# Can medical students accurately predict their learning? A study comparing perceived and actual performance in neuroanatomy

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Title: Can medical students accurately predict their learning? A study comparing perceived and actual performance in neuroanatomy

Running title: Self-assessment accuracy in neuroanatomy

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Abstract:

It is important that clinicians are able to adequately assess their level of knowledge and competence in order to be safe practitioners of medicine. The medical literature is rife with examples of poor self-assessment accuracy amongst medical students over a range of subjects however this ability in neuroanatomy has yet to be observed. Second year medical students attending neuroanatomy revision sessions at the University of Southampton and the competitors of the National Undergraduate Neuroanatomy Competition (NUNC) were asked to rate their level of knowledge in neuroanatomy. The responses from the former group were compared to performance on a 10 item MCQ examination and the latter group were compared to their performance within the competition. In both cohorts self-assessments of perceived level of knowledge correlated weakly to their performance in their respective objective knowledge assessments (r=0.30 and r=0.41). Within the NUNC this correlation improved when students were instead asked to rate their performance on a specific examination within the competition (spotter, r=0.64; MCQ, r=0.6). Despite its inherent difficulty, medical student self-assessment accuracy in neuroanatomy is comparable to other subjects within the medical curriculum.

Keywords:
Undergraduate Medical Education
Neuroanatomy
Teaching of neuroscience/neuroanatomy

## Introduction

Within the medical curriculum, neuroanatomy is widely regarded as one of the most difficult subjects to master (Kramer and Soley, 2002). The consequences of this include a lack of confidence amongst practitioners at diagnosing and managing neurological disorders which has implications for patient care and safety (Risdale et al., 2007). In order to ensure that standards of knowledge in such topics remain high, it is important that medical students are aware of both their abilities and their limitations.

There are numerous reports in the literature discussing medical student's self-awareness of their knowledge. A variety of methods for determining the level of agreement between self-assessment and performance have been used which concluded that medical students (Ward et al., 2002) and doctors (Minter et al., 2005) have limited awareness of their own abilities when compared to objective outcome measures (Eva and Regehr, 2005). Poor medical student self-assessment has also been demonstrated in anatomy (Sawdon and Finn, 2014), but not specifically for neuroanatomy. A meta-analysis showed that the inaccuracy in self-evaluation trended towards medical students underestimating their abilities (Blanch-Hartigan, 2011).

The lack of accuracy in self-assessment of students' abilities is not consistent across all medical students. One reproducible observation is that high achieving medical students under-estimate their abilities (Edwards et al., 2003; Mattheos et al., 2004; Blanch-Hartigan, 2011). Gender has also been recorded as a variable that affects self-assessment accuracy with female medical students (Lind et al., 2002) and female doctors (Minter, 2005; de Blacam et al., 2012) under-estimating their clinical placement scores and Faculty assessment in surgery respectively.

To the best of our knowledge there are no reports evaluating medical student self-assessment within neuroanatomy. Our aim is to determine which trends, if any, exist within neuroanatomical self-assessment.

**Methods**

Data on the student self-assessment in neuroanatomy performance was collected from two sources within the University of Southampton. The first was from near-peer teaching revision sessions and the second was from the National Undergraduate Neuroanatomy Competition (NUNC).

- Near-peer teaching sessions

Second year medical students on the undergraduate entry, 5 year course at the University of Southampton were invited by email to attend two near-peer teaching sessions run by senior medical students (year 3-final). The sessions were delivered two weeks prior to the neuroanatomy module examinations; the first taught the cranial nerves and the second taught the spinal tracts. Two hundred and forty second year students were invited of which 94 attended the cranial nerve session and 42 attended the spinal tract session. At each teaching session the students were invited to complete a paper based feedback questionnaire which used a 5-point Likert style question asking what they felt their level of general neuroanatomy knowledge was. These questions asked students to rate their knowledge as; very poor, poor, average, good or very good. This question formed part of a larger questionnaire which has been previously validated and used in near-peer teaching research at Southampton (Hall et al., 2013) and has a Cronbach alpha score of 0.84.

