Does Studying Veterinary Medicine Improve Students' Haptic Perception Ability? A Pilot Study With Two Age-Groups

Stephanie M. Mueller ■ Dora Bernigau ■ Christoph Muelling ■ Martin Grunwald

ABSTRACT

Haptic perception is an important tool for veterinarians. The present study analyzed the association between the haptic perception threshold of veterinary students and their palpatory experience. To approach this goal, 35 female students of veterinary medicine were divided into two groups with different levels of experience: (a) students with little practical experience, at the beginning of their studies (first year), and (b) students close to the end of their theoretical training (fourth year). To thoroughly evaluate the students' sense of touch, three different test procedures were used: the Haptic Threshold Test (HTT), the Haptic Figures Test (HFT), and tactile acuity. Contrary to our expectations, we found higher mean haptic perception thresholds (HTT) in the more experienced students than in the less experienced group. This effect was significantly correlated with age. Furthermore, we found that longer exploration times were not sufficient to compensate for shortcomings in haptic perception. We also found large interindividual differences.

Future studies should investigate whether and to what extend these effects have an impact on students' palpation performance on simulators and live animals. Moreover, which beneficial effects may be achieved through an additional haptic training for students with inferior haptic thresholds should be investigated. Improving haptic perception abilities in veterinary students could be one important step toward achieving satisfactory Day One Competences in university graduates.

Key words: aging, haptic, tactile, training, expertise, palpation, grating orientation

INTRODUCTION

Palpation is an essential aspect in the process of veterinary diagnostics of both small and large animals, as well as livestock. It plays an important role in clinical examinations on and through the body wall and is central during pregnancy diagnosis and estrus status for insemination in horses and cattle, as well as in the diagnosis of different causes of colic symptoms in horses via transrectal examination. To better prepare the students for the requirements of their first employment, academic education has become more application-oriented over the past years. [1,2] Thus, the European Association of Establishments for Veterinary Education (EAEVE) and the American Veterinary Medical Association (AVMA), among other associations, have defined essential practical skills that should be mastered by every graduate.[3,4] These include the ability to perform complete clinical examinations and propaedeutic practical training on all common domestic animal species. Besides visual appraisal, a major part of examination consists of palpation. Consequently, acquisition of palpatory skills is of substantial importance in veterinary education, although not explicitly mentioned in EAEVE's Day One Competences and just sparsely described in the AVMA's Recommended Skills List. Accordingly, in recent years, many institutions have established skills labs that enable students to gain practical experiences with animal simulators and models across their whole course of study, without the potential to harm live animals. This trend can be observed in veterinary academic training across many Western nations. By means of high- and low-fidelity simulators, competences such as insertion of a venous catheter, intubation, or pregnancy assessment can be acquired and practiced without unsettling or endangering live veterinary patients (among others[5–7]). Veterinary education in Germany includes 3,850 hours of theoretical training, and an additional 1,170 hours of practical training. In addition to their obligatory curriculum, students of veterinary medicine at the University of Leipzig, for example, can visit the skills lab, containing a vast variety of simulators, for self-directed training, from the beginning of their first year of study to practice their examination skills. Apart from practical training and consolidation of theoretical knowledge, sensorimotor skills are learned most notably during these sessions.

Essentially, palpation consists of actively exploring movements of the whole hand, as well as proprioceptive information from the arm and shoulder. Passive static contact, by contrast, seldom occurs during veterinary practice. In haptic research, the two types of touch are distinguished as “haptic” and “tactile” perception. During haptic perception, the subject actively moves to explore objects and surfaces; during tactile perception, the subject remains still while a body part is touched by an external stimulus.[8,9] The resulting perception thresholds differ intensively for these two types of touch. Under ideal conditions, a healthy young human adult can detect a single elevation of just 1 µm (1 mm = 1,000 µm) on an otherwise smooth surface via haptic exploration.[10,11] By contrast, the tactile detection threshold (measured through 2-Point Discrimination or Grating Orientation Task) reaches only approximately 1 mm.[12,13]

Women have been reported to have slightly lower thresholds for heat, cold, pain, vibratory stimuli, and tactile acuity.[14–16] Foundational research has shown that these gender differences cease to exist when body height, finger size, and body fat are taken into account.[14,16–18] The effect has been discussed to be caused by higher receptor densities in smaller fingers.[14] Since the test subjects actively move to explore during haptic perception, receptor densities should have no effect on haptic perceptual thresholds. Nonetheless, men have been reported to show better results in tasks requiring spatial abilities such as haptic orientation perception.[19–21] This effect has been discussed to be the result of men being more prone to using allocentric reference frames.[20]

