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The National Undergraduate Neuroanatomy Competition: Five years of educating, inspiring and motivating our future neurologists and neurosurgeons

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SUMMARY

Neurological conditions are common so a knowledge of neuroanatomy is necessary for junior doctors. Additionally, some students have a particular interest in neuroscience. However, little time is dedicated to neuroanatomy in the medical curriculum, and many students struggle with neuroanatomy. The National Undergraduate Neuroanatomy Competition (NUNC) aims to support the development of neuroanatomical knowledge among medical students and promote interest in neurosciences.

Students who attended the NUNC completed a series of neuroanatomy-based examinations and a questionnaire investigating aspects of neuroanatomy teaching and resources at their home university.

387 students attended the NUNC between 2013 and 2017, of which 382 had a complete data set (response rate 98.7%). Male students significantly outperformed female students (p<0.0001) and clinical students outperformed pre-clinical students (p<0.05). Best answered questions were on the spine (average score 53.9%), and the most poorly answered questions were on the vasculature (average score 44.7%). Students felt that the neuroanatomy teaching, time spent on neuroanatomy and dissection/prosection resources were all reasonable (6-7/10) at their home institution. E-learning resources were rated more poorly (5.4/10).

We conclude that the NUNC gives students the opportunity to enhance their neuroanatomical knowledge and gives keen students the chance to develop their interest.

Key words: Anatomy – Undergraduate – Medical education research – Medicine – Conferences

INTRODUCTION

There are three specialties within medicine that rely heavily on a knowledge of neuroanatomy: neurology, neurosurgery and psychiatry (Hazelton, 2011). However, neurological problems are common in routine clinical practice, and the 2014 Association of British Neurologists Acute Neurology service survey quoted that up to 20% of acute medical admissions are due to neurological conditions (Fuller and Lawrence, 2014). Junior doctors will care for these patients as part of general medi-

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cal teams, so it is crucial that they have a strong working knowledge of neuroanatomy in order to be able to confidently assess and care for their patient (Schon et al., 2002). As with all core clinical skills, this confidence should be based on a foundation of basic medical sciences, including anatomy, which are acquired at medical school.

Medical students frequently struggle with neuroanatomy, and the term ‘neurophobia’ was coined by Jozefowicz in 1994 to describe ‘a fear of the neural sciences and clinical neurology that is due to the students’ inability to apply their knowledge of basic sciences to clinical situations’ (Jozefowicz, 1994). The commonest reasons why doctors struggle with neurology are poor teaching and problems relating to neuroanatomy (Schon et al., 2002). This may be compounded by the move towards professionalism-based modern medical curriculum that has resulted in a reduction in time spent on the basic sciences, particularly anatomy (Drake et al., 2009; Sugand et al., 2010; Heylings, 2002). Some educators have had to simplify their teaching of neuroanatomy to focus on conceptual understanding and clinically relevant content, including the basic interpretation of radiological images, rather than finer details (Heylings, 2002; Krontiris-Litowitz, 2008). It is not clear if this is detrimental to an individuals’ ability to practice as a doctor, presuming that they are capable of communicating effectively with other medical professionals (Turney, 2007).

Additional experiences and resources may help improve students’ confidence in clinical neurosciences. In recent years, e-Learning resources have become central to the teaching of anatomy (Van Nuland and Rogers, 2016). These can come in various forms, including online videos, interactive educational packages and quizzes (Lowry et al., 2016; Richardson, 2016; Swinnerton et al., 2017). It has also been shown that these technologies produce notable improvements in knowledge gain compared to traditional paper-based resources (Pickering, 2016). It is also notable that intensive neuroanatomy courses, twenty-eight hours over a four-week period, significantly improve neuroanatomy knowledge and confidence in general practice trainees (Arantes et al., 2017).

The National Undergraduate Neuroanatomy Competition (NUNC) runs annually at the University of Southampton, UK, and consists of two examinations: a neuroanatomical 42-station spotter-style examination, and a 70-minute 60-question clinically-orientated neuroanatomical multiple-choice examination. The NUNC has several aims which include giving medical students with a particular interest in neuroanatomy the opportunity to develop an interest in neuroscience, promote a more extensive knowledge of neuroanatomy beyond that of the typical medical curriculum, and allow students to demonstrate commitment and ability in a particular specialty. Additionally, it is unique in that it permits data collection of student performance and perceptions of neuroanatomy on a national scale. Over the past five years, the NUNC has attracted almost four hundred students from thirty-one of the thirty-three medical schools in the United Kingdom. This paper will review the importance of a national competition to support medical students with an interest in neuroscience, with support from data collected at the NUNC over the past five years.

