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Original article

Teaching neuroanatomy through a memorable Olympic race

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SUMMARY

Objective

The year 2020 marks the 40th anniversary of a sporting event that is remembered as one of the greatest comebacks in Olympic sprinting: Pietro Mennea's gold medal in the 200m race at the 1980 Moscow Olympics. Mennea described his own performance as "a great psychological victory, more than physical". In line with Mennea's account, brain surgeon Giulio Maira dedicated a section of his newly published book ('The brain is wider than the sky', 2019) to the activity of Mennea's brain throughout the race, focusing on the activity of 19 key neuroanatomical regions before, during, and after the race.

Methods

The English adaptation of Maira's text was presented to postgraduate students at the end of a teaching session on neuroanatomy. The 39 occurrences of the 19 key neuroanatomical terms were removed, so that the students were provided with a text format suitable for an educational game. First, the students were introduced to the activity while watching a short videoclip of the thrilling 200 m Olympic final race. Then, the students were asked to fill the gaps in Maira's narration by inserting the missing neuroanatomical terms, based on the contents of the neuroanatomy lecture. One point was assigned for each neuroanatomical term that was correctly identified, with scores ranging from 0 to 39.

Results

A total of 16 psychiatry trainees actively participated in the educational game, which took about 30 minutes to complete. Student engagement was high, with a wide distribution of scores (mean 14.75; range 5-22). The feedback from the participants was overall positive: the educational value of the game was rated 8.50/10 (range 6-10) on a scale from 1 (lowest value) to 10 (highest value). All students recommended the addition of this activity to the postgraduate training curriculum, and reported that the game increased their interest in neuroanatomy.

Conclusions

The combination of a short, but memorable, video clip and an original educational game at the end of a neuroanatomy teaching session made the learning experience of psychiatry trainees more engaging and enjoyable. Linking neuroanatomical knowledge to the brain activity of an outstanding athlete, who recognised the role of his mind in his achievements, proved both educational and inspirational.

Key words: educational games, neuroanatomy, psychiatry, teaching, training

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Conflict of interest
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Introduction

The year 2020 marks the 40th anniversary of a sporting event that is remembered as one of the greatest comebacks in Olympic sprinting: Pietro Mennea's gold medal in the 200 m race at the 1980 Moscow Olympics [1]. In the 200 m final, Mennea (in lane 8) faced, among others, the third-fastest man in history and reigning champion, Don Quarrie (in lane 4), the fast-

TABLE I. *Results of the 200 metre final at the 1980 Moscow Olympics.*

Athlete	Time
Pietro Mennea	20.19 (gold medal)
Alan Wells	20.21 (silver medal)
Don Quarrie	20.29 (bronze medal)
Silvio Leonard	20.30
Bernhard Hoff	20.50
Leszek Dunecki	20.68
Marian Woronin	20.81
Osvaldo Lara	21.19

est man in the world from 1977, Silvio Leonard (in lane 1), and the newly crowned 100 m champion Allan Wells (in lane 7). Wells got out to a blistering fast start and was ahead of Mennea within the first 50 metres. Coming off the turn, Mennea was at least two metres back, behind all his main competitors, including Wells, Quarrie, and Leonard. Mennea accelerated down the straight, edging closer to them with every step. Towards the end of the straight, Mennea irresistibly gained ground and passed both Quarrie and Leonard. He caught Wells five metres before the finish and continued past him on the finish line, winning the gold by a mere 0.02 seconds. The winner's time was 20.19 (Tab. I).

At the time, Mennea (Fig. 1) was the standing world record holder: ten months earlier, in Mexico City, he had run the 200 m in 19.72, a time that stood for almost 17 years as world record (the longest duration in the event history) and is still unbeaten after over 40 years as European record [2,3]. In his exceptionally long career, Mennea competed in a total of five Olympics (1972, 1976, 1980, 1984, 1988), qualifying for the 200 m final in the first four of them – the first track athlete ever to do so. Mennea's accomplishments include academic achievements, as he went on to earn four university degrees: in Political Science, Law, Physical Education, and Literature. In 1997, Asteroid 73891 Pietromennea was named in his honour.

