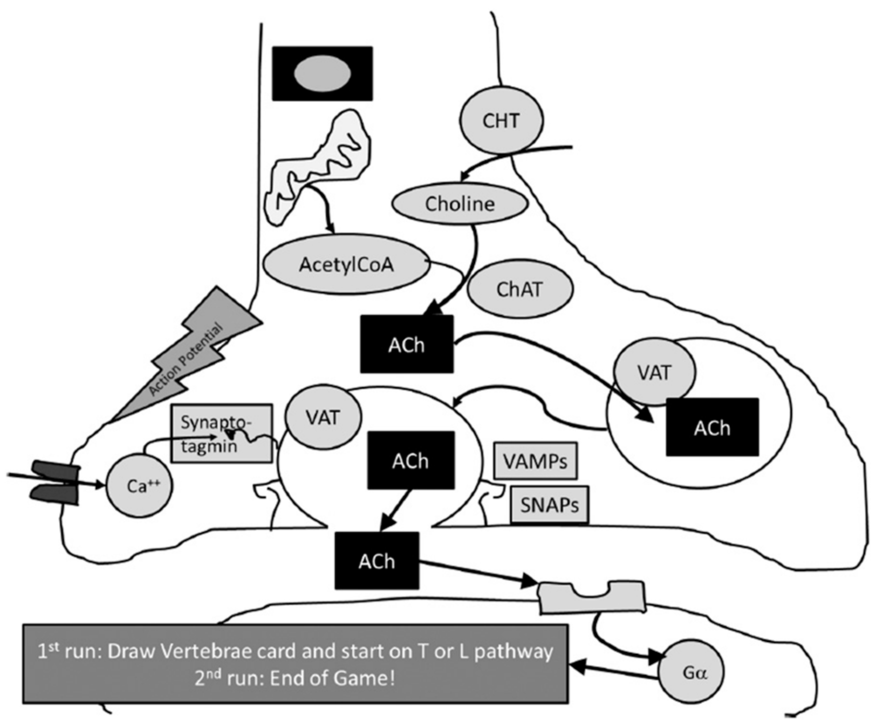

Figure 1B. Automatic Nervous System (ANS) Board Game Section, Cholinergic Postganglionic Synapse. A close-up of the postganglionic cholinergic nerve terminal and end effector cell synapse from the board game (labeled "1B" in Figure 1). Because most ANS parasympathetic nerves are cholinergic, the figure is included in the bottom half of the cranial and sacral pathways. CHT, choline hemi-transporter; ChAT, choline acetyltransferase; ACh, acetylcholine; VAT, vesicle-associated transporter; Ca^{++}, calcium ions; VAMPs, vesicle-associated membrane proteins; SNAPs, synaptosomal nerve-associated proteins; Ga, G-protein alpha subunit.

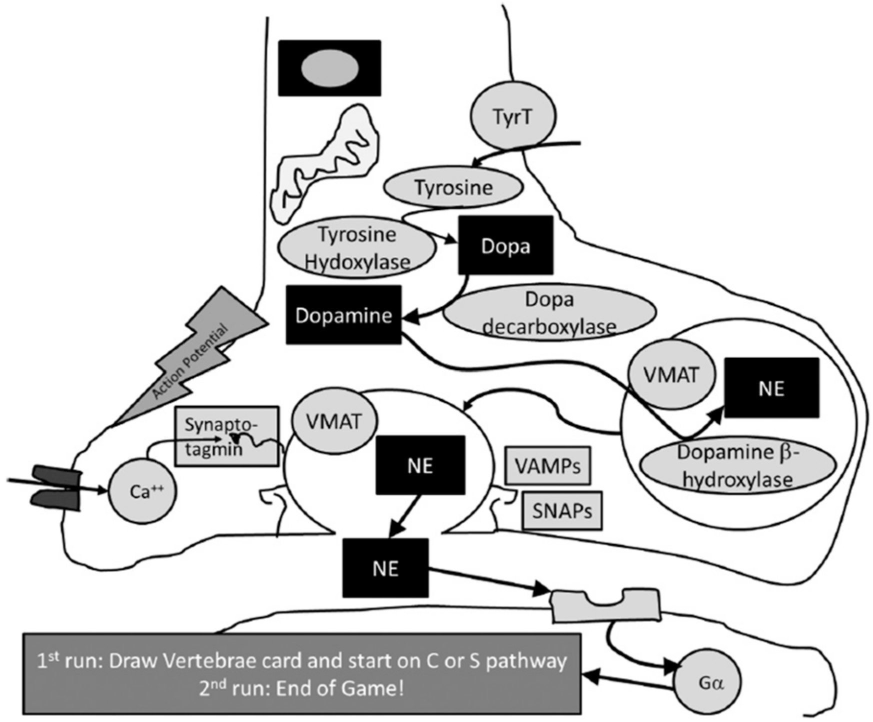

Figure 1C. Automatic Nerous System (ANS) Board Game Section, Adrenergic Postganglionic Synapse. A close-up of the post-ganglionic adrenergic nerve terminal and end effector cell synapse from the board game (labeled "1C" in Figure 1). Because most ANS sympathetic nerves are adrenergic, the figure is included in the bottom half of the thoracic and lumbar pathways. TyrT, tyrosine transporter; NE, norepinephrine; VMAT, vesicular membrane-associated transporter, Ca^{++}, calcium ions; VAMPs, vesicle-associated membrane proteins; SNAPs, synaptosomal nerve-associated proteins; Ga, G-protein alpha subunit.

