Learning style preferences and course performance in an undergraduate physiology class

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Submitted 16 June 2009; accepted in final form 28 September 2009

Dobson JL. Learning style preferences and course performance in an undergraduate physiology class. Adv Physiol Educ 33: 308–314, 2009; doi:10.1152/advan.00048.2009.—Learning styles may be classified according to the sensory modality that one most prefers to use when internalizing information. The four major sensory modalities are visual, aural or auditory, read/write, and kinesthetic. The purpose of this study was to investigate the relationship between preferred learning style, gender, and course scores in an undergraduate physiology class. Students from the fall 2008 and spring 2009 Applied Human Physiology courses completed an online questionnaire in which they were asked to both provide descriptive information about themselves (e.g., gender and major) and self-assess their preferred sensory modality. A total of 901 students completed the questionnaire, 75% of which were female and 25% were male. The results from a \( \chi^2 \)-analysis \( \chi^2 = 9.59, P < 0.05 \) indicated that females and males had significantly different learning style preferences. Females most preferred visual learning (46%) followed by aural (27%), read/write (23%), and kinesthetic (4%). Males most preferred visual learning (49%) followed by read/write (29%), aural (17%), and kinesthetic (5%). There was also a significant relationship \( P < 0.05 \) by ANOVA between preferred sensory modality and course scores. The mean overall course scores were 83.53 ± 8.25, 85.58 ± 8.18, 84.98 ± 7.78, and 76.70 ± 7.92 for those that preferred visual, aural, read/write, and kinesthetic modalities, respectively. These results support the findings of Wehrwein et al. (18): that female and male physiology students have different sensory modality preferences and that they provide the first step in determining if sensory modality preferences impact final course scores.

sensory modality; VARK; physiology; gender

Physiology is an important component of many diverse fields of study. The population of students that take physiology courses is likewise very diverse and represents many different age, cultural, and educational backgrounds. Because physiology is also an inherently difficult subject, physiology teachers need to be mindful that the effectiveness of any specific teaching strategy they use will vary with different types of students. Consequently, when teaching physiology to a diverse group of students, the most thorough and successful strategy is to present information using multiple learning styles (6, 7, 8, 11, 15, 17, 18). Teachers that incorporate multiple learning styles are more likely to use the specific style that is preferred by any given student (6, 11, 17). When information is presented using students’ preferred learning style, teachers are better able to connect with students (1, 7, 10) and students learn more effectively (6, 11, 17).

There are a number of different ways to define and assess learning styles, but one of the more practical and recently popular ways to do so is according to the sensory modality that one most prefers to use when learning. As Bruner (4) and Piaget (14) observed, the four different sensory modalities that humans use to assimilate information are visual, auditory, reading/writing, and kinesthetic (VARK). Flemming then built on that concept by developing an online questionnaire (5) that categorizes learning styles on the basis of one’s VARK modality preferences. Those interested in using the questionnaire simply visit the pertinent website (5) and answer the 16 specific questions, and the program then automatically compiles the results and determines a user’s sensory modality preferences. Sample questions from Flemming’s VARK questionnaire are shown in Table 1. Although most students can and do use all four of the VARK sensory modalities when internalizing information, many prefer two or three particular modalities, and some have one dominant preference (5). Students with visual preferences learn best using pictures, graphs, diagrams, etc. Auditory or aural learners prefer to listen to and discuss material. Those with read/write preferences learn best with textual materials. Finally, kinesthetic learners internalize information best when they are involved physically (e.g., touching and manipulating materials).

Over the last 5 yr, at least eight studies (1, 3, 8, 9, 10, 12, 15, 18) have investigated learning style preferences in physiology students. All eight of those studies were similar in that the investigators used some version of Flemming’s VARK questionnaire to determine their students’ sensory modality preferences. Six of those eight studies (1, 3, 8, 9, 12, 15) found that the majority of their physiology students had multimodal preferences, meaning that they preferred to use at least two to four sensory modalities when learning information. In contrast, Meechan-Andrews (10) found that the majority of their physiology students preferred to use only one VARK modality when learning information (unimodal). Yet another study conducted by Wehrwein et al. (18) found that the majority of their male physiology students had multimodal preferences, whereas the majority of their female students had unimodal preferences. It is important to point out that the unimodal preferences found both in females in the Wehrwein et al. study (18) and in all students in the Meechen-Andrews study (10) were fairly small (i.e., 54% of the students in both studies preferred unimodal learning vs. 46% preferred multimodal learning). In summary, the bulk of evidence from these eight studies (1, 3, 8, 9, 10, 12, 15, 18) indicated that the majority of physiology students prefer multimodal learning.