Both haptic and tactile perception ability differ between individuals across all ages. Underlying factors influencing haptic perception ability are individual disposition, age, training, and diseases that may cause polyneuropathy.[22–25] An earlier study conducted with physiotherapists showed, for example, that haptic perception ability and work experience (expertise) were linked.[23] These and other results have shown an increase in sensitivity with increasing intensity of use. Accordingly, in addition to cortical changes through neuroplasticity, as demonstrated by functional magnetic resonance imaging (MRI) examinations, professional musicians showed enhanced haptic perception thresholds.[26] Similarly, the haptic threshold of blind braille readers has been shown to be enhanced compared to a sighted control group. This gain was especially prominent in the finger predominantly used for reading.[27] The effects of sensorimotor training on neuroplasticity are also used in the treatment of patients with chronic pain or after stroke.[28]

Performing a good clinical examination requires experience on the one hand and great competence in palpation and haptic abilities on the other. The latter should be analyzed and trained in experimental settings. To the authors’ best knowledge, no investigations on haptic skills of veterinary medical students have yet taken place.

Based on the existing evidence from foundational haptic research, the present pilot study aimed to analyze the association between students’ haptic perception threshold and their palpatory experience. Overall, three hypotheses were tested. Due to the relatively small age range and the overall young age of the participants, we did not expect to find a decline in tactile or haptic sensitivity with age in this sample (Hypothesis 1). Concurrently with the abovementioned results concerning the plasticity of haptic perception due to practice, we expected to find a higher haptic sensitivity in fourth-year students compared with first-year students (Hypothesis 2). Since passive static (tactile) contacts only scarcely occur during palpation and are therefore not practiced in the skills lab, the two groups should not differ in their tactile perception thresholds (Hypothesis 3).

METHODS

Participants

Two groups of students with different states of experience were tested: (a) students with little practical experience at the beginning of their studies (first year, n = 13), and (b) students close to the end of their theoretical training (fourth year, n = 22).

Of the participants (N = 35, all female), 31 were right-handed. All participants had normal or corrected-to-normal eyesight. The participants in first year had a mean age of 21.08 years (SD = 2.53; range: 19–26 years). The participants in fourth year had a mean age of 24.09 years (SD = 3.16; range: 21–34). All participants were veterinary students recruited via advertisements at the Faculty of Veterinary Medicine of Leipzig University

Exclusion criteria were neurological and psychiatric disorders, as well as any known polyneuropathy or paresthesia of the hands. The information was gathered via a self-report questionnaire. Each participant gave written informed consent. All procedures were in accordance with the Declaration of Helsinki and were approved by the Institutional Ethics Committee.

Experimental Tests and Procedures

The participants were seated at a table in a quiet room. Polyneuropathy as well as neurological and psychological disorders were assessed via a questionnaire. To thoroughly evaluate the students’ sense of touch, we used both tactile and haptic test procedures. The tests were administered in random order.

Haptic Threshold Test

Haptic threshold perception was measured using the Haptic Threshold Test (HTT),[23] which consists of 13 stimuli of parallel groves and ridges that are covered by an opaque polyvinyl chloride (PVC) layer to obscure them visually (Figure 1). The separating PVC layer is 252 micrometers (µm) thick. With each stimulus, the distance between the ridges varies by 200 µm. Table 1 lists all 13 peak-to-peak values as well as the corresponding elongation values of the PVC layer measured with an indenter point at a force of 150 millinewtons (mN). These measurements present a good estimation of the palpable deformation values.[23] High HTT values indicate high sensitivity (i.e., low haptic thresholds).

