Relationships among video gaming proficiency and spatial orientation, laparoscopic, and traditional surgical skills of third-year veterinary students

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SPECIAL REPORT

Objective—To determine the relationships among traditional and laparoscopic surgical skills, spatial analysis skills, and video gaming proficiency of third-year veterinary students.

Design—Prospective, randomized, controlled study.

Sample—A convenience sample of 29 third-year veterinary students.

Procedures—The students had completed basic surgical skills training with inanimate objects but had no experience with soft tissue, orthopedic, or laparoscopic surgery; the spatial analysis test; or the video games that were used in the study. Scores for traditional surgical, laparoscopic, spatial analysis, and video gaming skills were determined, and associations among these were analyzed by means of Spearman's rank order correlation coefficient (r_s).

Results—A significant positive association ($r_s = 0.40$) was detected between summary scores for video game performance and laparoscopic skills, but not between video game performance and traditional surgical skills scores. Spatial analysis scores were positively ($r_s = 0.30$) associated with video game performance scores; however, that result was not significant. Spatial analysis scores were not significantly associated with laparoscopic surgical skills scores. Traditional surgical skills scores were not significantly associated with laparoscopic skills or spatial analysis scores.

Conclusions and Clinical Relevance—Results of this study indicated video game performance of third-year veterinary students was predictive of laparoscopic but not traditional surgical skills, suggesting that laparoscopic performance may be improved with video gaming experience. Additional studies would be required to identify methods for improvement of traditional surgical skills. (*J Am Vet Med Assoc* 2014;244:357–362)

Because of increasing numbers of students, expanding curricula, and limited time and financial resources, medical educators are compelled to develop innovative teaching methods for surgical skills instruction. Although there is a need for surgical training in veterinary and human medical educational institutions, operating rooms may not be ideal learning environments because of concerns regarding the learning of new skills during procedures for clinical patients, fiscal limitations, time constraints, and the need to reduce errors by inexperienced surgeons because of ethical and litigious concerns.[1–4] The numbers of students in veterinary education programs are increasing, and such students subsequently have decreased exposure to clinical cases.[5] Because of these factors—combined with increasing ethical concerns regarding the use of research animals for the sole purpose of surgical training and the unsustainability of cadavers owing to problems with availability, storage, and limited usefulness due to decay[1]—evaluation of alternate methods for surgical skills instruction is warranted.

Medical simulators, virtual reality simulators, benchtop models, and robotic surgical systems have been evaluated for education in human medical training programs. Although such systems are effective, they can be costly and time-consuming to set up, which has led to interest in the use of video games for surgical skills training. Video games are portable, easy to set up and use, do not necessitate the use of a specialized skills laboratory, can be used in small spaces, and require no consumables. Historically, video games were controlled by use of a standard joystick and buttons. New video game consoles are more advanced in that they have a motion-sensing interface that allows game players to move a controller in 3 dimensions.

An association between video gaming proficiency and level of performance during laparoscopic surgery has been identified for medical students, residents, and surgeons.[2] However, no studies have been conducted regarding the relationship between video gaming proficiency and laparoscopic surgical skills, 3-D spatial orientation skills, or traditional surgical skills for veterinary students, to the authors' knowledge. The objectives of the study reported here were to determine associations among video gaming skills and laparoscopic surgical skills, 3-D spatial orientation skills, and tradi-

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tional surgical skills of third-year veterinary students. We hypothesized that video gaming performance and 3-D spatial orientation skills would be predictive of laparoscopic surgical skills as assessed by use of trainer boxes but would not be predictive of traditional surgical skills.