Methods

Contrary to endurance, comebacks are relatively rare occurrences in sprint running, for several reasons. Performances across top athletes differ by fractions of seconds and winning times do not tend to exceed 10 seconds (in 100 m races) or 20 seconds (in 200 m races). By the time an athlete has been overtaken by a few metres, there is simply no time left for a comeback in the remaining distance within such a short timeframe. There have been suggestions that Mennea's exceptional brain played a key role in his unexpected 200 m final comeback. Mennea's comments on his performance were as follows: "This is a great psychological victory, more than physical. It had to do with what's inside. Coming down that final stretch, I wanted to win. I wanted it very badly" [4].

These comments might have been of interest to brain surgeon Giulio Maira, who dedicated a section of his newly published book ('The brain is wider than the sky', 2019) to Mennea's 200 m Olympic race or, more precisely, to the activity of Mennea's brain throughout the race [5]. In four dense pages, Maira details the role purportedly played by the main components of Mennea's brain during the twenty seconds that spanned the athlete's outstanding performance, from when he bent on the starting blocks waiting for the starting signal to the moment he crossed the finish line in first position. In this passage, 19 key neuroanatomical regions are mentioned 39 times in total. Specifically, the motor cortex, the prefrontal cortex, and the visual cortex are

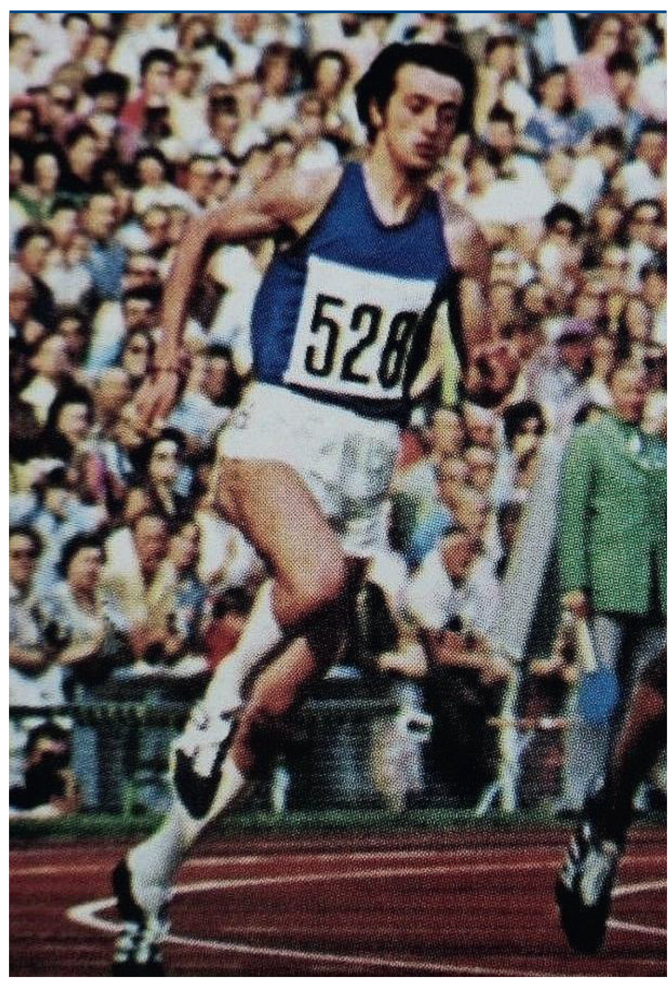

FIGURE 1. *Pietro Paolo Mennea (1952-2013).*

mentioned 5 times each. The amygdala is mentioned 4 times. The cerebellum and the retina are mentioned 3 times each. The hippocampus is mentioned twice. Finally, the auditory cortex, the basal ganglia, the frontal cortex, the limbic system, the nucleus accumbens, the optic nerves, the parietal cortex, the proprioceptive system, the spinal cord, the temporal cortex, the thalamus, and the vestibular system are mentioned once each.

Moscow Olympic stadium, July 28th 1980, just after 8 pm

An Olympic stadium, a red athletics track, tens of thousands of people screaming with excitement for a show that promises to be thrilling. From their homes, all over the world, millions of people are anxiously waiting in front of their television screens.

On the track there are eight men, bent on the blocks, waiting for the start of the race: they will run the 200 m final.

