Neurophobia: The inconvenient truth

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SUMMARY

Medical schools have implemented strategies in response to neurophobia to counteract the negative perception and improve neuroscience experiences for undergraduate medical students. In this study, we explored the attitudes, perceptions and preferred learning approaches of undergraduate and postgraduate medical students toward the teaching, facilitation, learning and assessment of neuroanatomy, as well as their perceptions on its relevance in the South African medical curriculum. A total of 299 undergraduate and five postgraduate students from the University of Pretoria participated in this study. We used a multi-method approach in which the undergraduate students completed an anonymous quantitative questionnaire, while the postgraduate students participated in a qualitative focus- group discussion. Undergraduate medical students preferred lecture notes to study from above any other type of literature and mainly used laptop computers as preferred electronic devices in preparation for their assessments. The favourite topic was cranial nerves, and the least popular was histology of the nervous system. Postgraduate students shared their undergraduate neuroanatomy experiences and provided constructive feedback and suggestions to undergraduate students and lecturing staff. Ineffective teaching methods and limited contact time remain factors that contribute to neurophobia in South Africa. Students perceive neuroanatomy as an interesting and important subject in their medical degree. However, changes are needed to modernize neuroanatomy and make it more accessible and student-friendly. The challenge then remains: how do we, as lecturers, modernize neuroanatomy in the medical curriculum to make it contemporary and clinically applicable?

Key words: Medical education – Neuroanatomy education – Neurophobia – Students' perceptions – Undergraduate education

INTRODUCTION

Human anatomy, which includes neuroanatomy, is regarded as a foundational subject of the medical curriculum (Sotgiu et al., 2020). If obstacles such as students' irrational fear towards the subject threaten the stability of this foundation, there will be dire consequences later in a medical students' career.

Students experience a fear toward neuroanatomy in their undergraduate medical training which can be attributed to their perception of neurosciences, limited exposure to neuroanatomy during their training, as well as the way in which this sub-

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ject is currently being presented and facilitated (Nham, 2012; Kam et al., 2013; Maranhão- Filho, 2014; Geoghegan et al., 2019). This leads to a deficit in their basic anatomy knowledge and, in turn, inhibits the application of basic neuroanatomy in the clinical environment (Nham, 2012). This deficiency of theory-practice integration could result in general medical practitioners who lack a sufficient level of applied theoretical knowledge of the human body. This may then have a direct influence on the way in which they assess, diagnose, treat, or refer patients with neurological disorders and diagnoses (Zinchuk et al., 2010; Gorgich et al., 2017). Therefore, the perceptions and attitudes of medical students towards neuroanatomy in the medical curriculum need to be explored, and measures put in place to address any negative perceptions.

Often, the perception of medical students is that neurosciences, including neuroanatomy and clinical neurology, are overwhelming in both content and context, and overly complex (Arantes et al., 2017). This, in turn, may lead to the development of an irrational fear towards the neurosciences (Maranhão-Filho, 2014; Geoghegan et al., 2019), known as neurophobia (Russell et al., 2015). The term 'neurophobia' was coined by Ralph Jozefowicz in 1994 (Josefowicz, 1994; Russell et al., 2015; Arantes et al., 2017). The irrational fear of the neurosciences has further been referred to as a "real and prevalent educational disease" (Kam et al., 2013) reported to manifest within the first two years of medical study (Geoghegan et al., 2019), affecting 50% of undergraduate medical students (Jozefowicz, 1994; Abushouk and Duc, 2016; Hall et al., 2018; Shelley et al., 2018), and has no gender preference (Jozefowicz, 1994). Neurophobia, as a symptom, has been recognized in a variety of countries such as Nigeria, United States of America, United Kingdom (McCarron et al., 2014), Saudi Arabia (Abulaban et al., 2015; Mohammed et at., 2018), Singapore (Kam et al., 2013), China (Lukas et al., 2017), Sri Lanka (Matthias et al., 2013), Brazil (Santos-Lobato et al., 2018), Trinidad and Tobago (Youssef, 2009), Portugal (Arantes et al., 2017), West India (Shiels et al., 2017), India (Shelley et al., 2018) and Sudan (Elnaeim et al., 2021).

Neurophobia is an all-inclusive term that describes the insights, beliefs, negative preconceptions, apprehensive feelings, dislikes, and disinterest that medical students have toward neuroscience education (Shelley et al., 2018). Unfortunately, even though neurophobia, its causes and possible prevention plans have been extensively described in the literature, some lecturing staff still view this as a trivial issue (Tarolli and Jozefowicz, 2018; Venter et al., 2022) and remain unwilling to acknowledge its existence.

Several factors influence the presence and severity of neurophobia. Causative and contributing factors to neurophobia can be divided into three risk categories. The first category is non-modifiable and includes all the preconceptions and past experiences that students have towards neurosciences before they start medical school (Fantaneanu et al., 2014). The second group consists of all the factors affecting the students during their pre-clinical years and include the students' inability to apply their basic science knowledge to the clinical environment (Nham, 2012), a lack of self-confidence in the approach and understanding of the elementary neurological concepts (Nham, 2012; Santos-Lobato et al., 2018), inadequate or inappropriate teaching techniques (Youssef, 2009; Nham, 2012; Kam et al.,2013; Abulaban et al., 2015; Mohammed et al., 2018; Venter et al., 2022), the complexity of neuroanatomy as a subject (Hudson, 2006; Nham, 2012; Kam et al., 2013; Shiels et al., 2017; Mohammed et al., 2018) and the habit of superficial learning instead of deep learning, as well as rote learning by students (Pandey and Zimitat, 2007; Sotgiu et al., 2020). The last group of contributing factors affects the medical students during their clinical training years and include the difficulty, complexity and length of the clinical examination (Nham, 2012), the lack of proper exposure to neurologically impaired patients and insufficient bedside teaching (Nham, 2012; Kam et al., 2013), the large number of rare and intricate diagnoses and, at times, the inability to have a conclusive curative treatment plan for many of the cases (Matthias et al., 2013). The second and third group of risk factors during the students' pre-clinical and clinical training years are modifiable (Fantaneanu et al., 2014)

and, therefore, the development of neurophobia can be classified according to intrinsic and extrinsic factors.