Materials and Methods

Study participants—Study procedures were approved by the Purdue University Institutional Review Board. The entire Purdue University third-year veterinary class was invited to participate. In compliance with protocol approval, an announcement was made prior to a lecture class to ask for volunteers. Twenty-nine of 68 Purdue University third-year veterinary students volunteered to participate in this randomized, controlled, prospective study. The students had undergone soft tissue surgical skills training with various suturing pads but had not participated in orthopedic simulator training or surgery of live animals. Students completed a questionnaire regarding previous video gaming experience.[a] Students were excluded from the study if they had previously played the video games used in this study or had laparoscopic box trainer experience. Students rotated among 4 training and assessment stations: laparoscopic surgical skills simulation, video games, traditional surgical skills simulation, and the Purdue University Visualization of Rotations Spatial Test for evaluation of 3-D spatial analysis skills.[6] The order in which students rotated among the stations was determined by use of a free online randomization software program.[b] Within each station, students also completed tasks in a random order by use of the same free online randomization software program.[b] Before each task, the students were allowed 5 minutes to read written instructions, which clearly indicated the objective criteria that would be assessed. The study was conducted with 11 students participating in the first week and 18 students participating in the subsequent week. The same individuals served as scorekeepers for both weeks for the same tasks (HATM, laparoscopy; surgery technician 1, video game 1; RPM, video game 2; surgery technician 2, video game 3; intern, traditional skill 1; junior surgery technician, traditional skill 2; surgery resident, traditional skill 3).

Video gaming skills evaluation—Three identical video game consoles[c] were each connected to 91.44-cm, high-definition, flat-screen monitors. Participants stood 2.3 m in front of the monitors. All participants used the normal difficulty setting and the same standardized video game character for each of the 3 games because each character had different virtual abilities in the games. Participants were allowed 6 minutes to complete each game. If a participant completed a game before the 6-minute period ended, he or she was allowed to begin the game again and play until the designated time limit.

In video game 1, participants played a skeet-shooting game[d] that involved moving an aiming cursor (which represented a virtual gun) to hit clay disk targets. The aiming cursor was controlled with a remote controller held in each participants' hand of choice. As for actual skeet shooting, the virtual clay disks were flung into the air at high speed at various angles. The objective was to place the cursor over moving targets to eliminate as many targets as possible.

In video game 2, participants played an archery game[e] that involved simultaneously moving 2 cursors controlled with sensor remotes held in each of the participant's hands. The objective was to place the cursors over a stationary target and to hit the center of a bull's-eye.

In video game 3, participants played a target-shooting game[f] that involved moving an on-screen aiming cursor controlled with a sensor remote control held in each participant's hand of choice. The objective was to place the cursor over stationary or moving targets of various sizes and to hit the center of a bull's-eye.

For the purposes of data analysis, the scores for each of the video games were the scores generated by the game consoles at the end of the designated play periods. These scores were summed to determine each student's summary video game score.

Laparoscopic surgical skills simulation evaluation—Three laparoscopic surgical trainer boxes were constructed. Results of other studies[7–9] conducted regarding human medical training indicate that such inexpensive trainers are comparable to commercially available trainers for the assessment of basic laparoscopic surgical skills. Each model included polyvinyl chloride pipe tubing, a cloth cover, a light source, a camera, a laparoscope, a monitor, and 2 endoscopic instruments.

For laparoscopic skills task 1, sugar cubes were randomly placed in the working area of the trainer. The participants were allowed 6 minutes to stack columns of 6 sugar cubes by use of 2 endoscopic grasping forceps. The score was determined by a count of the 6-cube columns that remained upright for at least 30 seconds (score range, 0 to 3).

For laparoscopic skills task 2, a block containing 3 pegs spaced 2 cm apart was placed in the working area of the trainer box. Students were allowed 6 minutes to complete this task and instructed to use endoscopic grasping forceps to place 6 circular ring candies (internal diameter of central hole, 5 mm) onto each peg. The score was recorded as the number of pegs that were filled with 6 candies (score range, 0 to 3).

For laparoscopic skills task 3, a nonsterile surgical glove with 3 sets of lines drawn on each finger was secured in the working area of the trainer box. Parallel lines in each set were placed 0.25 cm apart, and each set of lines was separated from the adjacent set by 1.5 cm on each finger of the glove (lines were oriented transversely on each glove finger). Participants were instructed to cut between all of the most distal parallel lines on each finger followed by the middle parallel lines and then the most proximal parallel lines by use of endoscopic grasping forceps and scissors. Cuts made outside the lines were assigned a score of 0. The final score was the number of accurate cuts that were made during a 6-minute period (score range, 0 to 15).

The time to completion of each task and the total scores for the 3 laparoscopy tasks were determined. These values were used to determine each student's summary laparoscopy score.