EVALUATION AND ASSESSMENT

To measure immediate learning from the board game, participants' pretest and posttest scores were compared using paired *t* test. As an indication of continued learning while studying after playing the game, scores for pretest, posttest, examination, and ANSQs were compared among participants using one-way analysis of variance (ANOVA) with Tukey post hoc test to adjust for multiple comparisons. Also, to test for efficacy of using the board game to assist students in learning the topic, scores for examination, ANSQs, and CTLQs were compared between board game participants (PART) and non-participating (NPART) classmates using independent samples *t* test. All data were analyzed using SPSS, v16.0 (IBM Corp, Armonk, NY).

Of 72 students who were enrolled in the second-year Pharmacology course, 22 students volunteered to play the board game. Of the 22 participants, 2 did not complete the posttest and were excluded from comparison between participants' pretest and posttest scores. Also, one participant did not take the examination with the class and was excluded from examination score analyses between participants and nonparticipating classmates.

Average pretest, posttest, examination, ANSQ, and CTLQ scores are listed in Table 1. The pretest and posttest instruments were identical. Participants' pretest scores were significantly lower than posttest scores ($p=0.003$). The in-class examination tested the same content as the pretest and posttest in the ANSQs and also included questions on a different topic in the CTLQs, which were used as an internal control. Board game PART scores were progressively higher (linear trend, $p<0.001$; data not shown) between pretest, posttest, examination, and ANSQ scores. Using ANOVA with the Tukey post hoc test for multiple comparisons, scores were higher between the pretest and posttest ($p=0.003$), pretest and examination ($p<0.001$), and pretest and ANSQs ($p<0.001$).

Additionally, PART scores were higher than NPART scores for examination ($p=0.036$) and ANSQs ($p=0.009$), as measured by independent sample *t* test, which compares mean scores between the groups. Using the same method, the difference in PART and NPART CTLQ scores was not significant ($p=0.161$).

DISCUSSION

The goal of this study was to create a board game that could help students in a PharmD program learn the