*In the far right lane, the eight one, there is an athlete wearing a blue shirt. With tension, he looks around at his opponents and, unwillingly, sees in his mind all his previous races, all the months spent training, all the efforts that led him there. His **hippocampus,** the memory centre, is working hard and has a continuous dialogue with the thalamus and with cortical areas to retrieve the memories of many years.*

*His right knee and his hands are on the ground, his eyes forward. In his brain, millions of cells are active: the emotion areas [of the **limbic system**] stimulate the release of adrenaline, the **prefrontal cortex,** the decision-making centre, is ready to activate the cells of the **motor cortex** at the signal to sprint from the blocks. Electrical discharges constantly leave the eyes to convey visual information to the **visual cortex,** while the athlete's gaze continues to shift from the other athletes next to him to the distance that he will have to cover as fast as he can.*

*The photoreceptors located in the **retina** generate a huge number of electrical signals that travel through the **optic nerves** and reach the **thalamus** and the **visual cortex.** From here, the visual information is transferred to the **temporal** and **parietal cortex,** so that what happens on the track is continuously analysed at high speed, and the athlete can activate, when needed, his muscles. The **cerebellum** is ready to coordinate automatic motor patterns stored as procedural memories [in the **basal ganglia**].*

*The **amygdala** is in frantic activity: fear, joy, anxiety, continuous signals to the adrenal gland. The **prefrontal cortex**, the conductor of our brain orchestra, is eager to activate the muscles, but knows that the starting signal will be captured by the **visual** and **auditory cortex,** that will raise the alarm; only then the **prefrontal cortex** will be able to activate the **motor cortex**, as fast as possible, possibly faster than the other athletes. The brain is waiting, ready.*

*At the warning signal, the athlete comes up, his head still down. Finally comes the starting signal. Every component of the brain is now active: as in a giant pinball machine, millions of contacts suddenly light up. These are all the nervous centres that need to be activated so that the running skills can be expressed at their best. The **frontal cortex** receives the auditory signal and plans the starting action, withholding its inhibition over the **motor cortex.** Finally, electrical signals travel down the **spinal cord** to activate the muscles. The **cerebellum** activates to control the coordination of the body movements.*

*As soon as the athlete hears the starting signal, he springs to his feet, stretches his body and starts to run, as always with a delay of a few hundredths of a second compared to the other athletes. He runs in the eight lane, in the most advanced position at the start, apparently ahead of the others. The Scottish athlete in the seventh lane is faster at the start and quickly overtakes him. The **retina**, with its cells that peer into the left hemifield, captures the position of the opponents and sends the information to the **occipital visual cortex**, which processes the retinal images and sends constant messages to the **amygdala**, so that it generates an alarm signal and triggers the release of more adrenaline, as if it were fuel for the engine. Otherwise, the race is lost.*

*The athletes get closer to the bend. The **visual areas,** the **vestibular system**, and the **proprioceptive system** that monitor position, movement, and body posture, register the need to change the race set up. The coordination centres, in the **cerebellum**, signal to the muscles to make the appropriate adjustments: thousands of small corrections are implemented so that the body can maintain its balance. At the end of the bend the brain realises that the other athletes are ahead. On reaching the straight, the athlete is virtually next to last, two-three meters behind the Scottish athlete in the seventh lane who is leading the race.*

*The **amygdala** requires an even more intense effort. The neurotransmitters activate the synapses with increasingly higher frequency so that the legs can increase the pace of their strides. The athlete begins an extraordinary comeback and – in the words of Gianni Brera – 'the ground seems to flee beneath him'.*

*The finish line is getting closer. In the final meters the mind, lacking oxygen, begins to struggle. The brain tells the heart: 'More blood'. 'I can't give you more than this', replies the heart to the brain, 'now it's up to you: you must resist and make it'. 'I'll try', the brain promises. The **prefrontal cortex** knows that the body will have to reach the limits of human capabilities to win, to push beyond what a man and an athlete can do.*

*The **motor cortex** sends continuous impulses to the motor neurons in the spinal cord, so that the muscles activate even more. There is only one man ahead, but the effort is not over: he has to be overtaken. More adrenaline, more discharges of impulses across the brain.*
*While the athlete in blue throws himself onto the finish line, the **retina** takes a final snapshot of the opponents' positions. The **amygdala** explodes with joy as it realizes that now there is no one ahead. With an instinctive movement, the **motor cortex** that controls the movements of the arms activate, and the athlete raises his head and arms towards the sky, pointing above with his index finger. The finish line has been crossed. Dopamine is released, the **nucleus accumbens** (the centre of pleasure) activates, the **hippocampus** stores this moment among the most precious memories, the **prefrontal cortex** signals that the race is over: it's fine to stop now.*
Pietro Mennea has won. His brain is Olympic champion.