Traditional surgical skills evaluation—The time required and the success in completion of 3 traditional soft tissue surgical skills (ligature placement, creation of an overhand knot, and creation of a simple continuous suture pattern) were evaluated. The time required and the success in completion of 1 traditional orthopedic surgical skill (drilling) were also evaluated.[g]

For traditional surgical skills task 1 (ligature placement), participants were instructed to tie as many ligatures as possible during a 3-minute period on a piece of latex tubing by use of Mayo-Hegar needleholders. Participants were instructed to create ligatures with a surgeon's knot and 4 total throws. Scores were determined on the basis of the time to completion of the first ligature, number of ligatures created, and successful task completion (ability to place the specified ligature, spacing ligatures evenly apart [spaced within 3 mm], forming of tight knots and forming of square knots [yes or no for each item]).

For traditional surgical skills task 2 (creation of an overhand knot), participants tied an overhand knot on a testicle-spermatic cord model. Scores were determined on the basis of the time to completion, ability to form the specified knot (yes or no), and whether the knot was tight (yes or no).

For traditional surgical skills task 3 (creation of a simple continuous suture pattern), participants were instructed to create a simple continuous suture pattern (length, 2.5 cm) on a cloth model by use of a square knot with 4 throws to start and 4 throws to end the pattern. Scores were determined on the basis of the time required for suturing and successful completion of each task (creation of a tight knot, creation of a square knot, placement of 4 throws on the starting knot, cutting of the suture tag from the starting knot, suture pattern started at the beginning of or outside the incision, creation of a tight ending knot, placement of 4 throws on the ending knot, cutting of the suture tag from the ending knot, formation of a square ending knot, suture pattern ended at the end of or outside the incision, use of the correct suture pattern, and no excessive slack or tightening in the suture line [yes or no for each item]).

For traditional surgical skills task 4 (orthopedic drilling), a 30-cm polyvinyl chloride pipe (inner diameter, 3.7 cm; wall thickness, 2.0 mm) with 12 evenly spaced dots on opposing sides of the tubing was fixed to a table with locking pliers. A 15-V battery-powered drill and a 4-mm drill bit were used. Students were instructed to start drilling at a dot on the side of the pipe and to drill to hit the opposing dot on the other side of the pipe to create a straight drill line (180°). This task simulated drilling through the cis cortex, medullary cavity, and trans cortex of a bone. Scores were determined on the basis of the time to drill through all 12 pairs of dots and the exit location of the drill bit relative to the dot on the trans cortex of the tubing (determined with 2-D measurements [ie, location along longitudinal and transverse axes of the pipe]).

The time to completion for the 4 traditional surgical skills tasks, ability to complete tasks in the specified manner (yes = 1; no = 0), number of successfully created ligatures for task 1, and proximity of the drill exit location to the dot for task 4 were summed. This value was the summary traditional surgical skill score for each student.

3-D spatial analysis evaluation—The Purdue University Visualization of Rotations Spatial Test was used to evaluate 3-D skills of participants.[6] Participants were allowed 20 minutes to complete the test. Each question had the image of an object on the left side of the top of the page, and the image of this object was placed in a different orientation on the right side of the top of the page. The image of another object was placed in the middle of the page. Five image choices were printed at the bottom of the page; participants were instructed to select the image that would represent the position of the object in the middle of the page on the basis of the direction and amount of rotation of the object in the top left corner of the paper to achieve the image orientation of the object in the top right corner of the paper. Scores were determined on the basis of the number of correct answers (maximum score, 20).