During testing, the participants were seated at a table with the test board in front of them. On the left side of the test board, the reference stimulus (peak-to-peak value = 7 mm)

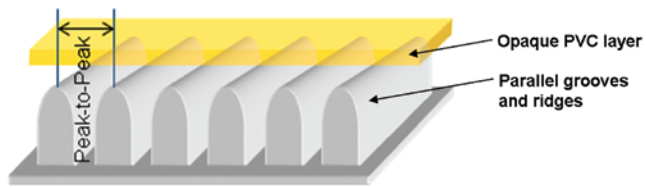

Figure 1: Scheme of the Haptic Threshold Test (HTT) stimulus structure

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Table 1: Technical plastic deformation gauge of the separating polyvinyl chloride (PVC) layer

Haptic-pad number	Peak-to-peak value (mm)	Elongation value (μm[1])
1	3.0	54.71
2	2.8	45.62
3	2.6	39.40
4	2.4	26.11
5	2.2	25.57
6	2.0	23.42
7	1.8	15.23
8	1.6	12.22
9	1.4	10.69
10	1.2	8.25
11	1.0	7.14
12	0.8	6.48
13	0.6	2.16

Note: Mean elongation values in micrometers (μm) of the PVC layer for each haptic stimulus pad measured with a force of 150 mN (millinewtons) applied by a perpendicular indenter tip.

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was firmly attached to the board with its parallel groves and ridges fixed in horizontal orientation (Figure 2a). It remained there for the entire test procedure and could be explored by the participant at any time. It served to indicate the horizontal orientation. On the right side of the board was a magnet that held the test stimuli in place while still allowing them to be spun. The participants were instructed to haptically explore the stimuli and to bring them into a horizontal orientation. The smaller the peak-to-peak distance of the respective stimulus, the more difficult it was for the participants to perceive the orientation of the grating structure. No time limit was given, and the participants were free to explore with any number of fingers and exploration strategies they liked. Because of the marks on the back of the experimental structure, the examiner could register the resulting orientation of the stimulus.

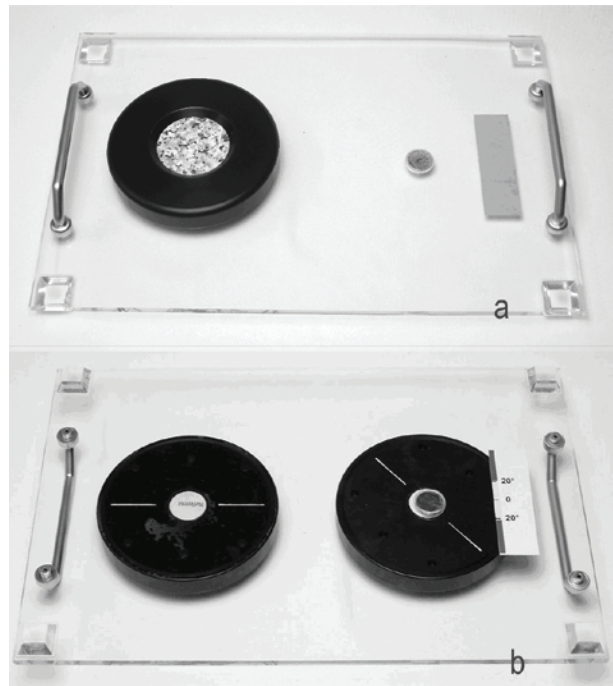

Figure 2: Haptic Threshold Test (HTT) test board with the reference stimulus on the left side **a)** Front view; **b)** Rear view with test stimulus in diagonal orientation (white line) and measurement scale on the right.

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If the line gratings were within 20 degrees above or below the horizontal line, the stimulus was considered recognized (Figure 2b). All 13 stimuli were presented in random order and orientation. After a 5-minute break, all 13 stimuli were presented a second time. The haptic threshold was indicated by the stimulus with the smallest peak-to-peak distance, which was correctly recognized twice.

Haptic Figures Test

Assessment of the participants' global haptic perception ability was achieved using the Haptic Figures Test (HFT).[21,29,30] The test consists of 16 two-dimensional relief stimuli (Figure 3a) which are covered by an opaque PVC layer and fixed in a rectangular plastic frame (Figure 3b). With slight pressure from fingertips, the stimulus structures are discernable through the PVC layer while remaining invisible. Testing began with a sample stimulus to explain the procedure. After exploration, the participant had to identify the stimulus on a visual display (on the table in front of the participant) depicting all 16 figures (Figure 3a). Stimuli were presented in random order and orientation. No limits were set on exploration time or procedure. The resulting dependent variables were exploration time and number of errors.