Intrinsic factors refer to the students and include the perception of neurology within the medical community (Nham, 2012; Tarolli and Jozefowicz, 2018), the students' perception of the complexity of neuroanatomy as a subject (Nham, 2012; Kam et al., 2013; Tarolli and Jozefowicz, 2018), their inability to apply basic scientific knowledge to the clinical environment (Nham, 2012), and a lack of self-confidence in the approach and understanding of the elementary neurological concepts (Nham, 2012; Geoghegan et al. 2019). Extrinsic factors include poor or insufficient teaching of neuroanatomy (Nham, 2012; Kam et al., 2013; Venter et al., 2022), and the limited exposure to the clinical environment and its relevance (Tarolli and Jozefowicz, 2018). In response to neurophobia, educational institutions have implemented various strategies to counteract this perception and improve neuroscience experiences for undergraduate students (Pakpoor et al., 2014). It is important to maintain high standards in neuroscience teaching, and this can only be upheld if the current cohort of undergraduate medical students are given the opportunity to develop the relevant knowledge, skills, and enthusiasm to cultivate an interest or career in the neurosciences (Geoghegan et al., 2019).

A study was therefore undertaken to explore undergraduate and postgraduate medical students' attitudes towards the teaching, facilitation, learning and assessment of neuroanatomy, as well as their perceptions on the relevance of neuroanatomy in the medical curriculum. The results reported in this study are part of a larger exploratory study into neuroanatomy within the South African medical curriculum.

MATERIALS AND METHODS

We used a multi-method approach which included both qualitative and quantitative research design characteristics. In a multi-method research approach, the objectives can run concurrently without one objective influencing, or depending on, another (Seawright, 2016).

Ethical approval

Permission to include students from the University of Pretoria was obtained from the Registrar and Deputy Dean of Teaching and Learning, in the Faculty of Health Sciences at the University of Pretoria. The questionnaires completed by the volunteering students were accompanied by a participant information leaflet which explained the details of the study, as well as the rights of the participant. All participants provided written informed consent prior to enrolment in the study. The anonymity of these participants was always maintained. The ethical consent required for this research project was acquired from the Research Ethics Committee of the University of Pretoria (Reference number: 587/2018) in October 2018.

Participants

We collected information from undergraduate and postgraduate medical students at the University of Pretoria. Email requests were sent to the undergraduate medical students to invite them to anonymously participate in a survey. These students had exposure to neuroanatomy during their previous years. Each volunteering student completed an anonymous electronic questionnaire. We further approached postgraduate medical students from the same institution, who were specializing in either Neurosurgery, Neurology or Psychiatry. They were invited to participate in a qualitative focus-group discussion.

Data collection

The questionnaires were developed by the researchers and validated by independent academic consultants and statisticians. These questionnaires were completed by the undergraduate students, contained mostly quantitative questions, and were designed to gather information on the perceptions of the students towards the current neuroanatomy teaching and facilitation approaches, as well as their perceived importance of neuroanatomy within the medical curriculum. Likert-scale-, matrix- and open-ended questions were included in the questionnaires.

The questionnaire requested information such as the year of study, other neuroanatomy expo-

sure, preferred teaching approaches and study materials including their use of electronic devices for studying neuroanatomy. Information regarding the students' view on the importance of neuroanatomy as part of their training was also requested. Eleven core categories previously identified by Moxham and co-workers (2015) were assessed in this questionnaire, and included questions on the development of the nervous system, histology of the nervous system, spinal cord, brainstem, cranial nerves, diencephalon and the pituitary gland, cerebral hemispheres, limbic system and reticular formation, autonomic system, ventricular system, meninges, and blood vessels. The perceptions on the importance and relevance of the eleven core categories were explored.

For the postgraduate students, we conducted a focus-group discussion t related to their undergraduate neuroanatomy experience, possible role-models, the reason for specializing in a neuroscience field, as well as their advice and suggestions to the current undergraduate students and lecturing staff. The focus-group approach worked well, since it allowed equal expression of the perspectives and views on the specific issues of neurophobia (Colucci, 2007; Bryman et al., 2014).

Data analysis

The data obtained from the undergraduate students' questionnaires was analysed with IBM SPSS, Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY) for the descriptive statistics and the statistical software SAS^{R}, Version 9.4 (SAS Institute) for the inferential statistics. The statistical significance was determined by a p-value of less than 0.05. The statistical analysis consisted mainly of descriptive statistics which included frequencies and means with standard deviations. Inferential statistical techniques such as the analysis of variance (ANOVA) were performed to find possible simultaneous relationships between continuous dependent variables and independent factors. Through the process of statistical model building, significant independent factors such as the year-group of students and time allocated to neuroanatomy could be identified to have a simultaneous influence on dependent variables such as preferred teaching approaches, literature used and neuroanatomy topics, as well as perceived importance of neuroanatomy within the medical curriculum.

All open-ended questions underwent thematic analysis by means of Atlas.ti^{TM} Version 8.0 software (Scientific Software, Berlin, Germany). The postgraduate focus-group discussions were transcribed and thematically analysed with the Atlas.ti^{TM} software. Relationships between the themes were identified, further analysed, and discussed (Lacey and Luff, 2001; Nowell et al., 2017).

RESULTS

Participants' characteristics

A total number of 299 undergraduate medical students and five (out of a possible 25) postgraduate students participated in this study. The undergraduate student sample self-identified as 101 males (34%) and 196 females (66%). Two students did not indicate the gender they associate with. The mean age of this group of students was 22.04 years, which ranged from 18-36 years.