Statistical analysis—The students' scores for each task were not disclosed to students or evaluators other than those involved in completion and scoring of each task. A commercially available spreadsheet[h] was used to record data for each student, and a commercially available software program[i] was used for statistical analysis. A summary score for video game skills was developed by expressing each participant's score as a percentage of the maximum recorded score for each game and then determining the mean value for the 3 evaluated tasks. A summary score for laparoscopic skills was developed by expressing each participant's score as a percentage of the maximum recorded score for the number of complete sugar cube columns stacked vertically, the number of pegs completely filled with circular candies, and the number of successful cuts made in surgical gloves; then the mean value for the 3 evaluated tasks was determined. A summary score for traditional surgical skills was developed by expressing each participant's time as a percentage of the minimum recorded time in seconds for completion of procedures (tying a ligature with 4 throws, creation of an overhand knot, creation of a simple continuous suture pattern, and orthopedic drilling) or as a percentage of the minimum recorded distance in millimeters from the polyvinyl chloride trans cortex dot in longitudinal and transverse axis directions. The maximum time allowed (3 minutes) was designated a value of 0% for the first 4 traditional surgical skills tasks evaluated, and the maximum drill exit distance from the trans cortex dot on the pipe was designated a value of 0% for the orthopedic drilling skill. The mean score for traditional surgical skills was determined by applying equal weight to the first 4 metrics and half weight to the last 2 metrics (drill exit distance from opposing dot in longitudinal and transverse axes of pipes) because those last 2 metrics were correlated. The summary scoring method provided a theoretical range of mean scores from 0% to 100% for each of the 4 skills evaluated and yielded a normal distribution (as assessed with a Shapiro-Wilk test) for each skill. Because they were ordinal, associations between summary scores were analyzed by use of Spearman rank order correlation coefficient (r_s). Values of $P \leq 0.05$ were considered significant.

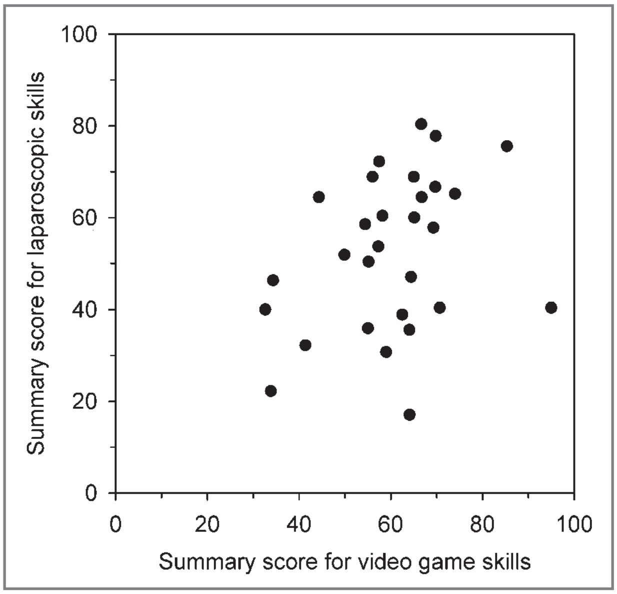

Figure 1—Scatterplot indicating a significant (P = 0.031) positive association (r_s = 0.40) between the summary score for 3 video games and the summary score for laparoscopic surgical skills of 29 third-year veterinary students.

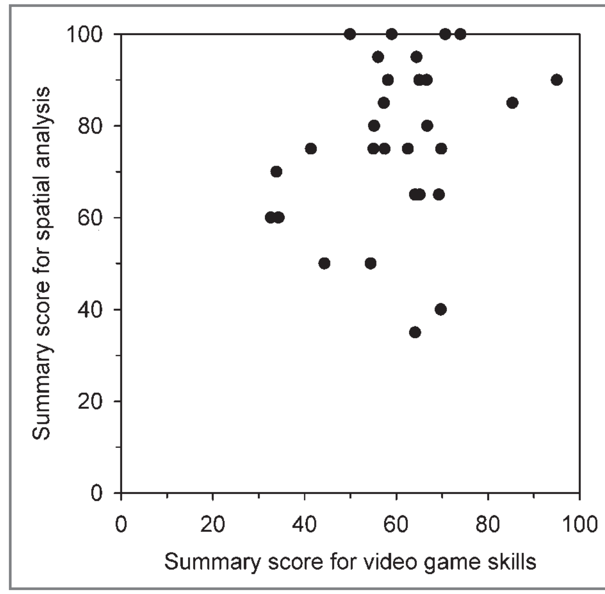

Figure 3—Scatterplot indicating a nonsignificant (P = 0.11) positive association (r_s = 0.30) between a summary score for 3 video games and the summary score for spatial analysis skills of 29 third-year veterinary students.