Tactile acuity

Participants' tactile acuity was measured with grating domes (Figure 4; Grating Orientation Task; JVP Domes, Stoelting Co., Wood Dale, IL).[12,13] Eight different groove

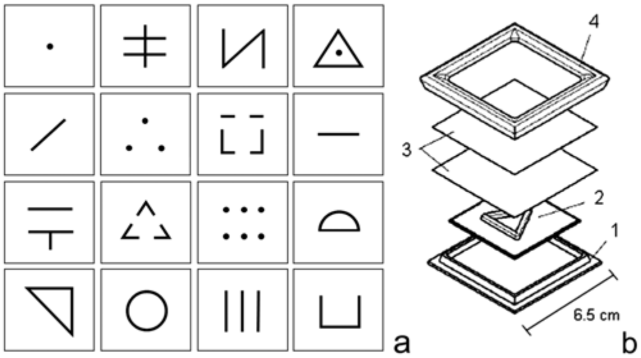

Figure 3: Haptic Figures Test **a)** 16 two-dimensional relief stimuli; **b)** Construction of the stimuli. 1 base plate; 2 two-dimensional geometric form; 3 opaque plastic film consisting of two layers; 4 bracket/frame

Figure 3b Reproduced from Grunwald[21] with permission of Springer Science+Business Media.

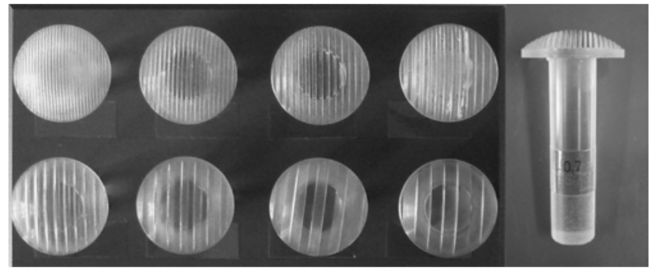

Figure 4: Tactile Acuity (Garting Domes; Stoelting Co., Wood Dale, IL) with groove and ridge widths of 0.3, 0.5, 0.7, 1.0, 1.2, 1.5, 2.0, and 3.0 mm

and ridge widths were used (0.3, 0.5, 0.7, 1.0, 1.2, 1.5, 2.0, and 3.0 mm). To perform the test, the examiner applied each dome 20 times to the distal part of the index finger of the participant's dominant hand for 1 second. The participants were asked to indicate the orientation of the groves and ridges after each application. Orientation was randomly varied between along and across the finger axis. The test began with the easiest stimulus of the widest grating width (3 mm) and became successively more difficult. Tactile acuity was then calculated in accordance with the test manual.

Data Analysis

To analyze the data, the statistics software SPSS 24.0 (IBM Corp., Armonk, NY) was used. A standard Pearson's correlation (one-sided) was used to assess the relationships