The student's level of knowledge was objectively assessed before each teaching session through the use of a paper based quiz, testing the cranial nerves or spinal tracts to match the subject of the teaching. Each quiz comprised 10 multiple choice questions (MCQ) which were standard set for alignment to the University of Southampton curriculum learning outcomes and the core syllabus developed by The Anatomical Society of Great Britain and Ireland (McHanwell et al., 2007). The content validity of the MCQ quizzes was ensured using the Nedelsky method with an expert panel comprising five members, including the Faculty Head and Neck Lead, a neurosurgical trainee, and three senior medical students, from the University of Southampton. Questions were only included if all were in agreement that it was appropriate for a second year medical student using.

- National Undergraduate Neuroanatomy Competition

The NUNC runs annually at the University of Southampton and was attended in 2013, 2014 and 2015 by 32, 59 and 91 medical students respectively from throughout the UK. The demographics of each competitor were collected via the online registration system.

The competition comprised two components; a 42 station spotter using prosected brain specimens (each station had 2 questions) and a 60 item MCQ paper. The former focused on naming topography while the latter evaluated the student's understanding of clinically orientated and functional neuroanatomy. Both components were weighted equally to give a final mark. The MCQ and spotter were validated using a modified Fixed-Percentage Method whereby questions were selected primarily to stretch the top-scoring competitors as well as to eliminate a ceiling effect and allow one best candidate to be selected. The expert panel was the same as for the NPT MCQ above with the addition of a junior doctor. The standard setting procedure did not provide a pass mark since the NUNC was designed to select one overall winner. The final examination papers were reviewed by a consultant neurosurgeon for accuracy. This approach to standard setting produced consistent examinations over three years of NUNC with the average competitor overall marks of, 51.0%, 46.2% and 50.6% ($p=0.45$).

At the end of the event competitors were issued a paper based feedback questionnaire which asked them to rate their own level of confidence in neuroanatomy knowledge out of 10. Furthermore, in 2014 and 2015 the competitors were asked at the end of each paper to document what score they thought they had achieved for that examination.

All of the data collected was collated and analysed using GraphPad Prism version 6. These two aspects of the study were approved by the University of Southampton's ethics committee (ethics ID 799 and 9351).

**Results**

- Near-peer teaching

Due to a number of incomplete forms being returned, the two teaching sessions combined generated 123 completed questionnaires and corresponding pre-teaching knowledge quizzes. As per the industry standard, the Likert responses were treated as a continuous numerical scale. The average rating for the students' level of knowledge before the teaching was $2.95 \pm 0.07$ out of 5 and the average pre-teaching quiz score was $7.0 \pm 0.17$ out of 10. The Spearman correlation between these two variables was 0.303 ($p=0.0007$).

- NUNC

The total attendance for the three NUNCs was 32, 59 and 91 medical students and of these 30 (94% response rate), 57 (97% response rate) and 87 (96% response rate) feedback forms detailing their level of confidence in neuroananatomy were returned. The ninety-one 2015 competitors also reported their previous neuroanatomy experience which included 4 students with a previous degree (neuroscience x 2, anatomy and Natural Sciences) and a further 12 who had completed, or were currently undertaking, a neuroscience intercalation.