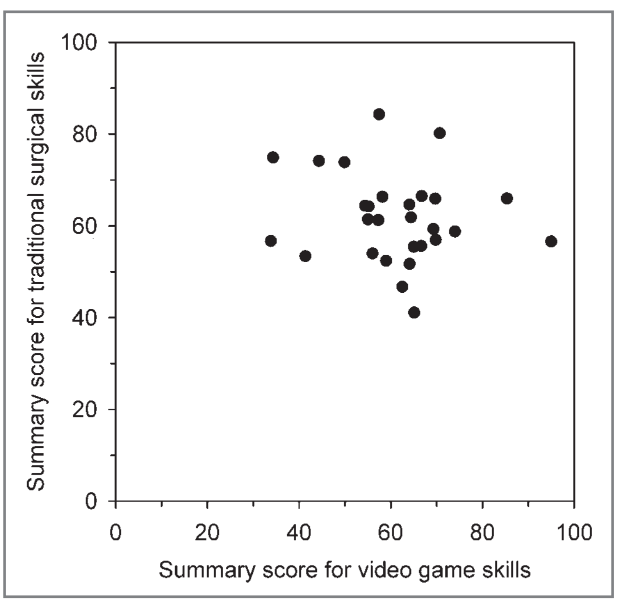

Figure 2—Scatterplot indicating a nonsignificant (P = 0.61) association between the summary score for 3 video games and the summary score for traditional surgical skills of 29 third-year veterinary students.

Results

Twenty-nine veterinary students (17 females and 12 males) participated in the study. Prior to the study, the students had completed surgical skills training by use of inanimate objects but had not participated in orthopedic simulator training or surgery with live animals. All students had previous video gaming experience, but none had played the specific video games used in the study. None of the students had previous experience with the laparoscopic skills trainer box or the Purdue University Visualization of Rotations Spatial Test.

A significant (P = 0.031) positive association was detected between the summary score for the 3 video games and the summary score for laparoscopic skills (r_s = 0.40; **Figure 1**). In contrast, summary scores for traditional surgical skills were not significantly (P = 0.61) associated with video game summary scores (**Figure 2**). Results of the spatial analysis scores were positively (r_s = 0.30) associated with video game summary scores; however, that result was not significant (P = 0.11; **Figure 3**). Spatial analysis scores were not significantly associated with laparoscopic surgical summary skills (r_s = 0.16; P = 0.39). Traditional surgical summary skill scores were not significantly associated with laparoscopic surgical summary skill scores (r_s = 0.25; P = 0.19) or spatial analysis skill scores (r_s = –0.03; P = 0.88).

Discussion

Results of other studies[10–15] regarding human medical education indicate video game proficiency is associated with laparoscopic skills but not traditional surgical skills. The present study is the first in which associations between video gaming performance and laparoscopic, traditional surgical, and 3-D spatial orientation skills were determined for veterinary students. Results of this study indicated a significant positive association between laparoscopic and video gaming skills for third-year veterinary students.

Results from numerous studies[2,12,16,17] of human medical education techniques indicate a strong positive correlation between video game performance and laparoscopic box trainer skills or endoscopic surgical performance. Other authors[13] found that surgeons who play video games for > 3 hours each week make 37% fewer errors, are 27% faster, and score 42% better overall during use of laparoscopic skills trainers versus surgeons who have no video game experience. Interestingly, other authors[18] found that teenagers with video gaming experience performed better during use of laparoscopy simulators than medical surgery residents with no video gaming experience.

Results of other studies[19,20] indicate that surgeons with a high skill level during use of laparoscopic simulators have a high skill level during performance of laparoscopy in humans. Other authors[19] found that junior surgery residents who undergo intense laparoscopy simulator training have significantly higher overall surgical performance versus residents that do not undergo such training. Results of another study[20] indicate surgery residents who undergo laparoscopy simulator training have significantly better laparoscopy skills scores than residents who do not undergo such training, suggesting use of laparoscopy simulators can improve laparoscopic surgical skills.

Few studies have been conducted regarding surgical simulator training during veterinary medical education. Other authors[21–23] have developed a laboratory for simulation training of laparoscopic skills. Although such training methods are effective, they can be costly and time-consuming to set up; use of contemporary home entertainment video games for surgical training may be a useful alternative.