MATERIALS AND METHODS

Assessment Structure

The NUNC includes two separate examinations conducted under standard University examination conditions. The first is a forty-two-station anatomy spotter which tests students’ ability to identify neuroanatomical structures on dissected human brains. Each station consists of two questions (*a* and *b*) for which competitors are allowed one minute to answer before moving on to the next station. All spotter dissections were prepared by medical students in collaboration with anatomists and clinicians from the Centre for Learning Anatomical Sciences at the University of Southampton. Examples of recent spotter questions are as follows:

Q: Identify this white matter tract specifically (pinned). Answer: Cingulum.

Q: Identify this gyrus specifically (pinned). Answer: Supramarginal Gyrus.

The second examination is a seventy-minute, sixty-question one-best-answer multiple choice question (MCQ) paper aimed at testing students’ clinical application of neuroanatomy. An example of a recent MCQ question is as follows:

Q: Which part of the limbic system is most strongly associated with addictive behaviour? a. Amygdala b. Fornix c. Hippocampus d. Mammillary Body e. Nucleus Accumbens. Answer: e, Nucleus Accumbens.

Typically, 6/42 (14.3%) of questions in our neuroanatomy spotter are image-based. Since 2015, the spotter and MCQ questions have been based on a published neuroanatomy syllabus (Moxham et al., 2015), but also contain extracurricular components at the organisers’ discretion based on their experience of clinically important knowledge. For examinations prior to the publication of this neuroanatomy syllabus, questions were retrospectively mapped to the syllabus (Hall et al., 2016a).

All students undertook both examinations, and scores from both examinations were collated with equal weighting to give each student an overall mark. Students were grouped into either a pre-clinical or a clinical category based on whether they had commenced full-time clinical placements at their host institution. As a result, there was one winner and one runner up in both the pre-clinical and clinical category each year.

Standard Setting Procedures

The questions for these papers are written by a team of students, Faculty members and clinicians based on guidelines for writing MCQs (National Board of Medical Examiners, 2002). Questions for both the spotter and MCQ were peer-reviewed within the team for accuracy and consistency. All questions were validated using a modified mixed percentage method whereby questions were selected to discriminate amongst the top-scoring competitors, as well as to eliminate a ceiling effect (Hall et al., 2016b). The questions were rated for difficulty (easy, moderate, hard or very hard), neuroanatomical sub-topic (cerebrum, cerebellum, brainstem/cranial nerves, diencephalon, vascular, spine, other) and whether the content was intra- or extra-curricular (based on the Southampton syllabus) to ensure an even distribution of questions. In total, seven hundred and twenty-two questions were asked between 2013 and 2017 NUNC. The final draft of the papers was quality assured by external representatives from both the Anatomical Society of Great Britain and Ireland and Royal College of Surgeons Edinburgh. No students involved in the organising of the competition were allowed to compete.

Questionnaire

Upon completion of the 2016 and 2017 competitions, each student completed a 17-question Likert style questionnaire (appendix 1). This questionnaire asked students to rate various aspects of anatomy teaching at their home university including their perspectives on neuroanatomy teaching, e-Learning resources, amount of time spent of neuroanatomy, and the quality of dissections/ prosections. Furthermore, students were also asked to rate their confidence in applying their neuroanatomy knowledge to understand findings from clinical examinations and medical imaging. To test for reliability a Cronbach's a test was performed for the above four items over the two years (a = 0.79), response rate 97.6%, n=201. The evolving nature of the questionnaire made it unsuitable for a complete and comprehensive analysis. Additionally, for the first four years of the NUNC, we asked students how many hours they spent preparing for the competition (0, 1-3, 4-6, 7-10, 10+ hours).

Student demographics including age, gender, university and year of study were collected during the online registration process. Examination performance was added to a database alongside the above data.

Statistical Analysis

Performance and feedback responses were compared using descriptive statistics and unpaired t-tests or Mann-Whitney U as appropriate. Statistical significance was set at p<0.05. All statistical tests were performed on GraphPad Prism, version 6 (GraphPad Software, La Jolla, CA).

