Miming neurological syndromes improves the long-term memorisation by medical students

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Abstract*

Objective: To evaluate the impact of a learner-friendly simulation training program on long-term memorization of neurological semiology by medical students.

Methods: Two classes of third-year medical students were enrolled in the study during their neurology rotation. The 2013 class received a standard neurological semiology training including lectures, bedside teaching and clinical reasoning sessions. The 2015 class received the same standard neurological training and was invited to voluntarily participate in The Move, a mime-based role-play training program of neurological semiology. Thirty months after the rotation, students from each class were evaluated on a semiology test specially designed for the research, that included 15 neurological semiology questions to evaluate long-term memorization and 10 general semiology questions to account for the general performance level.

Results: The semiology test was performed by 366/377 students from the 2013 class (standard education group) and by 272/391 students from the 2015 class, among which 186 participated in The Move (The Move group) and 86 did not (standard education group). The mean neurological semiology score of the 2015 class was higher compared to 2013 class (p = 0.007) and remained so after adjustment for the general semiology performance (p = 0.003). Compared to the standard education group, The Move group had a 0.94/15 points higher adjusted mean neurological semiology score, corresponding to an 11% better ranking.

Conclusions: A mime-based role-play training program, The Move, improves long-term memorization of neurological semiology by medical students. This learner-friendly interactive teaching may help overcome neurophobia in medical students.


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Introduction

The ever-growing number of patients with neurological disorders tend to be first assessed by general practitioners or internal medicine/geriatric medicine physicians before being, eventually, referred to a neurologist. Every medical student must therefore have basic diagnosis skills in neurology. However, graduating medical students often consider neurology as complex and difficult to master. They are uncomfortable with clinical diagnosis in neurology, perform poorly during the neurological examination, and frequently develop neurophobia, a ‘fear of neurology’.

We hypothesized that neurological semiology training could be improved through innovative means and we implemented The Move, a learner-friendly simulation training, for the third-year medical students of the Pierre et Marie Curie University in Paris, using mime-based role-play to teach neurological semiology. Our goal was to target the transition from preclinical to clinical years in medical school to improve knowledge and confidence in neurological semiology and to prevent neurophobia. After completing The Move, students reported that this training was emotionally pleasant, improved their understanding of neurology and their motivation to study this speciality. They also predicted that having participated would improve their future practice, but not their academic grades.

The effect of this program on long-term memorisation of neurological semiology has not been tested. We therefore compared the performance of two classes of students on a neurological semiology test especially designed for this research, 30 months after their neurology rotation. The 2013 class of students was only exposed to standard neurological teaching, whereas the 2015 class was offered the possibility to participate in The Move in addition to the same standard teaching.

Materials and Methods

Study approvals and consents

The study was approved by the internal review board of the Faculty of Medicine, Pierre et Marie Curie University (UPMC), Paris, France. The students were informed about study aims and were invited to voluntarily participate in the study test.

Study population, design and intervention

The 2013 and 2015 classes of third-year medical students from the Pierre et Marie Curie University in Paris were enrolled in the study during their neurology rotation. The 2013 class received standard neurological semiology training during a 14-week rotation including lectures, bedside teaching and clinical reasoning sessions. The 2015 class was invited to voluntarily participate in The Move in addition to the same standard neurological semiology training.
The Move is described in detail in a previous paper. Briefly, the students were trained to play a patient with a neurological syndrome (pyramidal syndrome, distal axonopathy, vestibular syndrome, cerebellar syndrome, parkinsonian syndrome, chorea, tonic-clonic seizures) or a physician examining this patient. The Move included two training sessions with all volunteer students currently on neurological rotation. After the first common training session, the students were divided into small subgroups (8-12 students) and worked on short clinical sketches for each of the studied syndromes, with the help of a coach (teaching physician). Their progress was monitored during the second common training session. During a final common session, each student’s subgroup performed sketches corresponding to randomly selected neurological syndromes in front of an expert panel during friendly battles. The experts selected the winners with regard to the originality of the scenario and the neurological authenticity of the performance.