There are a number of important issues pertaining to learning style preferences in physiology students that require more investigation. For example, although it seems reasonable that sensory modality preferences might vary with gender (13), three of the studies mentioned above (1, 3, 15) found no significant difference in preferences between males and females. On the contrary, the male and female physiology stu-
Table 1. Selected questions from Flemming’s online VARK questionnaire

You are not sure whether a word should be spelled “dependent” or “dependant.” You would:
A. Write both words on paper and choose one.
B. Think about how each word sounds and choose one.
C. Find it in a dictionary.
D. See the words in your mind and choose by the way they look.
I like websites that have:
A. Interesting written descriptions, lists, and explanations.
B. Audio channels where I can hear music, radio programs, or interviews.
C. Things I can click on, shift, or try.
D. Interesting design and visual features.
A group of tourists wants to learn about the parks or wildlife reserves in your area. You would:
A. Take them to a park or wildlife reserve and walk with them.
B. Show them internet pictures, photographs, or picture books.
C. Talk about or arrange a talk for them about parks or wildlife reserves.
D. Give them a book or pamphlets about the parks or wildlife reserves.

Table 1. Selected questions from Flemming’s online VARK questionnaire

<table>
<thead>
<tr>
<th>Resource Components</th>
<th>VARK Domains Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecturer</td>
<td>Aural</td>
</tr>
<tr>
<td>Speeches, discussion etc.</td>
<td>Visual</td>
</tr>
<tr>
<td>Illustrations drawn on the board</td>
<td>Visual</td>
</tr>
<tr>
<td>Lecture presentation materials</td>
<td>Visual</td>
</tr>
<tr>
<td>Lecture notes (text and illustrations)</td>
<td>Visual and read/write</td>
</tr>
<tr>
<td>Computer animations</td>
<td></td>
</tr>
<tr>
<td>Text</td>
<td>Read/write</td>
</tr>
<tr>
<td>Illustrations</td>
<td>Visual</td>
</tr>
<tr>
<td>Laboratory instructor</td>
<td>Aural</td>
</tr>
<tr>
<td>Speeches, discussion etc.</td>
<td>Visual and aural</td>
</tr>
<tr>
<td>Illustrations drawn on the board</td>
<td>Visual</td>
</tr>
<tr>
<td>Laboratory presentation materials</td>
<td>Visual</td>
</tr>
<tr>
<td>Laboratory notes (text and illustrations)</td>
<td>Visual and read/write</td>
</tr>
<tr>
<td>Computer animations</td>
<td></td>
</tr>
<tr>
<td>Laboratory manual</td>
<td>Visual and aural</td>
</tr>
<tr>
<td>Text</td>
<td>Read/write</td>
</tr>
<tr>
<td>Illustrations</td>
<td>Visual</td>
</tr>
<tr>
<td>PhysioEx activities</td>
<td>Visual and kinesthetic</td>
</tr>
<tr>
<td>Experiment animations</td>
<td>Visual and read/write</td>
</tr>
<tr>
<td>Booklet text and illustrations</td>
<td>Visual and read/write</td>
</tr>
<tr>
<td>Wet laboratory experiments</td>
<td>Visual and read/write</td>
</tr>
<tr>
<td>Experiments</td>
<td>Visual and aural</td>
</tr>
<tr>
<td>Laboratory reports</td>
<td>Visual and read/write</td>
</tr>
<tr>
<td>Text</td>
<td>Read/write</td>
</tr>
<tr>
<td>Illustrations</td>
<td>Visual</td>
</tr>
</tbody>
</table>

In their physiology course (Table 2).
above resources along with several traditional hands-on (i.e., wet) human physiology laboratory activities and laboratory reports (e.g., laboratories that focus on measuring metabolic and cardiorespiratory physiology during rest and exercise). The laboratory component also incorporated PhysioEx activities (16), which are a set of virtual simulations that students manipulate and use to conduct more basic science-type physiology laboratory activities (e.g., measuring endocrine responses using rats and performing single muscle fiber experiments).