Ethical Approval

This research received ethical approval from the University of Southampton Faculty of medicine ethics committee. Ethics ID: 9351.

RESULTS

NUNC Demographics and Performance Data

Three hundred and eighty-seven students attended the NUNC between 2013 and 2017. Of these, three hundred and eighty-two (98.7%) had a complete data set of examination performance data (Fig. 1). The questionnaire was distributed in NUNC 2016 and 2017 only, with 202 completed responses from 207 delegates (response rate 97.6%).

Of the 387 attendees, 336 stated their gender (86.8%) and of these 215 (63.9%) were male. The male medical students performed significantly higher overall than the female students (52.8% ±16.5 vs 45.4%±15.39, p<0.0001). The medical students who identified themselves as aspiring to enter a neuroscience based specialty (neurology, neurosurgery and psychiatry, n=210), performed significantly better overall than those without a neuroscience focus (52.8%±15.6 vs 47.3%±16.4, p=0.0009). Clinical students performed significantly better overall than pre-clinical students (44.8% ±1.7 vs 39.7%±1.2, p=0.0025) with significantly higher scores MCQ examination (48.7%±1.2 vs 42.3%±1.3, p=0.0004) but no significant differences in the spotter (41.0%±1.3 vs 37.3%±1.4, p=0.06).

From the 242 students who attended in the first four years of the NUNC, we found that most students spend 10+ hours preparing for the competition. (0 hours = 6% (n=15), 1-3 hours = 19% (n=47), 4-6 hours = 23% (n=55), 7-10 hours = 19% (n=46), 10+ hours = 33% (n=79)).

Of the students with a complete data set, we found that one hundred and thirty-two (34.6%) attended a London University and two hundred and fifty attended a University outside of London (Fig. 2). The overall examination score of students from

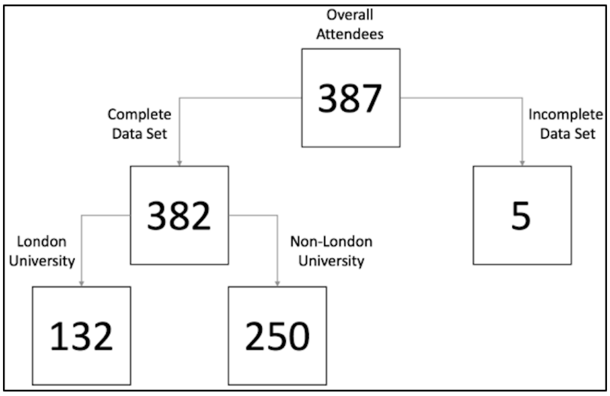

Fig 1. NUNC demographics and performance data.