The leading principles of the program were benevolence and fun (without mocking patients). Also, the students who felt uncomfortable with roleplaying in front of other students were given the opportunity to observe.

**Outcome measures**

To assess the long-term effect of participating in The Move, neurological semiology knowledge was tested 30 months after the neurology training in the two classes, at the end of the 5th year of medical school. During the time scheduled for semester examinations, volunteer students underwent a semiology test specially designed for the research. Students were informed in advance about the time schedule of this supplementary test but not about its topic, to prevent them revising their semiology lessons. They took the test in the Faculty examination room, during a 20-minute session without access to any reference material. These test scores were not taken into account for the semester grades. The test included 26 multiple-choice questions: 15 neurological semiology questions and 10 general semiology questions, corresponding in both cases to the knowledge expected from third-year medical students; the 26th question asked whether the student participated in The Move. The neurological semiology questions were intended to evaluate long-term memorization of this topic. The general semiology questions were added to evaluate the general performance level of students and to control for a possible selection bias (students with higher academic performance could be more likely to participate in The Move or in the study test).

**Statistical analysis**

Statistical analysis was performed using Stata 9 (StataCorp, College Station, Texas). The intention-to-teach analysis used Student’s t-test and ANCOVA adjusted for general semiology scores to compare the mean neurological semiology scores between the 2013 and 2015 classes, regardless of the participation in The Move for the students of the 2015 class.
The per protocol analysis used ANCOVA adjusted for general semiology scores to compare the mean neurological semiology score between students who participated in The Move and those who did not, from both classes. An interaction term was systematically tested to assess if the difference in mean neurological semiology scores between compared groups depended on the level of the general semiology score. The interaction term was dropped from the ANCOVA model if its effect was not statistically significant. P-values < 0.05 were considered significant for all analyses.

We used linear regression models adjusted by general semiology scores to estimate the effect size of participating in The Move (per protocol analysis) on the mean neurological score and the mean percentile rank difference.

Results

Sample overview

As shown on Figure 1, the 2013 class comprised 377 medical students (63% females, mean age 24.3 years) and the 2015 class 391 medical students (57% females, mean age 24.4 years). All students were enrolled in the neurological rotation.

Within the 2013 class, 11 students (2.9%) chose not to participate in the study test. The remaining 366 students underwent the study test and were classified in the 2013 class for the intention-to-teach analyses and in the standard education group for the per protocol analysis.

Within the 2015 class, 119 students (30%) chose not participated in the study test. The 272 remaining students underwent the study test and were classified in the 2015 class for the intention to teach analysis; 186 participated in The Move and were classified accordingly for the per protocol analysis, whereas 86 did not and were included in standard education group for the per protocol analysis.

Intention-to-teach analysis: 2015 vs 2013 classes

As shown in Table 1, the mean neurological semiology score was +0.52/15 [95% confidence interval +0.14, +0.90; p = 0.007] higher in the 2015 class in unadjusted analysis whereas the difference in mean general semiology score was not significantly different at +0.02/10 [95% CI -0.18, +0.22; p = 0.83].

ANCOVA analysis found no significant interaction between the class and the general semiology score (F(1,634) = 2.9, p = 0.09). The general semiology score and the class were both associated with the neurological semiology score (F(1,635) = 199, p < 0.001; and F(1,635) = 8.8, p = 0.003, respectively, in the model without interaction term).
After adjustment for the general semiology score, the mean neurological semiology score was +0.25/15 [95% CI +0.08, +0.42] higher in the 2015 class.

**Per protocol analysis: participants versus non-participants in The Move**

ANCOVA analysis found no significant interaction between participation in The Move and the general semiology score (F(1,629) = 3.3, p = 0.07). The general semiology score and participation in The Move were both associated with the neurological semiology score (F(1,630) = 192, p < 0.001; and F(1,630) = 27, p < 0.001, respectively, in the model without interaction term).