The students had to indicate in which year they were registered. One hundred and twenty-four (124) students (41.4%) were in their second year of studies, 60 students (20.1%) in their third year, 66 students (22.1%) in their fourth year and 49 students (16.4%) in their sixth and final year. The first-year group was excluded from this study since they have not had any neuroanatomy experience within the medical curriculum at the time of data collection. The fifth-year group was also excluded from this study as they were used as part of a pilot study to test the relevance of the questionnaires.

Ten students (3.3%) indicated that they were repeating the current neuroanatomy module, while 14 students (4.7%) indicated that they had previously studied another degree that included neuroanatomy content. The postgraduate students consisted of four females and one male.

Study materials and electronic devices used

We explored different types of study materials used by the undergraduate students. The participants had to indicate whether they did or did not use the prescribed and recommended literature,

as well as other information sources. The results are summarised in Fig. 1.

Lecture notes provided to the students was the most preferred resource used (93.7%) in preparation for neuroanatomy assessments. Self-identified gender had a statically significant impact on the usage of lecture notes, as 63.6% females preferred lecture notes, compared to 30.1% males (p-value=0.0025). The prescribed literature (80.3%) and internet resources (77.9%) were other preferred resources used for studying neuroanatomy. One-way ANOVA models were built for the preferred use of prescribed literature and internet resources. Scheffe's and Bonferroni tests revealed that the year-group of the students had a statistically significant impact on the study materials used in their preparation for assessments. A statistically significant difference was found between the second-year group and the third-year group regarding the use of prescribed literature (p-value = 0.022). Approximately 53.2% of the second-year group of medical students used prescribed literature, in comparison to 16% of the third-year group.

The participants had to further indicate whether they used the specified electronic devices in their preparation for assessment. The most preferred electronic device was laptop computers, as indicated by 90% of the undergraduate participants. A statistically significant difference was noted in the usage of the second-year students and the final year students (p-value < 0.0001). Approximately 50% of the second-year students prefer to use their laptop computers, compared to the 9.8% of final-year students. Smartphones and handheld devices were preferred by about 50% of the participants. The data obtained are summarised in Fig. 2.

Preferred teaching approaches

The undergraduate respondents had to indicate their most and least favourite teaching approaches for neuroanatomy from a list provided. An 'Other' option was supplied where the respondents could include approaches not mentioned. The highest ranking for favourite teaching approaches were practicals containing wet brain specimens, as preferred by 77 students (25.8%) and dissection of cadaveric brain specimens, indicated by 64 students (21.4%). Video demonstrations of dissected brain specimens were preferred by 46 students (15.4%). Seven students (2.3%) indicat-

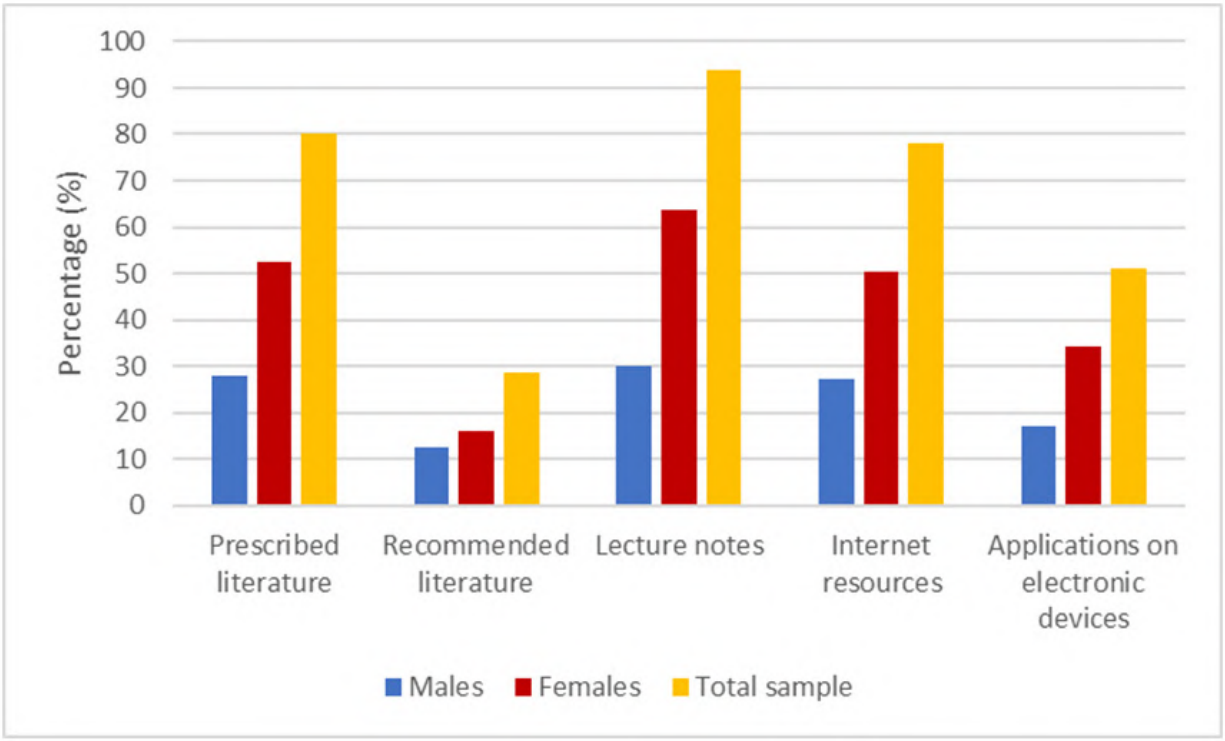

Fig. 1.- The use of literature by self-identified male and female students in their preparation for neuroanatomy assessments. Percentage values (%) are indicated.

ed the 'Other' option, which they described as a combination of the teaching approaches from the list provided. Teaching approaches that students disliked included didactic sessions (lectures) without the use of MS PowerPoint presentations, as indicated by 97 students (32.4%). Another unpopular approach was self-study or self-directed learning, which 60 students (20.1%) selected. Students were not asked to provide a rational for their choice. A possible follow-up study could be done to determine why this is not a favourite choice for students and whether the students' perceptions have changes after the COVID-19 lockdown, when they were forced into a higher level of self-directed learning. Table 1 summarises the results for preferred teaching approaches.