**Questionnaire.** The questionnaire was composed of 10 multiple-choice questions that were divided into 2 sections. The first section asked students to identify their gender, major, academic year classification, and whether or not they had completed the companion anatomy course. The second section was designed to prepare students to make an informed decision about the learning style they most preferred when completing the course by first asking them to think about each of the course resources they had been using. Students were asked to select the resources they found most helpful when completing the lecture portion of the course, the laboratory portion of the course, and the overall course (Table 3). Students were then asked to assess their learning style preference by selecting only one of the following choices: 1) visual (looking at and making pictures, animations, graphs, tables, etc.), 2) aural (listening to and participating in speeches, discussions, and question and answer sessions); 3) read/write (reading and writing text associated with the textbook, class notes, laboratory reports, etc.); or 4) kinesthetic (engaging in physical experiences, manipulating objects, etc.; e.g., laboratories). The questionnaire was administered during the last week of each semester, so that students had as much experience as possible with the course resources and incorporated sensory modalities before they were asked to choose their preferences. A very small amount of course extra credit (<1% of the total course points) was awarded to those students that completed the questionnaire.

**Data collection and analysis.** The questionnaire described above was created in, and administered by, the university’s E-learning course management system (ECMS). When students were ready to complete the questionnaire, they simply logged on to the class ECMS website from their personal computer. Once the students had clicked the link to begin the questionnaire, they were immediately notified that their responses would not be viewed by anyone else until after the semester had ended and final grades had been submitted. Students were therefore encouraged to answer the questions honestly. ECMS then automatically administered the questionnaire and collected the students’ responses. Because the questionnaire was associated with a very small amount of course credit, ECMS immediately informed the instructor which students had and which had not completed the questionnaire (i.e., before the end of the semester). Nevertheless, no one other than the individual student was able to view her or his questionnaire responses until after the course had been completed. Once the semester had ended, ECMS compiled each student’s course scores and questionnaire responses, replaced each student’s name with a numeric code, and then downloaded the data into a file for viewing and analysis. Since no student names appeared in the data file, it was not possible to connect any specific student with her or his specific questionnaire responses.

Once the data file had been finalized, statistical associations between gender and preferred sensory modality and between gender and most helpful course resource were made using χ²-analyses. Statistical comparisons between preferred sensory modality and student scores from the lecture portion (i.e., exams), laboratory portion (i.e., combined laboratory exam, laboratory report, and PhysioEx activity scores), and overall course (i.e., combined lecture and laboratory scores) were conducted using ANOVA with Bonferroni post hoc tests. ANOVA was chosen because it is a robust test and because data from a pilot study indicated both that the student scores were normally distributed and that the group variances were similar. Statistical significance was set at \( P < 0.05 \). Data are expressed as either means ± SD or as percentages.

**RESULTS**

A total of 1,037 students completed either the fall 2008 (358 students) or spring 2009 (679 students) Applied Human Physiology courses, and 901 of those students returned the questionnaire (87% response). Of those respondents, 75% were
female and 25% were male, and nearly 60% were either first- or second-year students (Fig. 1). The top 10 most common majors among the student respondents are shown in Table 4. Also, 54% of the respondents had completed the companion human anatomy course before taking physiology, whereas 42% had not yet taken anatomy and 4% took both courses during the same semester.

Student feedback about the most helpful resources for completing the lecture portion, laboratory portion, and overall course is shown in Table 5. Students overwhelmingly selected the lecture instructor and lecture presentation materials as the most helpful for completing the lecture portion of the course (53% and 42%, respectively) and for completing the overall course (45% and 47%, respectively). The top three most helpful course resources for completing the laboratory portion of the class were the laboratory manual (32%), laboratory presentation materials (25%), and laboratory instructor (24%). There was also a significant association ($\chi^2 = 21.87, P < 0.05$) between gender and the most helpful resource selected for completing the overall course (Table 6).

The relationship between gender and sensory modality preferences is shown in Fig. 2. Females most preferred visual learning (46%) followed by aural (27%), read/write (23%), and kinesthetic (4%). Males also most preferred visual learning (49%) followed by read/write (29%), aural (17%), and kinesthetic (5%). There was a significant association ($\chi^2 = 9.59, P < 0.05$) between gender and sensory modality preferences.