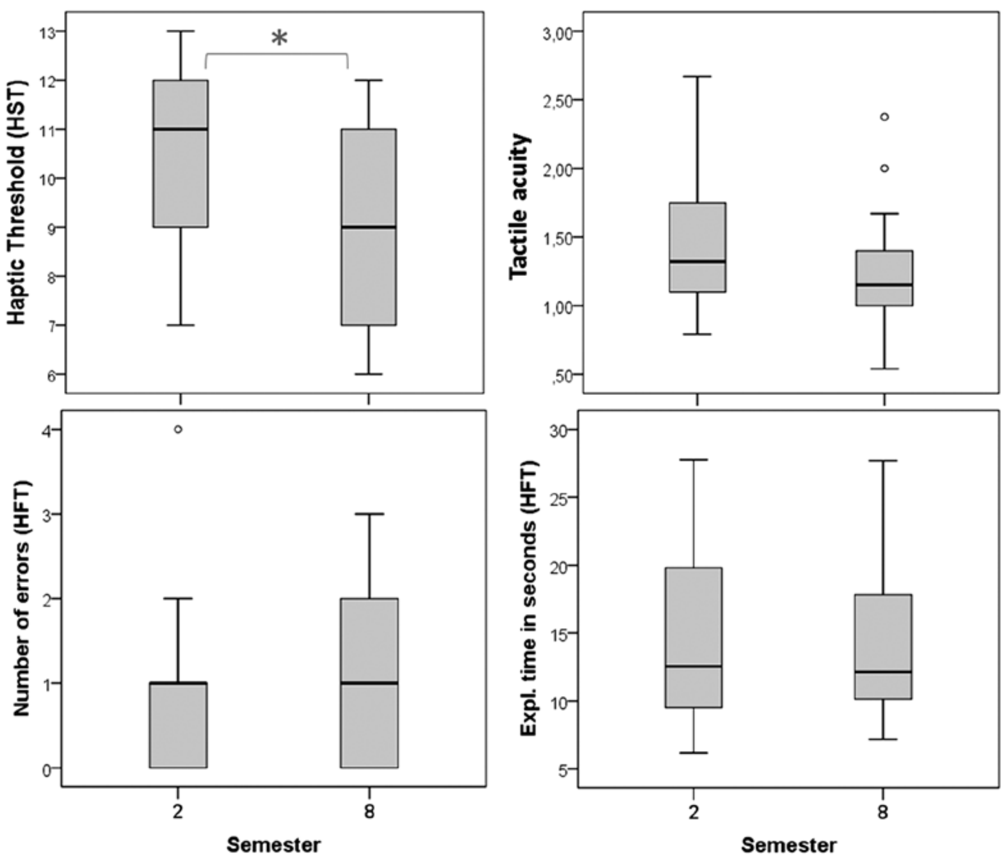

Figure 5: Box plots for Haptic Threshold Test (HTT), tactile acuity, and Haptic Figures Test (HFT) values

Note: High sensitivity is indicated by high values for HST and low values for tactile acuity. Outlier values are depicted as small circles.
* significant group differences.

of depending variables and age. Since the assumption of normal distribution of the data was not warranted, non-parametric Mann–Whitney U tests were used to conduct group comparisons. The alpha level was set at 5%.

RESULTS

The two groups were significantly different in age ($z = -3.031$, $p < .01$). Participants in their fourth year were slightly older ($M = 24.09$, $SD = 3.161$) than the participants in their first year ($M = 21.08$, $SD = 2.532$).

In addition, we found a marginally significant correlation between age and haptic threshold ($rHST = -.280$; $b1 = -0.176$; $p = .052$) when both groups (first- and fourth-year students) were combined, but we found no association between age and any other test measures (tactile acuity: $r = -.141$; $p = .210$; HFT exploration time: $r = -.029$; $p = .435$; HFT number of errors: $r = .109$; $p = .267$).

Furthermore, we found a significant difference of haptic thresholds between the two groups ($z = -2.500$, $p < .05$). Participants in their fourth year reached *lower* mean HTT values ($M = 8.86$, $SD = 1.910$) than the younger group ($M = 10.62$, $SD = 1.850$). For general haptic perception ability and tactile acuity no group differences were found (HFT exploration time: $z = -0.102$, $p = .918$; HFT errors: $z = -0.291$, $p = .771$; tactile acuity: $z = -1.230$, $p = .219$; Figure 5). All three tests revealed strong interindividual differences (Figure 5).

Further explorative analyses of possible interactions between the test measures revealed significant positive correlations between tactile acuity and HFT exploration time ($r = .295$; $p < .05$) and between HFT exploration time and HFT number of errors ($r = .396$; $p < .01$).

DISCUSSION

The present study revealed a decrease of haptic sensitivity (measured with the HTT) with age, disproving Hypothesis 1. This age effect on the haptic threshold is astonishing, since we did expect haptic perception to improve through educational experience. However, earlier studies have shown that the HTT is very sensitive to age-related decline and that the reduction approximates one HTT value every 5.3 years in a 35–50-year-old sample ($N = 44$).[23,31] The decline in the present sample (aged 19–34 years, $N = 35$) was slightly less steep, with a marginally significant decrease in haptic sensitivity of approximately one HTT value every 5.7 years. Other studies investigating age effects on haptic sensitivity in children and young adults are sparse. However, several studies investigating sensitivity to vibratory stimuli have shown that children exhibit the lowest vibrotactile thresholds and that age-related changes (especially concerning high frequencies) manifest as early as the teenage years.[32,33] The movement of the fingertip across the corrugated surface of the HTT stimuli with smaller distances between the grooves and ridges may result in vibratory sensations if the finger is moved with sufficient speed. While the HTT poses further demands on haptic spatial perception, these vibratory effects may be the cause of the age effect found in the present sample.