Preferred neuroanatomy topics

The undergraduate respondents were requested to indicate their most and least favourite neuroanatomy topics from a list provided, and then supplement their choice with a motivation. The most preferred neuroanatomy topic was cranial nerves, as indicated by 91 students (30.4%). Other preferred topics included blood vessels (21.4%), the cerebral hemispheres (19.4%) and the brainstem (12%). The rest of the topics had values lower than ten percent. The least favoured neuroanatomy topic was the histology of the nervous system, as indicated by nearly half of the students - 137 students (45.8%). Another unpopular topic was the development of the nervous system (19.7%). The results for all the topics are summarised in Table 2.

Students were further asked to indicate whether appropriate time was allocated to each of the topics during their contact sessions. The students agreed that enough time was allocated to the brainstem (70.8%), cranial nerves (77.5%), meninges (76.8%) and blood vessels (83.8%). They indicated that more time should be allocated to the histology of the nervous system (63.8%). We can assume that the dislike of the histology of the nervous system can be linked to the amount of time spent on this topic, since the students would prefer more time. The rest of the neuroanatomy topics had an almost 50/50 distribution between "enough time" and "not enough time" allocated to the assorted topics.

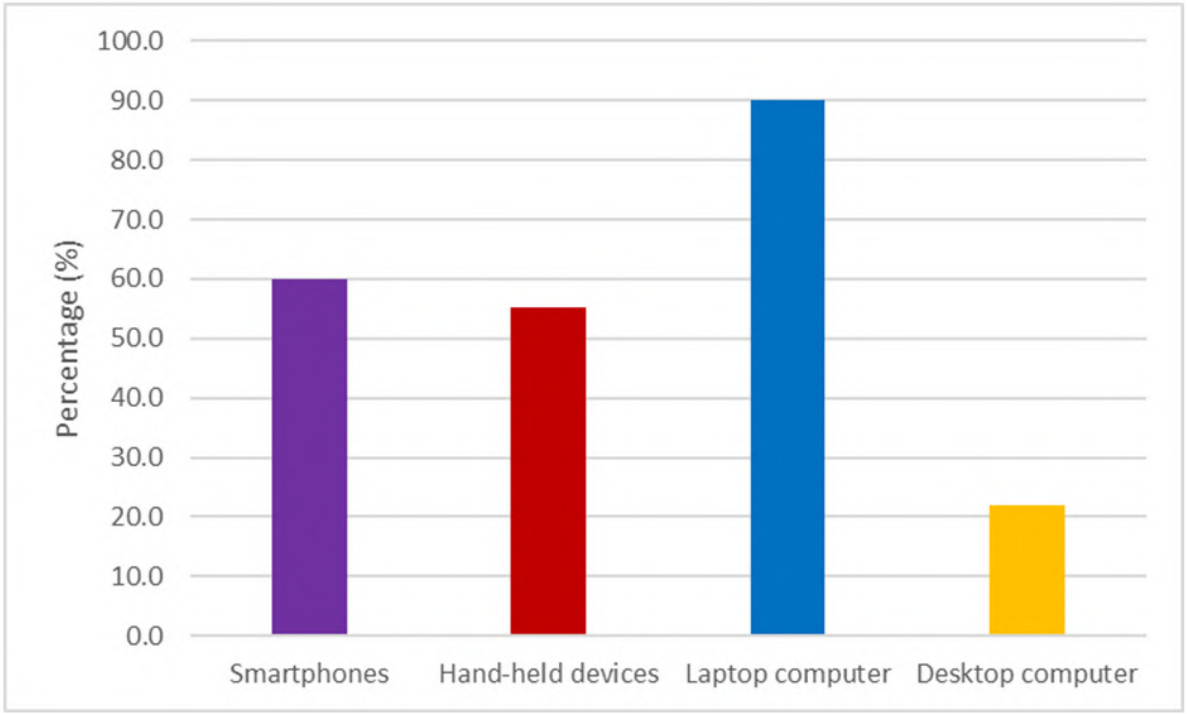

Fig. 2.- The use of electronic devices by students in their preparation for neuroanatomy assessments. Percentage values (%) are indicated.

Table 1. Teaching approaches in neuroanatomy as selected by undergraduate medical students.

Neuroanatomy teaching approaches	Indicated as most favourite (n=299)		Indicated as least favourite (n=299)	
	n	%	n	%
Lectures with MS PowerPoint presentations	56	18.7	22	7.4
Lectures without MS PowerPoint presentations	3	1	**97**	**32.4**
Video demonstrations	46	15.4	8	2.7
Computer-based practicals	-	-	24	8
Dissection of cadavers	64	21.4	13	4.3
Wet specimen / models practicals	**77**	**25.8**	13	4.3
Practical and lecture combined into a single session	21	7	14	4.7
Problem-solving scenarios	14	4.7	8	2.7
Self-study	9	3	60	21.1
Tutor-classes	-	-	29	9.7
Other	7	2.3	5	1.7

Table 2. The most- and least favourite neuroanatomy topics of undergraduate medical students.