### Table 4. Top 10 most common majors among the student respondents

<table>
<thead>
<tr>
<th>Major</th>
<th>Number of Students</th>
<th>Percentage of Total Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing</td>
<td>207</td>
<td>23.0</td>
</tr>
<tr>
<td>Health Science</td>
<td>157</td>
<td>17.4</td>
</tr>
<tr>
<td>Food Science and Human Nutrition</td>
<td>101</td>
<td>11.2</td>
</tr>
<tr>
<td>Applied Physiology and Kinesiology</td>
<td>71</td>
<td>7.9</td>
</tr>
<tr>
<td>Health Education and Behavior</td>
<td>60</td>
<td>6.7</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>54</td>
<td>6.0</td>
</tr>
<tr>
<td>Psychology</td>
<td>32</td>
<td>3.6</td>
</tr>
<tr>
<td>Athletic Training</td>
<td>20</td>
<td>2.2</td>
</tr>
<tr>
<td>Chemistry</td>
<td>18</td>
<td>2.0</td>
</tr>
<tr>
<td>Anthropology</td>
<td>17</td>
<td>1.9</td>
</tr>
</tbody>
</table>

$n = 901$ students.

### Table 5. Course resources and the percentage of student respondents that listed each to be the most helpful when completing the lecture and laboratory portions of the class as well as the overall course

<table>
<thead>
<tr>
<th>Resource</th>
<th>Lecture Portion</th>
<th>Laboratory Portion</th>
<th>Overall Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture instructor</td>
<td>53</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>Lecture presentation materials</td>
<td>42</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>Course textbook</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Laboratory instructor</td>
<td>0</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory presentation materials</td>
<td>&lt;1</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Laboratory manual</td>
<td>0</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>PhysioEx activities</td>
<td>&lt;1</td>
<td>3</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Wet laboratory experiments</td>
<td>&lt;1</td>
<td>8</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Laboratory reports</td>
<td>0</td>
<td>7</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

$n = 901$ students.

The significant interaction between learning style preferences and final scores in the lecture portion, laboratory portion, and overall class is shown in Fig. 3. The mean lecture portion scores were $80.19 \pm 6.2$, $82.56 \pm 9.84$, $81.98 \pm 9.06$, and $71.02 \pm 9.74$ for those that preferred visual, aural, read/write, and kinesthetic modalities, respectively. Bonferroni post hoc tests revealed that the lecture scores from the kinesthetic group were significantly lower than those from the other three groups. Those with visual preferences also had significantly lower lecture scores than those with aural preferences. The mean laboratory portion scores were $88.14 \pm 6.64$, $89.32 \pm 5.90$, $89.00 \pm 6.75$, and $86.20 \pm 6.49$ for those that preferred visual, aural, read/write, and kinesthetic modalities, respectively. The laboratory scores from the kinesthetic group were significantly lower than those from the aural and read/write groups. Finally, the mean overall course scores were $83.53 \pm 8.25$, $85.58 \pm 8.18$, $84.98 \pm 7.78$, and $76.70 \pm 7.92$ for those that preferred visual, aural, read/write, and kinesthetic modalities, respectively. As with the lecture portion, the overall course scores from the kinesthetic group were significantly less than those from the other three groups, and the scores from the visual group were significantly less than those from the aural group. The effect size pertaining to the difference in learning styles and overall scores was modest ($\eta^2 = 0.05$). There were no significant associations between gender, preferred learning styles, and course scores.

### Table 6. Course resources and the percentage of female and male student respondents that listed each to be the most helpful when completing the overall course

<table>
<thead>
<tr>
<th>Resource</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture instructor</td>
<td>46</td>
<td>42</td>
</tr>
<tr>
<td>Lecture presentation materials</td>
<td>48</td>
<td>45</td>
</tr>
<tr>
<td>Course textbook</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Laboratory instructor</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Laboratory presentation materials</td>
<td>&lt;1</td>
<td>4</td>
</tr>
<tr>
<td>Laboratory manual</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PhysioEx activities</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Wet laboratory experiments</td>
<td>&lt;1</td>
<td>0</td>
</tr>
<tr>
<td>Laboratory reports</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

$n = 901$ students. There were significant differences ($\chi^2 = 21.87, P < 0.05$) in the resources chosen by females and males.
DISCUSSION

Summary of main findings. The purpose of this study was to use a large group of predominately underclass physiology students to examine the relationship between preferred learning styles, gender, and course performance. The main conclusions of this investigation were that there were significant associations between preferred sensory modality and both gender and course scores.