After adjustment for the general semiology score, the mean neurological semiology score was +0.94/15 [95% CI +0.58, +1.30] higher in students who participated in The Move (Table 1), corresponding to an 11 % [95% CI 6.6 %, 15 %] better mean percentile rank.

**Discussion**

This study shows the efficacy of a mime-based learner-friendly teaching program on the long-term memorization of neurological semiology by medical students. Students who participated in The Move outperformed those in the standard semiology group on the neurological semiology test 30 months after their rotation, whereas scores in general semiology remained equal.

**Limitations**

Our study has several limitations. First, participation in The Move resulted in a relatively small improvement of the neurological semiology test score. However, such a long-term effect is expected to be of a smaller size than a short-term effect. Moreover, it translated into a 11 % better ranking within the class, although the majority of students thought that participating in The Move would improve their future clinical practice but not their academic grades.

Second, participation in The Move was not randomized. However, the 2013 and 2015 classes were very similar in demographics and in general semiology scores, and they received the same standard neurology teaching. Moreover, we addressed a participation bias (better students from the 2015 class more likely to participate in The Move) by pooling all students from the 2015 class in the intention to teach analysis, regardless of their participation in The Move, and by adjusting the per protocol analysis on the general semiology score as a proxy for their general academic performances.

Third, participation rates in the study test differed for the 2013 and 2015 classes. We have no clear explanation for this difference but it might induce another selection bias.
(better students from the 2015 class may be more likely to take the study test). We controlled this bias by adjusting comparisons on the general semiology score.

Fourth, beyond the positive learning experience of the students 10 and their better long-term memorization of neurological semiology, it remains unknown whether participating in The Move eventually improves real-life neurological skills at the bedside.

**Interpretation and comparison with previous studies**

The Move may promote long-term memorization by involving the use of gesture, multimodal encoding of information, and various positive emotions 11, 12. First, the performance of gesture enhances perceptual and motor information, which then incorporates in reasoning 13, a process known as cognitive embodiment 14, 15. Second, gesture also facilitates active learning by focusing attention and promoting cognitive offloading 16, as movements play a role of external placeholders for internal processes. Third, performing gestures improves information recall and concept concretization 17, 18, as students must think about and visualize the symptoms that they will mime. One functional neuroimaging study confirmed that the association of words and gesture activated the hippocampus of learners and that this activation was predictive of better subsequent memorization 19. Thus, we can speculate that miming the neurological syndromes could promote long-term memorization by cognitive embodiment 20 and subsequent activation of the hippocampal neuronal network.

Previous studies based on the theory of embodied cognition used gestures to picture the knowledge to be remembered and showed improved mid-term memorization of anatomy 11 and physiology 21. In contrast to these experiences, the gestures performed by students participating in The Move are themselves the knowledge to be remembered and we showed a positive impact on long-term memorization of neurological semiology.

When students are spectators during both common training sessions and the final common battle session, they repeatedly observe other subgroups miming neurological syndromes and hear and see the feedback from experienced neurologists on each performance. Reflective observation of repeated examples likely drive long term memorization 22.

Enjoyment, pride of achievement and collegiality are other important factors that shaped The Move experience and could contribute to long-term memorization. For example, previous studies have shown that positive emotions such as enjoyment and pride predicted subsequent academic achievements 23. On the neuronal level, the positive emotions enhanced reward-related neuronal activity, promoted goal-directed (motivated) behaviours 24 and sustained motivational attention 25, which are powerful factors for successful learning. Finally, collegiality or team-based learning, which is also one of the principals of The Move, was shown to promote learning of neuroscience in medical students 26.
Neurology is frequently considered by medical students as one of the most difficult specialties, mostly due to its complex semiology. Neurophobia impairs both their performance in the examination of neurological patients and their desire to consider neurology as a future career path. Poor undergraduate teaching has been shown as one of the modifiable factors of neurophobia and team-based learning has been promoted as one of the possible solutions.