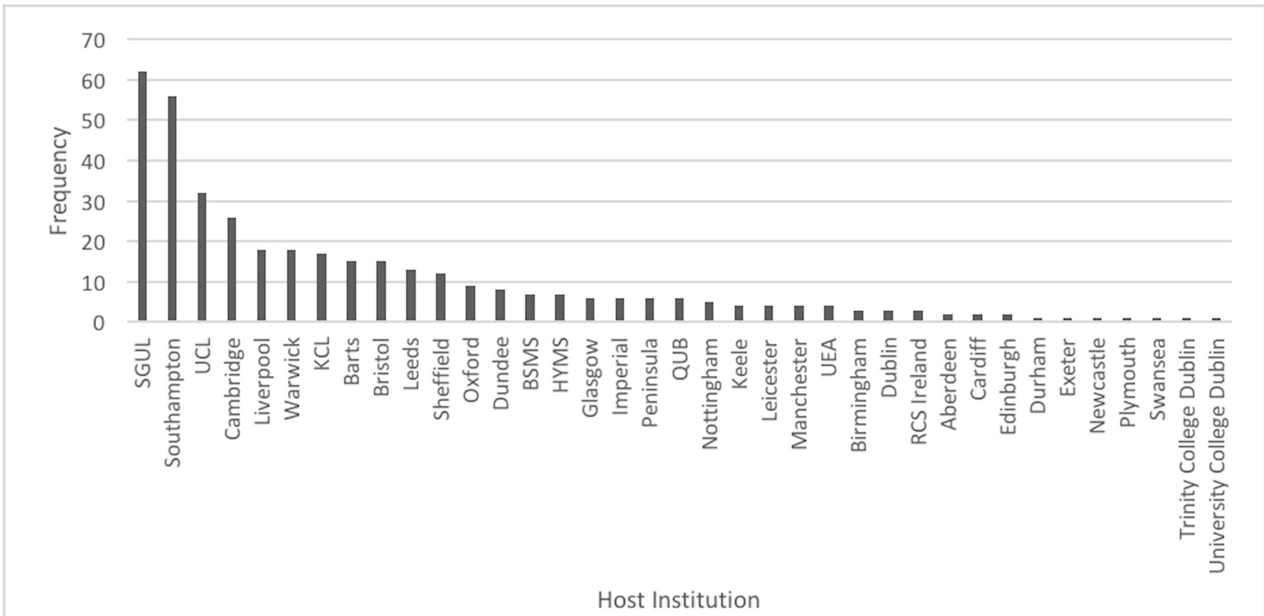

Fig 2. Distribution of the students with a complete data set by Universities.

a London university was significantly higher than students from non-London universities, 49.1% ±17.6 vs 39.0%±14.6 (p<0.0001).

Table 1. A summary of performance particular subtopic (percentage of correct answers) for the MCQ and Spotter examinations both individually and combined.

Subtopic	MCQ	Spotter	MCQ + Spotter Combined
Spine	53.84	54.21	53.90
Other	56.32	51.45	53.24
Diencephalon	57.79	46.96	51.84
Brainstem/CN	52.54	42.29	47.81
Cerebrum	55.87	42.44	46.04
Cerebellum	51.21	40.60	45.34
Vascular	45.23	44.49	44.70

Table 2. Prize winners from each competition from 2013 to 2017. For each competition, there was one winner and one runner up for both the clinical and pre-clinical category.

Year	Category	Winner	Runner Up
2013	Pre-Clinical	Barts and the London	UCL
	Clinical	UCL	Nottingham
2014	Pre-Clinical	St. Georges	Southampton
	Clinical	UCL	Liverpool
2015	Pre-Clinical	Hull York	St. Georges
	Clinical	St. Georges	St. Georges
2016	Pre-Clinical	Dundee	St. Georges
	Clinical	St. Georges	Manchester
2017	Pre-Clinical	St. Georges	Cambridge
	Clinical	Southampton	Cambridge

Of the twenty prize-winners from the NUNC between 2013 and 2017, 11 were from a London institution (55.0%). Specifically, seven (35.0%) were from St. Georges University London, three (15.0%) were from University College London, two (10.0%) from Southampton and Cambridge and one (5.0%) each from Barts and the London, Nottingham, Liverpool, Hull York, Dundee and Manchester (Table 2).

Subtopic Data

When the MCQ and spotter examinations are combined, the subtopic with the highest percentage of correct responses was spine at 53.9%, and the worst was vascular at 44.7% (Table 1).

Questionnaire

On average, students rated the neuroanatomy teaching at their home institution as 6.8 out of 10 (0=poor, 10=excellent), with no significant difference between London and non-London students (7.2 vs 6.6, p=0.13). When asked whether they felt enough time was committed to neuroanatomy at their home institution, students gave an average score of 6.0 out of 10 (0=definitely not, 10= definitely yes). When investigating the quality of teaching approaches, students scored their dissection/ prosection and e-learning resources as 6.6 and 5.2 out of 10 respectively (0=poor, 10=excellent). When asking about confidence in applying their neuroanatomical knowledge to examination findings and to interpret imaging, students scored 6.6 and 6.4 out of 10 respectively (0=low confidence, 10=high confidence).

DISCUSSION

Medical students should have an understanding of neuroanatomy to allow them to safely care for neurological patients in their future clinical practice (Schon et al., 2002), and neuroanatomy is often taught in the second year of medical school. Furthermore, some students have an interest in neuroscience and should be given the opportunity to develop this in the hope of inspiring the future generations of neurologists and neurosurgeons. Given that three hundred and eighty-seven students attended the NUNC over a five-year period, it is clear that there are still students who are enthused and engaged by neuroanatomy despite cuts to the time spent on neuroanatomy education and resources. In fact, in the first four years of the NUNC, most students spent over ten hours preparing for the competition. Positively, these results do imply that not all students experience 'neurophobia' during their time at medical school. Further exploration into how and why these students were unaffected by neurophobia may help shed some light on possible preventative measures. Given the reduction in time spent on neuroanatomy in the modern medical curriculum (Drake et al., 2009), the NUNC helps to fill this educational void and encourages students to develop an interest in the neurosciences that may otherwise be more challenging during medical school. As a result of an evolving curriculum, the NUNC may play a role in maintaining standards in neuroanatomy among our future neurologists and neurosurgeons in the UK.