Neuroanatomy topic	Indicated as most favourite (n=299)		Indicated as least favourite (n=299)	
	n	%	n	%
Development of nervous system	2	0.7	59	19.7
Histology of nervous system	2	0.7	**137**	**45.8**
Spinal cord	6	2	10	3.3
Brainstem	36	12	5	1.7
Cranial nerves	**91**	**30.4**	15	5
Diencephalon and pituitary gland	2	0.7	9	3
Cerebral hemispheres, limbic system and reticular formation	58	19.4	20	6.7
Autonomic system	14	4.7	17	5.7
Ventricular system	15	5	21	7
Meninges	8	2.7	6	2
Blood vessels	64	21.4	-	-

Relevance of neuroanatomy

The undergraduate respondents had to indicate whether they agreed or disagreed with statements regarding the importance of neuroanatomy within the medical curriculum. The statements were adapted from a previous study by Moxham and co-workers (2007). The results of these statements are summarised in Table 3. Most of the participants (97.7%) agreed that knowledge of neuroanatomy is essential for safe medical practice. Without this knowledge, the medical practitioner's effectiveness will be limited, as indicated by 83.9% of the participants. A two-way ANOVA model indicated that the year-group of the students and their self-identified gender had a simultaneous impact on the student's disagreement with the statement: "Neuroanatomy needs to modernize if it is going to be really useful in medicine". A statistically significant difference was noted in the students who disagreed with the statement in which 29.6% were males and 70.4% were females (p-value=0.011).

Table 3. The importance of neuroanatomy within the medical curriculum as perceived by undergraduate medical students.

Statement	Agreed with the statement (n=299)		Disagreed with the statement (n=299)	
	n	%	n	%
Neuroanatomy is an important component in my medical training.	293	97.9	5	1.7
Although neuroanatomy is interesting, the subject needs selective understanding in the clinical setting.	224	75.4	73	24.4
Neuroanatomy is necessary for safe medical practice.	**291**	**97.7**	7	2.3
Neuroanatomy is of some use in the clinical setting, but its importance may be exaggerated.	59	19.9	238	79.6
Neuroanatomy is only beneficial in certain medical specialities.	70	23.6	227	75.9
Neuroanatomy is so old-fashioned that is has no importance in contemporary medicine.	5	1.7	294	98.3
Neuroanatomy is time wasted in the medical curriculum.	6	2	292	97.7
Neuroanatomy needs to modernise if it is going to be really useful in medicine.	**110**	**37.2**	**186**	**62.2**
A very good doctor must have a good understanding of neuroanatomy.	279	93.3	20	6.7
It is impossible to conceive a good medical training without a major neuroanatomy component.	229	76.8	69	23.1
It is not possible to make a reasonable medical diagnosis without a sound knowledge of neuroanatomy.	204	68.7	93	31.1
Medicine would not exist without neuroanatomy.	235	78.6	64	21.4
Only a limited neuroanatomical knowledge is required for safe medical practice.	99	33.2	199	66.6
Rather than studying neuroanatomy, medical students should concentrate on clinical sciences.	44	14.8	254	84.9
Without knowledge of neuroanatomy, the doctor is of limited effectiveness.	**250**	**83.9**	48	16.1

Further significant differences were noted between the second-year group and third- year group of students (p-value = 0.025), as well as the second-year group and final- year group of students (p-value = 0.037). In the second-year group, 48.4% of the students disagreed with the statement, in comparison to the third-year group with 16.1% and the final-year group with 13.4%. We can then assume that female second- year students do not want modern changes to occur in the medical neuroanatomy curriculum, and that they are content with the current stance of neuroanatomy.

Advice from postgraduate students

The postgraduate student sample is small (five out of a possible 25 students) due to the small number of students who want to specialize in neurosciences for an MMed degree. These students had to elaborate on their undergraduate neuroanatomy experiences. Only one student (20%) had positive comments regarding his/her experience with the statement "*I find the neurosciences interesting, it's not difficult, just need to have enough time to study it, it can be fun.*" The rest of the group (80%) described their negative experiences which included "*very difficult and not easy to understand", "cannot remember anything about undergraduate neuroanatomy training besides that it was difficult and confusing" and "we had to rely on ourselves".*

This group was further asked to provide constructive feedback and suggestions on how to approach neuroanatomy. Most of the group suggested that the lecturing staff should make neuroanatomy more fun, accessible, and simplified to the students. Their advice to the students was mainly to understand the fundamentals of neuroanatomy and allocate enough time for study purposes. Only one of the participants indicated that she had a neuroanatomy role-model during her undergraduate training.

DISCUSSION

Neurological disorders constitute more than 6.4% of the health burden and 12% of mortality

globally (Ridsdae, 2009; Abulaban et al., 2015) The prevalence and impact of neurological conditions place a higher demand on the healthcare system to improve on neurological care. Therefore, doctors/physicians need to be better prepared in their approach and diagnosis to this specialty (Fantaneanu et al., 2014). Given these statistics, the effect that neurophobia has on medical students will greatly affect the treatment provided to patients who complain of neurological symptoms (Nham, 2012). Medical students consider neurology to be the most difficult, but also the most interesting of all the internal medicine specialties, especially after completion of that specific rotation (Hudson, 2006; Nham, 2012; McCarron et al., 2014). Neuroanatomy has even been mentioned as the main reason for this perception of difficulty (Arantes et al., 2017).

In this study, we explored the perceptions of medical students towards neuroanatomy, as well as its position and assumed importance within the undergraduate medical curriculum. This study forms part of a larger study which investigates neuroanatomy within the South African medical curriculum. The results of this study can be used to create awareness of the perceptions, preferences and needs of undergraduate medical students towards neuroanatomy and its teaching, facilitation, and assessment within the South African curriculum.

Study material and electronic devices

The respondents indicated that they prefer lecture notes, supplied by the lecturers, above any of the other forms of literature. Ninety percent (90%) of the students used laptop computers in their preparation for neuroanatomy assessments in comparison to smartphones and hand-held devices, which are only used by 55-59%. This contradicts assumptions that students prefer to use their smartphones and hand-held devices for studying, as these devices are always readily available.

Students mainly use electronic devices, including smart phones and hand-held devices, for information retrieval (Morris et al., 2016). In the UK, the successfully integrated use of hand-held devices in neuroanatomy practicals and learning support has been reported with an increased success-rate in the students' results (Morris et al., 2016). The students' perception of their learning and class enjoyment can be enhanced by integrating mobile learning opportunities within the curriculum (Morris et al., 2016). Medical students in Ireland deem internet sources for neuroanatomy as very useful, as indicated by 81.8%, especially in understanding the clinical relevance of neuroanatomy (Javaid et al., 2018).