Although several previous investigations have examined the relationship between preferred learning style and gender in a physiology course (1, 2, 15, 18), only one of those studies (18) found significant differences. However, that study by Wehrwein et al. apparently did not use a statistical analysis to confirm their descriptive findings. Therefore, this is the first investigation to have found a statistically significant difference in learning style preferences between female and male physiology students. In this study, both females and males most preferred the visual sensory modality (46% and 49%, respectively), but there were considerable differences in the second most preferred modality between the two groups. About 27% of females preferred aural learning versus only 17% of males, whereas 29% of males preferred read/write learning versus only 23% of females. Interestingly, a very small, but also very similar, proportion of both females (4%) and males (5%) preferred kinesthetic learning. This disproportionately low preference for kinesthetic learning was unexpected because it is often listed as the modality that is most preferred by students in physiology courses (2, 3, 8, 10, 15, 18) and because this course did have a fairly extensive laboratory (e.g., hands-on) component.

In terms of the class resources that students identified as being the most helpful, there were no significant differences between females and males. Well over 90% of the class selected either the lecture instructor or lecture presentation materials as being the most helpful resources for completing both the lecture portion of the course (53% and 42%, respectively) and the overall course (45% and 47%, respectively). The three most helpful resources for completing the laboratory portion of the course were the laboratory manual (32%), laboratory presentation materials (25%), and laboratory instructor (24%). Given the students preference for visual learning, it was not surprising that the most helpful resources for completing the lecture portion, laboratory portion, and overall course all had visual components. It was similarly not surprising that a very small proportion of the class selected kinesthetic-style resources like the wet laboratory and PhysioEx activities as the most helpful because so few in the class indicated a preference for kinesthetic learning.

The second major finding of this investigation was the significant relationship between preferred sensory modality and course performance. Aural learners had the highest mean overall class score and, as would be expected given its predominant aural component, the highest mean lecture portion score. Since a distinctly greater percentage of females preferred aural learning (27% vs. 17% in males), it would not have been surprising if class scores had varied with gender, but there was in fact no significant difference between females and males. Perhaps the most interesting trend with class scores was that kinesthetic learners had the statistically lowest mean scores in every portion of the class, including the laboratory portion. It is important to note that kinesthetic learners did perform relatively much better in the laboratory portion of the
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How We Teach

class than the lecture portion, as would be expected given the laboratory’s much greater dependence on physical involvement and manipulation. However, the very small proportion of the class that affirmed kinesthetic preferences when internalizing course information, coupled the relatively poor overall performance of those students, indicates that the kinesthetic component of the course may need to be strengthened.

Limitations and comparisons. The most significant limitations to this study were that the questionnaire that was used had not been statistically validated and the students were asked to self-assess their preferred sensory modality. It is also possible that one single question is not adequate to determine one’s preferred sensory modality, which is itself only one of many learning style dimensions (5). Furthermore, if indeed most physiology students have multimodal preferences, as the bulk of evidence seems to indicate (1, 3, 8, 9, 10, 12, 15, 18), then it is also possible that many of the students in this study had a difficult time selecting a single sensory modality preference. In light of the types of concerns mentioned above, it is understandable that similar previous investigations (1, 3, 8, 9, 10, 12, 15, 18) assessed sensory modality preferences using Flemming’s VARK questionnaire (5). Despite its popularity, however, there were several reasons why Flemming’s questionnaire was not used in this study. First, Flemming’s VARK questionnaire had also not been statistically validated (5). Second, an expert that had evaluated the VARK instrument deemed it unsuitable for use as a research tool (5). Third, and most importantly, the expert that evaluated Flemming’s questionnaire explained that the wording of the questions and the multiple-answer choices given were both confusing to the reader (5). Conversely, because this study sought to focus on the broader relationship between preferred sensory modality, gender, and course performance, the investigator felt it was essential to assess preferences using a simple and direct question and with clear and distinct answer choices. Therefore, rather than use Flemming’s questionnaire, this study instead first asked students to think critically about how they best learned information in the course (e.g., what resources they used and how they studied) and then asked them to select the single VARK modality that most closely matched their preferred method(s) of internalizing course information (Table 3).