One key feature of the success of the NUNC is the student partnership approach. Students and faculty work together to organise and run this competition, and this has a number of advantages. One advantage is that medical students have recently themselves been taught neuroanatomy at medical school, and given their particular interest in the topic, may be well suited to advising on how to best challenge and develop neuroanatomical knowledge in other medical students. Although viewed as good practice by the Higher Education Academy (Healey et al., 2014), the partnership model does challenge the existing ways in which students and staff work together, and is a potential obstacle in the development of innovative initiatives like the NUNC (Border, 2017).

Benefits of the NUNC to the competitors

It is important that medical students are given the opportunity to consider and prepare for their future careers during medical school. There are three main neuroscience-based clinical specialties: neurology, neurosurgery and psychiatry. These neuroscience based specialties tend to be male dominated professions (Jagsi et al., 2014), so it was of little surprise to have more male participants attending the NUNC. Male students have significantly outperformed female students in the competition to date. Reasons for this are unknown but sex differences in spatial abilities favouring males have been previously described in the cognitive psychology literature (Maccoby and Jacklin, 1974; Peters et al., 2007; Vorstenbosch et al., 2013). This may go some way to explaining the difference, but would only relate to differences in performance in the spotter element due to the requirement of interpreting three-dimensional brain structures. It is possible that males outperform females simply because they are more likely to have an interest in neuroanatomy which is founded in their studies. Supporting this, students who are actively interested in neuroanatomy have traditionally performed better in the NUNC (Hall et al., 2014). Interestingly, a number of non-neuroscience enthusiasts have frequently attended NUNC over the years, possibly due to a general lack of opportunity of national competitions for medical students in the UK (Hall et al., 2014).

As students get closer to graduation, foundation programme applications become more important and therefore students are possibly more likely to try to enhance their portfolios. Additionally, neuroanatomy is typically taught in the second year of medical school, providing a core understanding of the basic science that will continue to be developed and built upon during later clinical studies (Leveritt et al., 2016; Papa and Vaccarezza, 2013). It is therefore unsurprising that we found clinical students significantly outperformed pre-clinical students. It would be assumed that most preclinical students who attend the NUNC have recently had it taught to them (given that very few first years attended). It is therefore also unsurprising that there was no difference in performance between clinical and preclinical students in the spotter. However, it has been documented that clinical students typically forget a large portion of the basic science they were taught at in pre-clinical years (Ling et al., 2008; Custers, 2010), although our results do suggest that clinical students retain their basic preclinical neuroanatomical knowledge throughout their clinical studies. It is possible that this phenomenon has not been identified in the NUNC because of a particular interest in the topic. In the traditional medical curriculum, students are unlikely to encounter complex clinical neuroscience until full time clinical study. However, the growing popularity of an integrated modern curriculum may explain why pre-clinical students are performing similarly to clinical students (Al-Hazimi et al., 2004). In our spotter examination, approximately 15% of our questions are imaging based. The interpretation of imaging is an important application of anatomy in clinical medicine that junior doctors will be expected to develop. Clinical experience is only likely to impact performance on the MCQ paper as this is a clinically orientated problem-solving paper. Accordingly, we found that clinical students also performed significantly better in this assessment, given that they have clinical experiences of neuroscience specialties to draw upon, unlike preclinical students. Therefore, a major attribute of the NUNC is that it promotes vertical integration of neuroanatomy which is not always achieved effectively in medical curriculums; the bringing together of clinical and pre-clinical students in the same educational environment is thereby promoting the preservation of neuroanatomical knowledge beyond pre-clinical years for those who attend.