The average overall examination performance, student ratings for their level of confidence in neuroanatomy and the correlations between them are detailed in Table 1. The correlation coefficients were averaged using a Fisher Z transformation method. There was a moderate correlation between the overall examination score and a student's confidence in neuroanatomy over three of NUNC attendees with a co-efficient of 0.44.

| Table 1 | Average overall score | Average confidence rating | Correlation co-efficient (p value) | Average correlation co-efficient |
|---|---|---|---|---|
| 2013 | 51.2 | 5.8 | 0.42 (0.02) | 0.44 |
| 2014 | 46.2 | 5.6 | 0.41 (0.001) | |
| 2015 | 50.6 | 5.2 | 0.58 (<0.0001) | |

| Table 2 | | Average actual score (%) | Average perceived score (%) | Correlation co-efficient (p value) | Average correlation co-efficient |
|---|---|---|---|---|---|
| Spotter | 2014 | 41.2 | 41.5 | 0.64 | 0.68 |
| | 2015 | 51.3 | 47.0 | 0.72 | |
| MCQ | 2014 | 50.0 | 51.2 | 0.60 | 0.58 |

| | | | | | |
|---|---|---|---|---|---|
| | 2015 | 49.9 | 51.9 | 0.57 | |

The 2014 and 2015 competitors' (n=150) self-assessment of their performance in each of the two competition components was also correlated against the respective actual scores (table 2). The self-assessment in the spotter had an average co-efficient of 0.68 and the MCQ paper had a co-efficient of 0.58. The student's self-assessment in both the spotter and MCQ was thus more accurate than their rating of their general confidence in neuroanatomy.

When examining the influence of gender on self-assessment accuracy we see that male medical students (n=119) performed higher overall (50.6% ± 0.17) than female medical students (n=63, 46.8%± 1.8) over the three years. When comparing the difference between their overall score and their level of confidence in neuroanatomy the male students had a higher correlation (r=0.49, p<0.0001) than female students (r=0.45, p=0.0003). For the 2014 and 2015 competitions the students recorded how well they felt they had done on the spotter and MCQ examinations. The difference between the perceived score and the actual score for both examinations was summed. The average perceived-actual difference for the male students (n=96) was 1.0 compared to the female students (n=54) whose difference was -5.8 which demonstrates that males had a tendency to over-estimate their performance whereas women tended to under-estimate theirs.

The 150 competitors from 2014 and 2015 were then divided in half based on their academic ability as determined by their overall score in the competition. The Pearson correlation co-efficients were again calculated for the competitor's overall competition score compared to their confidence in neuroanatomy. The highest performing half of the cohort had a notably stronger correlation (r=0.55, p<0.0001) than the bottom half (r=0.20, p=0.06).

**Discussion**

The unpredictability of clinical practice requires doctors to be prepared for many eventualities. However, there is a consensus within the medical literature that students have poor self-awareness regarding their level of knowledge and skills (Eva and Regehr, 2005). Medical students and doctors often avoid difficult subjects such as neuroanatomy because they worry about making mistakes (Risdale, 2007) however a good practitioner's caution should be based on accurate assessment of one's own limitations rather than fear.

The results from NPT demonstrate that medical students are unable to accurately assess the overall level of knowledge they possess in neuroanatomy following standard curriculum teaching. In an information rich topic such as neuroanatomy this may be a representation of Dunning's *Unknown Errors of Omission (Dunning et al., 2004)* whereby a lack of appreciation for the total knowledge required causes a poor frame of reference against which to compare one's own level of knowledge. This is supported by the fact that the self-awareness of surgical trainees increases with experience (de Blacam, 2012) therefore extra opportunities to increase student's familiarity with the curriculum material may be the key to improving self-assessment accuracy in expansive subjects like neuroanatomy.

In contrast to the students receiving NPT, the NUNC attendees might be expected to have a better awareness of the neuroanatomy curriculum and be more mindful of their knowledge due to their extensive preparation. However, their correlation between perceived level of knowledge and their overall examination performance mirrored the NPT results. One explanation is that they have not attended the NUNC before and lack awareness of its curriculum which, while based on the core curriculum, contains many additional topics designed to stretch the best competitors. Self-assessment accuracy relies on external sources of feedback for reference points (Mann et al., 2011) which students won't have received if it is their first time competing. Matched examinations with competitors over multiple years would confirm if this was the case since we would expect their accuracy to improve.