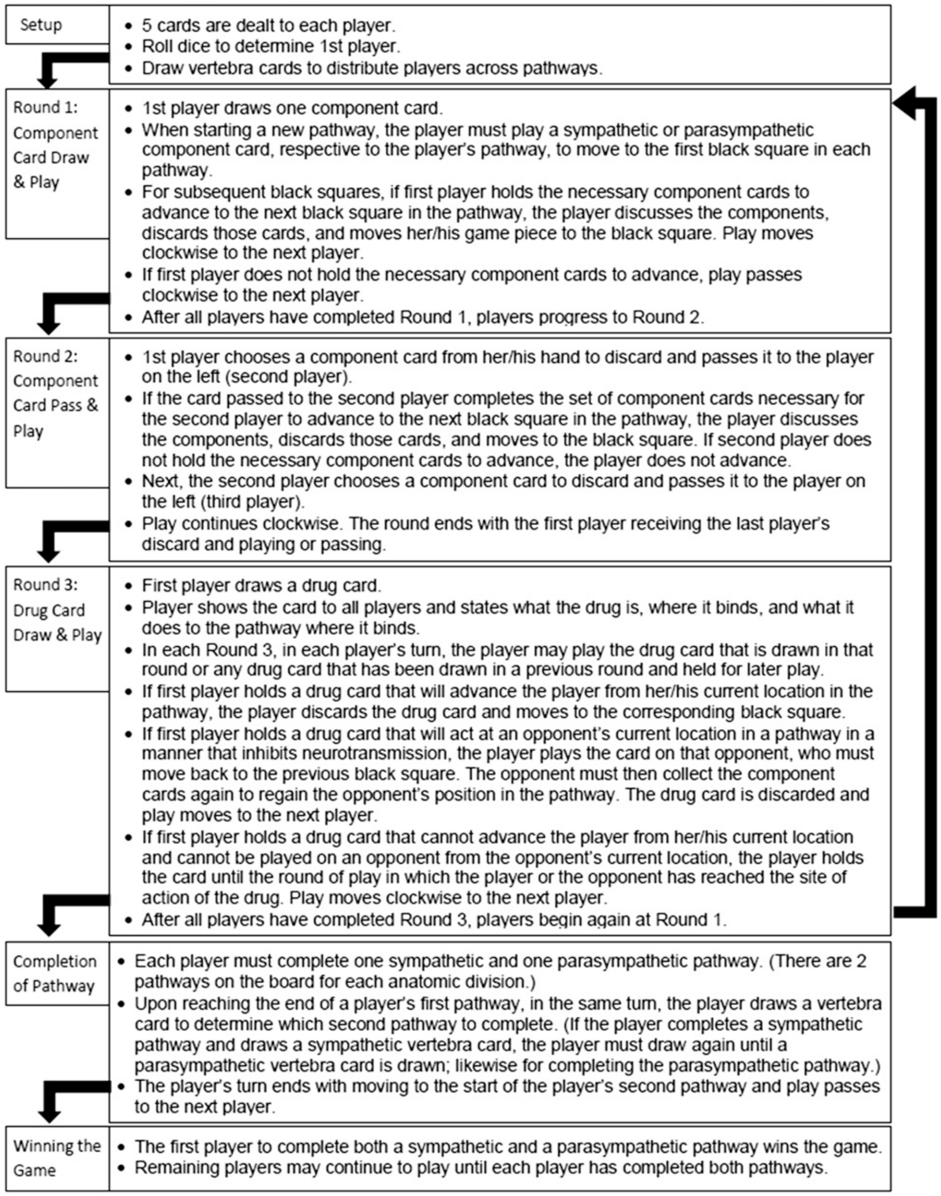

Figure 2. Flow chart of steps for playing the Automatic Nervous System (ANS) Board Game.

pharmacology of the autonomic nervous system. Learning styles were not assessed because the board game sessions were voluntary, outside of class time, and at times that were accommodating to students' schedules. Because of these factors, students who chose to participate might have been more likely to have a learning style that is compatible with learning from a board game, which could have created a selection bias for measuring learning styles. While the goal of the study was not to make learning more enjoyable, students stated they did enjoy learning in this way. A formal survey was not administered because the goal was to assess the effect of the game on learning. Instead of a formal student survey that would measure student enjoyment and opinions of learning, student scores were used to determine whether the board game was successful. Results indicate this goal was met.

The board game style was chosen because it allowed a visual representation of the neural network and all of the physiological and drug reactions described in lecture and in the course textbook but were difficult for students to assimilate, as was observed in delivery of the course during the previous 6 years. Test question analysis of prior examinations indicated difficulty with concepts such as autoreceptor agonists that inhibit neurotransmission or antagonists that stimulate it. When the students were asked at the end of the game whether they found it helpful, they replied that the image of the system that made up the board helped them understand the network as a whole,

Table 1. Scores (% mean) of Board Game Participants (PART) and Nonparticipating (NPART) Pharmacology Classmates

Assessment	PART	n	NPART	n	Independent Samples *t* Test *p* value*
Pretest Score	47.1	22	–	0	–
Posttest Score	68.3	20	–	0	–
ANSQ Score	87.6	21	78.8	50	0.01
CTLQ Score	78.0	21	84.0	50	0.16
Examination Score	86.3	21	79.6	50	0.04

*PART vs NPART, independent samples *t* test, $p<0.05$; CTLQ, control examination questions; ANSQ, autonomic nervous system examination questions

which, in turn, helped them understand why the drugs created their response in the system. While this student feedback was anecdotal, analysis of the test results supports these verbal reports.

The fact that students increased their average scores by 21 points immediately after playing the game indicated the game had immediate positive effects on learning. If the participants had played longer or more often, posttest scores may have been even higher. The fact that the students scored progressively higher between the pretest, posttest, and class examination indicated students continued learning between playing the game and taking the examination. That game participants scored higher on the class examination than their nonparticipating classmates provides strong evidence that the game was the factor responsible for helping them learn. Also, the difference between participant and nonparticipant scores was greater when the comparison was restricted to game topic questions and disappeared when comparing scores on nontopic questions. These facts argue against the possibility that only the "best" or higher scoring students participated and provide stronger evidence that the board game was responsible for helping the students learn ANS pharmacology.

SUMMARY

The board game assisted pharmacy students in learning ANS content. Although posttest scores were low, the scores were much higher than pretest scores, indicating an immediate assimilation of ANS knowledge as a direct result of playing the board game. In addition, student comments to the instructor following game play indicated that playing the board game helped them to better understand the ANS system as a whole and how effects at one receptor affect the system downstream. Subsequent studying allowed for better assimilation and retention of the material by participants, as demonstrated by the higher examination scores of board game players than their classmates who did not play the game. When scores were limited to questions pertaining to ANS material, the difference was even stronger. Combined with a lack of difference in control question scores, this indicates that the improvement in examination scores was a result of playing the board game, rather than of differential abilities between participants and nonparticipating classmates. Thus, the ANS board game assisted students in learning ANS pharmacology at the level of the receptor and the ANS system.

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