A role for the NUNC in maintaining standards in neuroanatomy

Given the limited amount of time spent on neuroanatomy at medical school, it is pleasing to find that students were reasonably satisfied with the amount of curriculum time dedicated to neuroanatomy at their home institutions (Drake et al., 2009) However, it is unclear if this is enough time for students who wish to pursue a particular interest in the topic. Whillier and Lystad (2013) found that increasing the duration of a neuroanatomy course significantly improved satisfaction. It is possible that further reductions in the course duration may decrease interest in the specialty. A key feature of the NUNC is that it encourages students to spend more time on their neuroanatomy in preparation for the competition, as highlighted in our results. Given that the scope of questions in the NUNC extends beyond the typical medial curriculum, it may also encourage competitors to study neuroanatomy in more detail than they have previously. This is important if we aim to produce motivated and talented neuro-enthusiasts to apply for future jobs in neurology and neurosurgery. On a more basic level, this may help other competitors recap their neuroanatomy in preparation for graduation and beginning foundation training, which, as already mentioned, is important given the frequency of neurological conditions and the role of junior doctors in general medical teams.

Advancing neuroanatomy practices in future clinical practice

We found that students rated themselves as reasonably confident at using their neuroanatomical knowledge to interpret clinical examination findings and radiology. It has been shown that both medical students (Ward et al., 2002) and doctors (Minter et al., 2005) do not accurately self-assess their abilities (Hall et al., 2016a). It is also known that high-achieving medical students often underestimate their abilities (Edwards et al., 2003; Blanch-Hartigan, 2011). How, or even if, these traits translate into better academic performance is yet to be determined. At the NUNC, we commonly have at least one clinical speaker deliver a talk. In 2017, the Associate Dean of medicine for education at the University of Southampton Professor Karen Morrison delivered a talk on ‘Clinical Neurology: What do Medical Students Need to Know?’ Talks such as these may help offer transparency of the subject among medical students, and the NUNC is an opportunity for these types of talks to be delivered to a nationwide audience.

Recently, we have run the first postgraduate neuroanatomy competition aimed at junior doctors with a particular interest in neuroanatomy. It is hoped that data collected during this event in future years will be able to recommend changes in undergraduate neuroanatomy education according to what junior doctors feel is important and relevant. This event may also help us improve the NUNC in the future by identifying key areas that we are not currently targeting, and highlighting how to add educational value. A significant difference between the NUNC and the postgraduate competition is the inclusion of a dedicated neuroimaging spotter examination. An appreciation of how well junior doctors perform on this examination will inform us on the effectiveness of basic clinically-orientated neuroanatomy. This knowledge may help us to identify topics that are important for junior doctors but not well understood so that interventions can be provided to medical students on these topics.

Impact of neuroanatomy education on performance

One possible contributor to neurophobia is the availability and quality of teaching resources (Schon et al., 2002). In our questionnaire, we asked competitors to rate their dissection/ prosection resources and e-learning. We found that students on average rated their dissection/ prosection resources at 6.6/10. The benefits of dissection over prosection has been a long running debate within the UK and USA, and has resulted in the decrease in popularity of dissection-based learning in UK medical schools (Ali et al., 2015). There is evidence to suggest that dissection does not suit the learning preferences of all medical students, although it may be of some benefit to students at the NUNC (Dissabandara et al., 2015) since many of the NUNC specimens were intricate deep dissections and not classic midline slices. Supporting this, Rae et al. found that a one-hour brain dissection course for medical students significantly improved retention in those who participated in dissection compared to those who did not (Rae et al., 2016). Both surgeons and medical students highly value the use of anatomy demonstrations in learning anatomy (Sheikh et al., 2016; Finkelstein et al., 2001; Davis et al., 2014). It is therefore possible that exposure to more complicated neuroanatomical dissections may be a valuable learning experience for those with an interest in neuroanatomy. This opportunity may act as a substitute for dissection for those students with an interest but who have not been given the opportunity at their home institution. A possible addition to the NUNC in future would be to offer more extensive feedback by allowing delegates to view the neuroanatomical specimens following the examinations.