All other measures (general haptic perception ability and tactile acuity) were not associated with age in this sample, which is in line with the results of existing literature.[34] Although other studies using tactile threshold measures have shown a decline of tactile sensitivity in participants between 20 and 80 years of age, these results may have been skewed due to a steeper decline in older adults.[35] Group comparisons between tactile thresholds of children and young adults routinely do not elicit statistical significance.[34,35]

In line with the results above, Hypothesis 2 was disproven as well: we could not find any improvement in haptic perception in the fourth-year students. Instead, we found that the mean HTT value of the fourth-year group was significantly lower than that of the first-year group. This result is in accordance with the correlation analysis of age and haptic threshold in Hypothesis 1 and may therefore be attributed to age-related decline.

Hypothesis 3, concerning the group differences in tactile acuity, however, was confirmed: first- and fourth-year students did not differ in their tactile thresholds. Similarly, in a different study, tactile acuity was not sensitive to age in middle-aged participants in contrast to haptic threshold.[23] It is not yet known why haptic threshold would be more susceptible to age than tactile threshold. Tactile perception may be considered a simpler task since the test subject is inert. Therefore, less sensory integration and processing capacities are required.[36] A recent study investigating participants aged 40 to 90 years even showed a strong correlation between cognitive performance and haptic perception but only minor relations between tactile and haptic perception.[37] Decline in tactile sensitivity, on the other hand, has been shown to be linked to decreasing receptor numbers and slower nerve conduction velocity in older age.[35,38] Also, cognitive performance is known to be very susceptible to fatigue and stress.[39] The fourth-year students were approaching their final exams and may have been more stressed than the younger participants. It may be speculated that this could have had an influence on their vigilance and concentration, and therefore on their haptic performance. However, additional cognitive tests would be necessary to evaluate this possibility. Besides the statistically indicated age effect, we can only speculate about the underlying factors of the higher mean haptic threshold in the fourth-year group. Negative motivational effects are unlikely, since all other test measures would have been influenced as well, especially as the order of testing was randomized. Future studies should consider gathering additional psychophysiological and/or cognitive data to analyze the underlying factors. Future studies should also consider conducting longitudinal investigations to facilitate the analysis of individual differences across individual trajectories.

It has been shown repeatedly that any age-related decline in touch perception may be compensated through training and occupation-related intensive use up until old age.[23,34] However, in the present study with students of veterinary medicine, educational experience and practice were sufficient neither to induce a measurable increase in haptic sensitivity nor to compensate the apparent age effect.

We also found strong interindividual differences within the groups, similarly to those other studies have found.[22–24] Since the participants were homogenous in gender and experience, these differences are most likely dispositional in nature.

Additional exploratory analyses of interaction effects between the test measures indicated an association between tactile acuity and global haptic perception ability. In other words, participants who did less well on the tactile acuity task also needed more time to solve the HFT. Longer HFT exploration times in turn coincided with higher HFT error rates—meaning that longer exploration times were not sufficient to compensate for potentially global shortcomings in haptic perception. Long exploration times in combination with high error rates have been shown to be indicative of cortical sensory integration dysfunction in clinical studies.[29],[40] However, in the present sample of healthy veterinary students, the exploration times were still relatively short, and the error rates relatively low. The respective impact on a students' ability to accurately palpate may be equally low in a best-case scenario. For clarification, future studies should investigate whether and to what extend individual differences in haptic perception have an impact on the students' palpation performance on simulators and live animals. Furthermore, future studies should also analyze what beneficial effects may be achieved through an additional haptic training. Earlier studies have shown that despite intensive theoretical preparation and simulator practice, students differ greatly in their palpation performance on live animals.[5] Studies should assess whether these performance differences are in any way connected to individual haptic thresholds. To the authors' knowledge, the present study was the first attempt to evaluate haptic perception ability in veterinary students via standardized tests.

CONCLUSION

The present study revealed lower haptic sensitivity in fourth-year veterinary students than in first-year students. Therefore, the students' palpatory experience was not sufficient to elicit a favorable effect on haptic perception thresholds in the fourth-year students. Instead we found a decline in haptic perception with age; strong interindividual differences; and a correlation of tactile acuity, error rates, and exploration times. Further studies are necessary to investigate the impact of interindividual differences in haptic perception on the students' palpation performance on simulators and live animals. Furthermore, it should be analyzed what beneficial effects may be achieved through an additional haptic training for students with lower haptic sensitivity.

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