The Move also belongs to a broad category of simulation-based learning, which contains valuable tools for neurological education. However, simulation has to date mostly been used in neurology to learn technical skills such as lumbar puncture or to improve medical reasoning for complicated cases.

In the 19th century, Jean-Martin Charcot made an important contribution to education in neurology by changing abstract teaching into concrete teaching by putting his patients on stage during the lecture. At the very same place, we implemented the learner-friendly program The Move at the medical school. To make it fun and modern, we used some of the staging elements of the well-known TV show The Voice (such as teams, battles, coaches, and performing in front of a jury). Although we did not specifically compare the long-term perception of neurology between participants and non-participants, we suggest that The Move not only improves neurological education at early stages of clinical training, but might also help overcome neurophobia in medical students.

Conclusions and perspectives

The long-term effectiveness of teaching interventions and their evaluation is crucial but rarely addressed in medical education. We have previously shown that participating in The Move, a mime-based role-play program, was a satisfying experience for medical students and might thereby help prevent neurophobia. Here, we showed a positive effect of The Move on long-term memorization of neurological semiology, which might improve the clinical proficiency of future physicians and promote conscientious and judicious patient care.

References:


11. Dickson KA, Stephens BW. It's all in the mime: Actions speak louder than words when teaching the cranial nerves. Anatomical sciences education 2015;8:584-592.


22. St-Onge C, Martineau B, Harvey A, Bergeron L, Mamede S, Rikers R. From see one do one, to see a good one do a better one: learning physical examination skills through peer observation. Teaching and learning in medicine 2013;25:195-200.


Figure 1. Flow chart of the study

1. Intention to teach analysis

   - Class 2013
     - n = 377
     - Standard neurological semiology training
     - Semiology test
       - n = 366
     - Standard education group
       - n = 366

   - Class 2015
     - n = 391
     - Standard neurological semiology training
     - Semiology test
       - n = 366
     - Standard education group
       - n = 86
     - The Move group
       - n = 186

   Per-protocol analysis

   30 months

   2013
   2015
   2017
Table 1. Mean test scores in compared groups of students.
SD: standard deviation; 95% CI: 95% confidence interval; NA: not applicable;
* Adjusted on the general semiology score

<table>
<thead>
<tr>
<th></th>
<th>2013 class (n=366)</th>
<th>2015 class (n=272)</th>
<th>Crude difference [95% CI]</th>
<th>Adjusted difference* [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neurological semiology</strong></td>
<td>7.46/15 (SD 2.27)</td>
<td>7.98/15 (SD 2.59)</td>
<td>+0.52/15 [+0.14, +0.90]</td>
<td>+0.25/15 [+0.08, +0.42]</td>
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<tr>
<td><strong>General semiology</strong></td>
<td>4.47/10 (SD 1.23)</td>
<td>4.49/10 (SD 1.36)</td>
<td>+0.02/10 [-0.18, +0.22]</td>
<td>NA</td>
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</tbody>
</table>

**Per-protocol analysis**

<table>
<thead>
<tr>
<th></th>
<th>Standard teaching group (n= 447)</th>
<th>The Move group (n = 186)</th>
<th>Crude difference [95% CI]</th>
<th>Adjusted difference* [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neurological semiology</strong></td>
<td>7.37/15 (SD 2.34)</td>
<td>8.48/15 (SD 2.44)</td>
<td>+1.11/15 [+0.70, +1.51]</td>
<td>+0.94/15 [+0.58, +1.30]</td>
</tr>
<tr>
<td><strong>General semiology</strong></td>
<td>4.43/10 (SD 1.27)</td>
<td>4.62/10 (SD 1.32)</td>
<td>+0.19/10 [-0.03, +0.41]</td>
<td>NA</td>
</tr>
</tbody>
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