E-Learning materials have become more accessible and are more commonly being incorporated into the undergraduate medical curriculum to compensate for reduced face-to-face curriculum time (Van Nuland and Rogers, 2016; Choules, 2007). It was therefore surprising to find that students rated the e-learning resources at their home institution relatively poorly (5.2/10). Although there is no evidence that watching educational videos improve anatomy examination scores (Mahmud et al., 2011), Pickering (2016) found that screencasts in anatomy do have a positive influence on examination scores as they improve short term knowledge retention (van Merrienboer and Sweller, 2005). The effectiveness of these resources can be tied in with the cognitive theory of multimedia learning which is firmly grounded in the educational literature (Mayer and Moreno, 2003). Increasingly, medical students are becoming involved in producing such education videos, which has been aided by platforms such as YouTube. Groups such as Soton Brain Hub and Geeky Medics produce popular bitesize videos that can help fellow medical students better understand somewhat complicated topics.

Benefits of the NUNC to the local institution

It is of note that the NUNC has driven up the quality of resources in neuroanatomy at the University of Southampton. This includes e-learning resources as detailed above, but also neuroanatomical dissections and experienced neuroanatomy near-peer teachers. The neuroanatomical specimens will be used to facilitate understanding of neuroanatomy in the new taught master's programme in neuroscience at the University of Southampton. Furthermore, these specimens have been used as a resource for education by our local neurologists and neurosurgeons which encouraged discussion and feedback on the teaching of neuroanatomy and the use of specimens. This is not only educational for the clinicians, but also provides quality-assurance for our examination and allows us to discuss the clinical relevance of neuroanatomical structures with clinicians. This type of collaboration between academics and clinicians is crucial to ensure undergraduates are being taught the appropriate material in their studies. Furthermore, this helps build a relationship with the hospital trust that may be supportive of future endeavours.

Impact of the NUNC on educational practices

It is important that educators know which subtopics to target when teaching neuroanatomy. Therefore, in our cohort we also investigated the performance in particular subtopics of neuroanatomy. We found that questions on spine and 'other' (typically ventricular system and meninges) were most commonly answered correctly, while vascular and cerebellum questions were answered the poorest. There was relatively little variation between the average score of each subtopic, suggesting that there is no distinct area of deficit in neuroanatomy teaching in those medical schools represented in the NUNC. Nonetheless, average scores were relatively low. While our cohort probably reflects the elite performers in neuroanatomy throughout the UK, it is likely that difficult areas will be similar for the average student. A possible explanation for a high proportion of correct answers on the spine may be that there are a relatively limited number of gross anatomical structures that can be pinned on the spinal cord, and a great deal of the complexity of this structure comes instead from functional anatomy which is not assessed in the NUNC spotter (Schoenen, 1991). Furthermore, the spine is commonly taught in detail along with spinal nerves, dermatomes, myotomes and reflexes throughout the early years of medical school, which may support a better understanding of spine anatomy. Similarly, for meninges and the ventricular system, there are a relatively limited number of questions that could be asked that extend significantly beyond the medical curriculum. Despite this, students typically struggled with vascular anatomy which is surprising given its significant clinical relevance for conditions such as stroke and aneurysm (Portegies et al., 2016). Furthermore, the three-dimensional representations of the cerebral vasculature are small, complex and variable and so may no longer be taught to medical students (Nowinski et al., 2009). It is possible that this difficulty may be partly attributed to the vast detail of the cerebral vasculature, much of which will fall outside of the medical curriculum (Prince and Ahn, 2013). At Southampton, the details of some of the cerebral vasculature have been reclassified from Moxham's allocation of 'core' to 'good to know', meaning it is not compulsory learning for students. It is likely that this trend is reflected across much of the UK. This may also be true for the cerebellum, a structure that is seldom studied in great detail anymore in modern curriculums. Nonetheless, a core understanding of these structures is useful for junior doctors to confidently care for their patients. The NUNC gives students the opportunity to visualise and consider these areas of anatomy that may not be experienced during medical school, which again helps students to challenge their neuroanatomical knowledge.

Limitations

It should be noted that students self-select for NUNC, meaning they choose to attend the event and receive no direct benefit from their home universities for doing so. This will result in a cohort with presumably higher than average neuroanatomy knowledge, and thus will not reflect the general medical student population. Their outlook on their university's neuroanatomy resources however may be confounded by their positive feelings towards the subject and not representative of all of the students at their university. Furthermore, differences in curriculum structure between medical schools may favour some students over others, for example those students from institutions where neuroanatomy is taught through dissection or have a longer period of curriculum time dedicated to it.