This English adaptation of Maira's text (with minor adjustments) was presented to postgraduate students at the end of a teaching session on neuroanatomy. The 39 occurrences of key neuroanatomical terms (in bold) were removed, so that the students were provided with a text format suitable for a quiz game [6]. First, the students were introduced to the activity while watching a short videoclip (about two minutes, including a slow motion replay) of the thrilling 200 m Olympic final race [7]. Then, the students were asked to fill the gaps in Maira's narration by inserting the missing neuroanatomical terms, based on the contents of the neuroanatomy lecture. One point was assigned for each neuroanatomical term that was correctly identified (with its name or equivalent – e.g. visual cortex and visual area), with a total maximum score of 39.

Results

The neuroanatomy quiz game based on Maira's report of Mennea's brain activity during his most celebrated race was piloted during a teaching session that was part of the United Kingdom Royal College of Psychiatrists – Core Training scheme. A total of 16 psychiatry trainees actively participated in the quiz game. The educational activity took about 30 minutes to complete. Student engagement was high, with a wide distribution of scores (mean 14.75; range 5-22). The feedback from the participants was overall positive [6]. The educational value of the game was rated 8.50/10 (range 6-10) on a scale from 1 (lowest value) to 10 (highest value). All students recommended the addition of this activity to the curriculum, and reported that the game increased their interest in neuroanatomy. To the question "how likely are you to integrate this activity into your study habits?" (1, very unlikely; 10, highly likely), the average score was 6.44/10 (range 1-10). To the question "how well does this activity help you to prepare for the exam?" (1, not at all; 10, extremely well), the average score was 7.38/10 (range 5-10). The formative feedback (free text) focused on the suggestion to dedicate more time to this educational activity.

Discussion

Educational games are immersive active learning strategies, which encourage student interaction and increase the time spent 'on task' [8,9]. Moreover, quiz games also provide a 'safe to fail' environment and immediate feedback to the learner [10-12]. By encouraging students to perform at their individual maximum skill level, immediate feedback promotes engagement with the educational material in a different way and decreases the level of faculty member facilitation involved in the learning exercise [10]. The combination of a short, but memorable, video clip and an original quiz game at the end of a neuroanatomy teaching session made the students' learning experience more engaging and enjoyable [13].
Finally, there was something more to this teaching session. Mennea's life is inspiring to say the least. His attitude and commitment to training are a testament to meritocracy, in any field. Mennea explained that "the Olympic gold medal was the fruit of years of hard work […] Talent is not enough to become a world or Olympic champion, you need other qualities […] During my career, I always trained very hard without trying to take the short route to success […] I always trained with a lot of passion and determination and my ambition to succeed has pushed me to the highest results in my sport" [14]. Mennea's legacy is summed up in the words of his last television interview: "My sport history has a deep meaning, because I was not a predestined and I built it through my work. I trained for 5-6 hours per day, every day, including Christmas and New Year's Eve, for almost 20 years. This is how I succeeded where many others have failed" [15]. To the question "If you could go back, would you do the same thing?", Mennea replied "No: instead of 5-6 hours, I would train 8 hours per day – or even more, because that's the secret" [16]. It is therefore not surprising that when Mennea's coach, Carlo Vittori, shared his training schedule at an international meeting, someone commented: "But the person who completed this training is still alive!?!" [17]. Mennea was not exceptionally gifted in his physical structure compared to elite sprinters [18,19]: his height was 1.80 m (5 ft 11 in) and his weight 73 kg (161 lb). However, he understood that his brain could drive him to exceptional results, and his willpower proved it. Sharing his attitude and a few anecdotes about him with the students complements a learning experience that is at once educational and motivational.

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