After comparing student's confidence in the overall neuroanatomy knowledge this study determined the student's accuracy at rating their performance in a self-contained examination using the two components of the NUNC. The student's self-assessment accuracy when reflecting on a single examination had moderate-strong correlation co-efficients (table 1) and thus is better than an overall self-assessment. This observation mirrors the theory proposed by Eva and Regehr (2007) whereby *self-monitoring* at the time of a specific activity is more instinctive and thus more accurate than an overall, cumulative *self-assessment*. These authors propose that the assimilation of many experiences over time which then forms the basis of a *self-assessment* is warped by bias in the student's selection of memories to include in this assessment as well as how the student's perception of their past experiences. Frequent and detailed feedback based on objective performance may overcome errors incurred in student assimilation and thus better align *self-assessment* to *self-monitoring*.

The demographic data obtained from the NUNC was analysed for several other trends in self-assessment accuracy which have been previously observed in other subject areas. These results show a non-significant under-estimation of abilities by female medical students which replicate the gender differences in self-assessment accuracy already described in the literature (Minter, 2005). The inaccuracy of both genders as determined by the correlation between predicted and actual performance was comparable (table 1) despite their tendency to err in the opposite direction. It has been proposed that female medical students have higher levels of performance anxiety which lowers their self-assessment scores (Colbert-Getz et al., 2013) and it would be important to determine whether or not this is also true for neuroscience.

Another well reported trend is the influence of academic standing on self-assessment accuracy. Many reports (Edwards, 2003; Mattheos, 2004; Blanch-Hartigan, 2011) state that high achieving students tend to underestimate their performance. This may be a result of their higher levels of criticism and fault finding in their own abilities. Our results do not support this trend since both the upper and lower halves of the NUNC attendee's have similar correlations. However, the competition does self-select for high-achieving students, all of whom will have critiqued their knowledge during their preparation. Therefore results from this cohort of medical students might not be directly comparable to those studies which have come before.

The moderate degree of correlation between perceived and actual level of knowledge in neuroanatomy is comparable to the existing literature which supports the external validity of these findings (Weiss et al., 2005; Papinczak et al., 2007). Furthermore, these results show that self-assessment accuracy in neuroanatomy is not noticeably worse than other subjects because of its inherent difficulty. If students are struggling to determine their level of knowledge themselves then extra methods of external feedback should be incorporated into the medical curriculum or greater effort made to reinforce basic science knowledge later on in the curriculum, at a time when it can be integrated and more deeply understood in clinical context.

There are some limitations to this study which should be considered. As mentioned above we had an incomplete data set both for feedback questionnaires and knowledge quizzes therefore some key sets of students e.g. the weaker candidates may have been missed. Secondly, there is a selection bias in the competition data as only those with a special interest in neuroscience will compete and they will be doing extra work beyond the curriculum in order to compete.

In conclusion we have demonstrated that medical students are unable to accurately determine their own level of knowledge in neuroanatomy. This finding is consistent with other literature reports on different medical subjects and has implications for future medical practice and patient safety.

Notes on contributors:

SAMUEL HALL, BM, MMedSc is an ST1 neurosurgical trainee and Visiting Fellow at the Centre of Learning Anatomical Sciences. He co-ordinated both the teaching research and led the team organising NUNC.

JONNY STEPHENS is an FY1 doctor and Visiting Fellow at the Centre of Learning Anatomical Sciences. He organised the neuroanatomy teaching sessions and was a member of the NUNC team and as such contributed to both the data collection and the final manuscript.

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ELEANOR SEABY is a final year medical student. A member of both the teaching and NUNC team and as such contributed to both the data collection and the final manuscript.

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CLAIRE SMITH BSc (Hons), Ph.D is a reader in anatomy and head of the BSMS anatomy department. Validated all of the knowledge tests used in this study and approved the final manuscript.

SCOTT BORDER BSc (Hons), Ph.D is a principal teaching fellow in anatomy and the University of Southampton. Faculty supervisor for all work contained in this article.

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