Preferred teaching approaches

The undergraduate students prefer their contact sessions in neuroanatomy to be in the format of practicals with cadaveric brain specimens and plastic models, as well as dissections of human cadaveric brains. These students want to interact with the content instead of attending didactic lectures, especially those that do not include MS PowerPoint presentations. They want to be actively involved in their learning processes which is in line with the transferrable skills of the twenty-first-century student. However, self-directed learning is a very unpopular approach to neuroanatomy, according to these students. One can speculate that it can be ascribed to factors such as poor self-management, readiness, openness, work-drive and even access to resources which might be challenging (Lunyk-Child et al., 2001; Morris, 2019). A follow-up study with the same cohort of students is advisable to confirm these assumptions. Exposure to more complicated brain dissections is a valuable learning experience for students (Myers et al., 2018; Karamaroudis et al., 2020). In Ireland, senior medical students (already in their clinical years) valued the use of case-based learning more than prosected brain specimens, in comparison to the junior medical students (still in their basic sciences years) (Javaid et al., 2018). This supports the findings of this study.

Our findings concur with those reported in Saudi Arabia, in which 70.4% of students ascribed their lack of interest in neurology to bad teaching experiences (Abulaban et al., 2015). In the United Kingdom (UK), 35% of the participating medical students indicated that the time allocated for neurology and related content is insufficient (Pakpoor et al., 2014). Medical students from

Brazil, especially senior students, also indicated that more teaching was needed for neurosciences (Santos-Lobat et al., 2018). Students from West India indicated that they prefer educational interventions such as team-based learning, problem-based learning, and case- based teaching for neuroscience (Shiels et al., 2017).

Although the responsibility to engage in learning opportunities in neurosciences remains the responsibility of the student (Nham, 2012), the lecturer can contribute by making the subject interesting, contemporary, and engaging by using various student-centred teaching modalities and techniques. Furthermore, the lecturers need to guide the students into taking responsibility for their own learning through student-centred teaching and facilitation methods. Educational interventions in the early stages of a medical career may enhance long-term motivation and interest in the neurosciences (McCarron et al., 2015). Such interventions to expand the student's competency in neurology include more clinical or bedside teaching, more case discussions, additional teaching aids, as well as extra neurology and neuroanatomy lectures (Matthias et al., 2013).

Preferred neuroanatomy topics

The participants in this study indicated that cranial nerves, on average, was their most favourite neuroanatomy topic. We explored the reasons for this choice and five themes emerged from their answers. The participants indicated cranial nerves as a topic that is interesting and easy to understand. They see the topic's clinical relevance for their future careers, they understand how cranial nerves are integrated with the rest of the body, and they had a good teaching experience on this topic. Medical students in Ireland made similar statements, in which they rated the cranial nerves as an easy neuroanatomy topic, except for the cranial nerve nuclei (Javaid et al., 2018). The students indicated that their least favourite topic is the histology of the nervous system, and ascribed this to unconducive didactic teaching experiences, complex and uninteresting content, not enough time allocated, and, in their opinion, lack of clinical relevance.

Importance of neuroanatomy

Overall, the undergraduate medical students perceive neuroanatomy as an interesting and important, but not stand-alone component in their medical curriculum. They understand that a good foundational knowledge of neuroanatomy is necessary for safe medical practice, irrespective of the discipline. When asked whether neuroanatomy needs to be modernized, more than 50% of the students, mostly females, were in support of the statement, indicating the need to revamp the teaching approaches in the current medical neuroanatomy curriculum,. which might be ascribed to the fact that female students are more likely to be neurophobic (Kam et al., 2013), perceive neuroanatomy as complicated and not consider a future career in the neurosciences in comparison to male students (Abulaban et al., 2015). However, the perception of difficulty, with reference to the three-dimensional complexity of the brain might also affect the student's attitude towards neuroanatomy, and it is reported to affect females more than males (Clements-Stephens et al., 2009; Palomera et al., 2014). Furthermore, male students tend to be more reliant on images and prefer "hands-on" during contact sessions in comparison to females (Clements-Stephens et al., 2009).

As part of our own personal introspection, reflections and contemplations, the question that needs to be answered is: how can we, as lecturers, modernize neuroanatomy in the medical curriculum and subsequently prevent the development of neurophobia? Recommendations include more clinical relevance in the neuroanatomy content for the students (Pakpoor et al., 2014), as well as the inclusion of medical images, anatomical models, and virtual anatomy. We need to acknowledge that, by separating basic neuroscience from clinical sciences, and removing clinical relevance, the students become neurophobic as they struggle to implement the basic neuroanatomy concepts in the clinical environment, therefore enhancing the lack of theory-practice integration. Neurophobia is a result of our teaching and attitudes towards the content, as well as the use of a non-transformed, outdated curricula. We as lecturers, therefore, need to take ownership of the fact that we might be the cause of neurophobia among our under-

graduate medical students and, consequently, have to adapt our attitude and teaching methods towards the student's training in medical school (Ridsdale et al., 2007; Arantes et al., 2017; Shiels et al., 2017) We need to allocate more time to basic neuroscience concepts, as medical students worldwide indicated that more time is needed for basic neuroanatomy (Pakpoor et al., 2014: Santos-Lobato et al., 2018).

Our teaching approaches should be person-focused and student-friendly, as suggested by the postgraduate students. Lecturers should engage in student-centred teaching methods to assist students in overcoming/minimizing neurophobia. We, the lecturers, are not the centre-point of the teaching environment anymore, as we are mere facilitators in the learning process of our students. We can instil in them the enthusiasm for neuroanatomy and not drown them with cognitive and content overload or attempt to make content-experts of them in the early years of their medical degree (Palomera et al., 2014; Greville et at., 2016). We should provide them with the necessary tools and guidance, but they, themselves, must master the neuroanatomy content and apply it, when necessary, in the clinical environment.