Difficulties encountered when learning laparoscopic surgical skills include coordination of 3-D movements with 2-D video images, compensation for the fulcrum effect of equipment, development of hand-eye coordination, and lack of tactile perception.[11] Contemporary video games may be similar to laparoscopic skills training because they assist trainees with coordination of 3-D information and 2-D video images, improve precision of movement, and improve coordination of both hands.[10] Each video game used in the present study was chosen on the basis of similarity of skills required to play each game with the skills required during performance of laparoscopy (eg, fine motor control, visual-spatial processing, reaction time, hand-eye coordination, and 3-D depth perception on the basis of 2-D images). Therefore, the finding of an association between video gaming skills and laparoscopic trainer box skills was not surprising. The target-shooting game was intended for assessment of precision and accuracy skills, the archery game was intended for assessment of ability to use both hands simultaneously to complete a task, and the skeet-shooting game was intended to assess reactionary movements.

Traditional surgical skills such as making an incision, instrument handling, knot tying, and gentle tissue handling and anatomic dissection are typically difficult to evaluate in an objective manner. Accuracy and precision of students were assessed in the present study by means of measurement of the time required to complete procedures and scoring of various tasks. Traditional surgical skills do not correlate with minimally invasive surgical skills for human medical physicians.[3,24] Results of the present study for third-year veterinary students were similar.

The findings of the present study suggested that 3-D spatial skills may be an important factor for surgical performance when there is a lack of depth perception. The Purdue Visualization of Rotation Test was developed for assessment of undergraduate chemistry and biology students to identify those who might have difficulty with spatial tasks. This method is helpful for identification of students who might need additional assistance during instruction.[25] Use of spatial analysis acuity results has been evaluated for instruction of canine head anatomy.[26] Results of that study indicated veterinary students with higher Purdue University Visualization of Rotations Spatial Test scores have higher scores for anatomic tests that rely on 3-D spatial skills, versus other students. Learning of anatomy may enhance spatial skills, and learning of spatial skills enhances learning of anatomy.[27] Spatial skills acuity may also be useful for interpretation of ultrasonographic, MRI, and CT images and performance of laparoscopic surgical skills.

The present study had several limitations. Students had various levels of prior experience with video games; however, we were able to discern differences in video game performance by use of contemporary video games. Results of this study cannot be used to predict the future surgical performance of the students who were included. However, results of other studies[12–14,17] indicate video games can be inexpensive learning tools that allow trainees to improve hand-eye coordination, coordination of 3-D movements with 2-D images, and spatial orientation. The measures of traditional surgical skills used in the present study may not have been sensitive enough to discriminate small but clinically important differences in technical skills among students. In addition, only psychomotor performance of students was assessed in this study. We used time as an endpoint for surgical skills assessments and also evaluated performance of various skills to ensure students did not compromise quality to increase speed during performance of tasks. Time to completion of a surgical skill is an unreliable measure of the quality of performance.[28] Global rating scales and dexterity analyses are other methods that can be used to evaluate performance of traditional and laparoscopic surgical skills.[28] Psychomotor abilities are important for surgeons, but competent surgeons should also have knowledge of procedures and anatomy, attention to detail, patient care skills, appropriate surgical decision-making skills, situational awareness, appropriate behavior, interpersonal communication skills, and teamwork skills.[11,28]

Results of the present study indicated video game aptitude was significantly associated with laparoscopic surgical skills scores, but not with traditional surgical skills scores, for third-year veterinary students. Use of video game training in addition to benchtop models and surgical simulators should be considered for surgical training of veterinary students, interns, and residents. Further studies are warranted to determine methods for improvement of traditional surgical skills in third-year veterinary students.

a. Copies of the video game experience questionnaire are available on request from the corresponding author.
b. True random number generator, Randomness and Integrity Services Ltd, Dublin, Ireland. Available at: www.random.org. Accessed Oct 31, 2013.

c. Nintendo Wii, Nintendo of America Inc, Redmond, Wash.
d. Skeet shooting, Mario and Sonic at the Beijing 2008 Olympic Games, Nintendo of America Inc, Redmond, Wash.
e. Archery, Mario and Sonic at the Beijing 2008 Olympic Games, Nintendo of America Inc, Redmond, Wash.
f. Target shooting, Mario and Sonic at the London 2012 Olympic Games, Nintendo of America Inc, Redmond, Wash.
g. Copies of the traditional surgical skills scoring form are available on request from the corresponding author.
h. Microsoft Excel, version 14.0.6129.5000, Microsoft Corp, Redmond, Wash.
i. SAS, version 9.3, SAS Institute Inc, Cary, NC.

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