Furthermore, we acknowledge that our form of assessment differs from that of typical medical school examinations. For example, many medical schools combine neuroanatomy with head and neck anatomy, and some have no spotter examinations. As the examinations are therefore not entirely comparable, it is possible that some students who perform well in our competition may not perform as well in their medical school curriculum, and vice versa.

We conclude that the NUNC offers students the opportunity to enhance their neuroanatomical knowledge, develop an interest in the neurosciences, and demonstrate commitment and ability to a particular specialty. The benefits of NUNC are multiple, but our results show that a sample of enthusiastic students from a range of medical schools generally perform well in a neuroanatomy competition and rate their neuroanatomy teaching highly. The NUNC is an important addition to neuroanatomy in the UK, and continues to offer a unique opportunity to study neuroanatomy in a level of detail that has been phased out of the typical modern medical curriculum. It is important that we adapt the NUNC to meet the needs of interested students and fill the void left by a reduction in the time spent on neuroanatomy in the typical medical curriculum. As such, future improvements to the NUNC include dedicated time for examination feedback and discussion, a greater emphasis on neuroimaging and possibly hands-on activities. We have unearthed some possible issues in neuroanatomy education within the UK including a poor perception of e-learning resources. However, further study is required into the teaching needs within neuroanatomy throughout the UK to make evidence-based suggestions that will improve nationwide neuroanatomy teaching.

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Appendix 1. Likert style questionnaire model completed by the students in the NUNC 2016

Medicine

UNIVERSITY OF Southampton

Competition ID number:

National Undergraduate Neuroanatomy Competition 2016

Please complete this questionnaire and hand it back to one of the marshalls

1) In which specialty do you wish to work in the future (tick the most applicable)?

Neurology	Neurosurgery	Other surgery	Undecided	Other

Other (please specify)______________________________________

2) How do you rate neuroanatomy teaching at your own institution? (1 = poor, 10 = excellent)

1	2	3	4	5	6	7	8	9	10

3) Do you think there is enough curriculum time dedicated to learning neuroanatomy at your own institution? (1 = definitely not, 10 = definitely yes)

1	2	3	4	5	6	7	8	9	10

4) How would you rate neuroanatomical learning resources at your own institution? (1 = poor, 10 = excellent

- Human tissue prosection/dissection

1	2	3	4	5	6	7	8	9	10

- eLearning packages

1	2	3	4	5	6	7	8	9	10

5) How daunting do you find learning neuroanatomy? (1 = little, 10 = a lot)

1	2	3	4	5	6	7	8	9	10

6) Select the ONE neuroanatomical topic that you find MOST difficult?

Cranial nerves/brainstem	Cerebellum	Cerebrum	Diencephalon	Vascular	Spinal tracts

7) Select the ONE neuroanatomical topic that you find easiest?

Cranial nerves/brainstem	Cerebellum	Cerebrum	Diencephalon	Vascular	Spinal tracts

8) How much do you enjoy learning neuroanatomy? (1 = not at all, 10 = a lot)

1	2	3	4	5	6	7	8	9	10

9) How important do you think neuroanatomy knowledge is in clinical medicine/surgery? (1 = not important at all, 10 = very important)

1	2	3	4	5	6	7	8	9	10

10) How confident are you in your level of neuroanatomy knowledge? (0= not confident, 10 = very confident)

1	2	3	4	5	6	7	8	9	10

11) How confident are you that your level of neuroanatomy knowledge is sufficient for clinical practice

a. understanding examination findings

1	2	3	4	5	6	7	8	9	10

b. interpreting CT/MRI imaging

1	2	3	4	5	6	7	8	9	10

12) How much did you enjoy the National Undergraduate Neuroanatomy Competition? (1 = not at all, 10 = a lot)

1	2	3	4	5	6	7	8	9	10

13) How many hours did you spend preparing for this competition?

0	1-3	4-6	6-10	10+

14) How would you rate the quality of brain dissections used in the spotter exam? (1 = poor, 10 = best)

1	2	3	4	5	6	7	8	9	10

15) How would you rate the organisation of the event? (1 = poor, 10 = excellent)

1	2	3	4	5	6	7	8	9	10

16) Would you recommend this event to one of your colleagues? Yes / No

If "No", why not?

17) If eligible would you compete again? Yes / No

If "No", why not?

If you would be willing to let us use the above feedback for analysis and research please tick this box ☐