In conclusion, a less than optimal teaching experience and limited contact-time for students remain crucial factors contributing to neurophobia, even in the South African medical schools. This affects how our students perceive neuroanatomy and its importance in the medical curriculum, irrespective of whether the students are undergraduates or postgraduates. If we, as lecturers, can address these issues at our institutions, we can start to make a difference in our students' lives regarding neurophobia. Dedicating more time to neuroanatomy is a challenging task to accomplish, as it implies that time must be negotiated and reduced from another discipline or subject to accommodate this change. Collaboration between the basic sciences departments and clinical departments is vital for such changes. Nonetheless, we can reflect on our teaching approaches and make the necessary changes to help our students overcome this fear for the neurosciences. After all, we want our students to be competent healthcare professionals with a sound foundation in neuroanatomy.

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SUPPLEMENTARY MATERIAL: STUDENT QUESTIONNAIRE

Dear Student

I am a PhD student in the Department of Anatomy, University of Pretoria. You are invited to volunteer to participate in my research project, by completing the following questionnaire regarding the exploration of perceptions and attitudes of both staff and students towards neuroanatomy in the South African undergraduate medical curriculum. This letter provides you with information to help you decide whether you want to take part in this study. Before you agree you should fully understand what is involved. You should not agree to take part unless you are completely happy about what we are requesting from of you.

The aim of this study is to investigate the attitudes of anatomy lecturers, undergraduate and postgraduate students towards the teaching and learning of neuroanatomy in the medical curriculum. This study will further examine the perception of students on the importance of neuroanatomy as it relates to their future careers as well as the current teaching and assessment practices used by anatomy lecturers at South African Universities.

This study involves answering some questions regarding your personal opinion on the facilitation and learning of neuroanatomy and the relevance of neuroanatomy as part of your medical curriculum.

We would like you to complete an anonymous online questionnaire. This may take about 10 minutes. This will ensure confidentiality and anonymity. The Research Ethics Committee of the University of Pretoria, Faculty of Health Sciences granted written approval for this study (nr 587/2018). This study has been structured in accordance with the Declaration of Helsinki, of which a copy may be obtained from the primary investigator, should you wish to review it.

This questionnaire consists of the following two parts:

- Section A: General information which involves answering some questions about your age, current year of studies etc.
- Section B: Perceptions and attitudes towards neuroanatomy which involves answering some questions about your personal view on neuroanatomy and its place in the medical curriculum

Your participation in this study is voluntary. You can refuse to participate, omit questions or stop at any time without providing any reason. As you do not write your name on the questionnaire, you give us the information anonymously. Once you have submitted the questionnaire, you cannot recall your consent as we will be unable to trace (identify) your information-sheet. Therefore, you will also not be identified as a participant in any publication that results from this study.

There is no foreseeable physical discomfort or risk involved. If there are questions that are too sensitive for you to answer, you do not need to answer them. This study may help to make key recommendations towards the formation of a framework for a revised neuroanatomy module for undergraduate medical students, specific to the South African context.

Note: The implication of completing the questionnaire is that informed consent has been obtained from you. Thus, all information derived from you and all records from this study will be regarded as confidential (which will be depersonalised and anonymous) may be used for e.g. publication, by the researchers. If you have any questions concerning this study, you should contact the primary investigator, Mrs Gerda Venter at (+27)12 319 2536 or gerda.venter@up.ac.za.

We sincerely appreciate your help.
Gerda Venter

Consent to participate in this study:

- I confirm that the person requesting my consent to take part in this study has informed me about the nature and process, any risks or discomforts, and the benefits of the study.
- I have received, read and understood the attached written information leaflet about the study.
- I am aware that the information obtained in the study, including personal details, will be anonymously processed and presented in the reporting of results.
- I am participating willingly.

o I agree (1)
o I do not agree (2)

Q2 The gender I identify with:
o Male (1)
o Female (2)
o Prefer not to answer (3)
o Other (4) .....

Q3 My current age in years:
.....

Q4 I am currently completing the _____ of my medical degree.
o First year (1)
o Second year (2)
o Third year (3)
o Fourth year (4)
o Fifth year (5)
o Final year (6)

Q5 The neuroanatomy module(s) that I am currently registered for / completed:
.....

Q6 I am repeating this Neuroanatomy module.
o Yes (1)
o No (2)

Q7 Have you done any other Neuroanatomy course(s), excluding the ones in your medical degree?
o Yes (Please specify) (1) .....
o No (2)

Q8 Did you receive a study-guide for your Neuroanatomy modules in your medical degree?
o Yes (1)
o No (2)
o Not in all of the modules (please elaborate) (3) .....

Q9 Did you find the study-guide useful for: (Select the most relevant options)

	Extremely useful (1)	Useful (2)	Somewhat useful (3)	Not useful (4)
Administrative information (1)				
Assessments (2)				
Preparation for contact sessions (3)				
Overview of the syllabus (4)				

Q10 How often did you make use of the following types of study materials to study Neuroanatomy. (Select the most relevant options)

	All the time (1)	Most of the time (2)	Almost never (3)	Never (4)
Prescribed literature (1)				
Recommended literature (2)				
Lecture notes (3)				
Internet resources (4)				
Applications on electronic devices (5)				

Q11 How often did you make use of the following types of electronic devices to study Neuroanatomy. (Select the most relevant options)

	All the time (1)	Most of the time (2)	Almost never (3)	Never (4)
Smartphone (1)				
Hand-held devices (2)				
Laptop (3)				
Desktop computer (4)				

Q12 Indicate your liking / interest in the following Neuroanatomy topics. (Select the most relevant options)

	Do not like at all (1)	Like a little (2)	Like (3)	Like a lot (4)	Was not covered in this module (5)
Development of the nervous system (1)					
Histology of the nervous system (2)					
Spinal cord (3)					
Brainstem (4)					
Cranial nerves (5)					
Diencephalon and pituitary gland (6)					
Cerebral hemispheres, limbic system and reticular formation (7)					
Autonomic system (8)					
Ventricular system (9)					
Meninges (10)					
Blood vessels (11)					

Q13 Which Neuroanatomy topic is your MOST favourite?

o Development of the nervous system (1)
o Histology of the nervous system (2)
o Spinal cord (3)
o Brainstem (4)
o Cranial nerves (5)
o Diencephalon and pituitary gland (6)
o Cerebral hemispheres, limbic system and reticular formation (7)
o Autonomic system (8)
o Ventricular system (9)
o Meninges (10)
o Blood vessels (11)

Q14 Please supply the reason for choosing this specific topic as your MOST favourite (in the box below).