In light of the differences stated above, caution must be used when comparing the results of this investigation to those of similar studies that have examined learning style preferences using some version of Flemming’s VARK questionnaire (1, 3, 8, 9, 10, 12, 15, 18). Still, as stated on Flemming’s VARK website (5), at least 60% of those that complete the online VARK questionnaire say that their self-assessment of their preferred learning style matches their questionnaire result, whereas only 4% say it doesn’t match. Moreover, the percentages of students that indicated aural (24%) and read/write (24%) preferences in this study were nearly identical to the percentages of students listed with aural (25%) and read/write (26%) preferences on the VARK website (5). The major distinctions were with those students that indicated visual and kinesthetic preferences, which were 47% and 5%, respectively, in this study compared with 21% and 28%, respectively, on the VARK website (5). As stated above, it is not clear why so few students in this study preferred the kinesthetic modality. Nonetheless, this was not the first study to report both a relatively greater preference for visual learning and a very low preference for kinesthetic learning in a physiology course. Murphy et al. (12) administered Flemming’s VARK questionnaire in a physiology course and found that 33% of the students preferred the visual modality and only 1% of the students preferred the kinesthetic modality.

One final characteristic that needs to be discussed was the large disparity between the number of female and male respondents. The fact that 75% of the student participants were female and only 25% were male raises concerns about both how the sample was collected and the validity of the results. As to the issue of sampling, the class roles pertaining to the two courses from which students were sampled indicate that over 70% of the students enrolled were female. Therefore, the response rates for both female and male participants were actually very similar. As to the latter concern, it is possible that the significant relationship between preferred sensory modality and course performance would have been different if a greater proportion of the respondents had been males. That is, however, very unlikely because the course scores for female and male respondents were statistically the same, were both normally distributed, and had very similar variances.

Conclusions. The study of preferred learning styles in physiology courses is important to help maximize the quality of physiology instruction. Professors that better understand the preferred learning styles of their students can tailor the course information to the styles that are most effective for their students. Regardless of the specific style(s) that professors choose to use when teaching, however, students that understand their own learning style preferences can organize course information into the style that they most prefer. To those ends, the results of this investigation indicate that the female and male student respondents preferred different sensory modalities and that those with different sensory modality preferences performed differently in the course. Those results must, however, be considered within the context of the major limitations of the investigation, which were that students were given only one question to self-assess their preferred sensory modality and there were no choices corresponding to a multimodal preference. The results of this investigation contribute to the growing body of evidence showing that learning style preferences may change over time and with different levels of education (3). The students in this study, which were mostly first- and second-year undergraduates, had different sensory modality preferences than senior-level undergraduate physiology students (3), who, in turn, had different sensory modality preferences than graduate-level physiology students (1, 8, 9, 10, 12, and 15). Bearing that trend in mind, and considering the different types of students that were used in all of the similar previous studies mentioned above, the students in this investigation were more comparable in educational level to those used in the study by Wehrwein et al. (18). Furthermore, that study (18) and this investigation are also comparable in that they are the only two of five total investigations (along with Refs. 1, 3, and 15) that found distinct differences in the sensory modality preferences of female and male physiology students. In light of those distinguishing similarities, it is also important to recognize that Wehrwein et al. (18) found that the majority of their female students preferred a single sensory modality. That finding, with a comparable group of students, may be relevant to the limitation to this study that the questionnaire used did not provide a choice corresponding to multimodal preferences.
That is, if indeed the majority of undergraduate female physiology students have unimodal preferences, and given that 75% of the participants in this study were female undergraduate students, then the scope of the above-described limitation would not be expected to be great. As to those students in this study that would have indicated a multimodal preference if they had had the choice, it is reasonable to think that at least some of those students had a dominant sensory modality preference and were therefore able to adequately choose a single preference.

In summary, the results of this investigation lend additional support to the conclusion of Wehrwein et al. (18): that female and male physiology students have different sensory modality preferences. This investigation also provides the first of many steps needed to determine if sensory modality preferences impact final scores in a physiology course. Future studies in this area should use a different, and preferably a statistically validated, method for assessing sensory modality preferences and should include students with different levels of education (e.g., undergraduates and graduates).

REFERENCES