.....

Q15 Which Neuroanatomy topic is your LEAST favourite?

o Development of the nervous system (1)
o Histology of the nervous system (2)
o Spinal cord (3)
o Brainstem (4)
o Cranial nerves (5)
o Diencephalon and pituitary gland (6)
o Cerebral hemispheres, limbic system and reticular formation (7)
o Autonomic system (8)
o Ventricular system (9)
o Meninges (10)
o Blood vessels (11)

Q16 Please supply the reason for choosing this specific topic as your LEAST favourite (in the box below).

.....

Q17 In your opinion, was enough time allocated to the following Neuroanatomy topics? (Select only the appropriate boxes)

	Yes (1)	No (2)
Development of the nervous system (1)		
Histology of the nervous system (2)		
Spinal cord (3)		
Brainstem (4)		
Cranial nerves (5)		
Diencephalon and pituitary gland (6)		
Cerebral hemispheres, limbic system and reticular formation (7)		
Autonomic system (8)		
Ventricular system (9)		
Meninges (10)		
Blood vessels (11)		

Q18 Please evaluate the following teaching approaches for Neuroanatomy according to your liking / interest. (Select only the appropriate boxes)

	Do not like at all (1)	Like a little (2)	Like (3)	Like a lot (4)	Not used in this module (5)
Lectures with PowerPoint presentations (1)					
Lectures without PowerPoint presentations (2)					
Video demonstrations (3)					
Wet specimens / models demonstrations by a staff member (4)					
Computer-based practicals / tutorials (5)					
Dissection of human cadavers (6)					
Wet specimens / models practicals (7)					
Practical and lecture combined into a single session (8)					
Problem-solving scenarios (9)					
Self-study (10)					
Tutor classes (11)					
Other (12)					

Q19 If 'other' was selected, please specify. (Write your answer in the box below)

.....

Q20 Which teaching approach, for Neuroanatomy, was your MOST favourite? (Select only the appropriate box)

o Lectures with PowerPoint presentations (1)
o Lectures without PowerPoint presentations (2)
o Video demonstrations (3)
o Wet specimens / models demonstrations by a staff member (4)
o Computer-based practicals / tutorials (5)
o Dissection of human cadavers (6)
o Wet specimens / models practicals (7)
o Practical and lecture combined into a single session (8)
o Problem-solving scenarios (9)
o Self-study (10)
o Tutor classes (11)
o Other (please specify) (12) _____

Q21 Please supply the reason for choosing this specific approach as your MOST favourite (in the box below).

.....

Q22 Which teaching approach was your LEAST favourite? (Select only the appropriate box)

o Lectures with PowerPoint presentations (1)
o Lectures without PowerPoint presentations (2)

- o Video demonstrations (3)
- o Wet specimens / models demonstrations by a staff member (4)
- o Computer-based practicals / tutorials (5)
- o Dissection of human cadavers (6)
- o Wet specimens / models practicals (7)
- o Practical and lecture combined into a single session (8)
- o Problem-solving scenarios (9)
- o Self-study (10)
- o Tutor classes (11)
- o Other (please specify) (12) .....

Q23 Please supply the reason for choosing this specific approach as your LEAST favourite (in the box below).

.....

Q24 Regarding your attendance in this Neuroanatomy module: (Tick only the appropriate boxes)

	All the time (1)	Most of the time (2)	Half the time (3)	Almost never (4)	Never (5)	Not applicable for this module (6)
How often did you attend the Neuroanatomy lectures? (1)						
How often did you attend the Neuroanatomy practicals? (2)						
How often did you attend the Neuroanatomy practical-lectures? (3)						
How often did you attend the additional tutor classes / supplementary instruction sessions? (4)						

Q25 Indicate your level of agreement. (Select only the appropriate options)

	Strongly agree (1)	Agree (2)	Disagree (3)	Strongly disagree (4)
Neuroanatomy is an important component in my medical training. (1)				
Although Neuroanatomy is interesting, this subject needs selective understanding in the clinical setting. (2)				
Neuroanatomy is necessary for safe medical practice. (3)				
Neuroanatomy is of some use in the clinical setting, but its importance may be exaggerated. (4)				
Neuroanatomy is only beneficial in certain medical specialities. (5)				
Neuroanatomy is so old-fashioned that it has no importance in contemporary Medicine. (6)				
Neuroanatomy is time wasted in the medical curriculum. (7)				
Neuroanatomy needs to modernise if it is going to be really useful in Medicine. (8)				
A very good doctor must have a good knowledge of Neuroanatomy. (9)				
It is impossible to conceive a good medical training without a major Neuroanatomy component. (10)				
It is not possible to make a reasonable medical diagnosis without a sound knowledge of Neuroanatomy. (11)				
Medicine could not exist without Neuroanatomy. (12)				
Only a limited neuroanatomical knowledge is required for safe medical practice. (13)				
Rather than studying Neuroanatomy, medical students should concentrate on clinical sciences. (14)				
Without a knowledge of Neuroanatomy, the doctor is of limited effectiveness. (15)				

Q26 Please write comments regarding your Neuroanatomy experience in the box below.

.....

Q27 Please write any suggestions for the Neuroanatomy lecturers in the box below.

.....