Correlating fibreoptic nasotracheal endoscopy performance and psychomotor aptitude

A. K. DASHFIELD AND J. E. SMITH

Summary
We have investigated the correlation between the scores attained on computerized psychometric tests, measuring psychomotor and information processing aptitudes, and learning fibreoptic endoscopy with the videoendoscope. Sixteen anaesthetic trainees performed two adaptive tracking tasks (ADTRACK 2 and ADTRACK 3) and one information management task (MAZE) from the MICROPAT testing system. They then embarked on a standardized fibreoptic training programme during which they performed 15 supervised fibreoptic nasotracheal intubations on anaesthetized oral surgery patients. There was a significant correlation between the means of the 15 endoscopy times and both ADTRACK 2 ($r = -0.599, P = 0.014$) and ADTRACK 3 ($r = -0.589, P = 0.016$) scores. The correlation between the means of the 15 endoscopy times and MAZE scores was not significant. The ratios of the mean endoscopy time for the last seven endoscopies to the mean endoscopy time for the first seven endoscopies were not significantly correlated with ADTRACK 2, ADTRACK 3 or MAZE scores. Psychomotor abilities appeared to be determinants of trainees’ initial proficiency in endoscopy, but did not appear to be determinants of trainees’ rates of progress during early fibreoptic training. (Br. J. Anaesth. 1998; 81: 687–691).

Keywords: intubation nasotracheal; intubation nasotracheal; training; anaesthetists, training; equipment, fibreoptic laryngoscope

Perceptual–motor skills involve the combination of perceptual, cognitive and motor abilities in a closed-loop stage. First, sensory information is detected and assembled and passed on to the information processing stage. Here, decisions about appropriate responses are made and a motor programme is organized. This programme is effected by the motor system and the resulting action generates response feedback which presents further sensory information for evaluation.

Much psychological research has been directed towards the objective assessment of perceptual–motor abilities. Abilities are inherited, stable and enduring aptitudes that an individual brings to the performance of his life tasks. There may be up to 50 enduring aptitudes that an individual brings to the loop system. First, sensory information is detected and perceptual, cognitive and motor abilities in a closed-loop system. Perceptual–motor skills involve the combination of abilities. Abilities are inherited, stable and enduring aptitudes that an individual brings to the performance of his life tasks. There may be up to 50 enduring aptitudes that an individual brings to the loop system. First, sensory information is detected and perceptual, cognitive and motor abilities in a closed-loop system. Perceptual–motor skills involve the combination of

by their genetic make-up. Skill describes an individual’s proficiency at a particular task that has developed with and is modified by practice. An individual may acquire countless skills but each particular skill is based on a specific combination of the relatively small number of fundamental abilities. Thus abilities underlie and are limiting factors of the individual’s skilled performance of a task.13

Microprocessor-controlled neuropsychological or psychometric tests have been developed to measure a range of perceptual–motor abilities. Psychometric tests may be classified according to the type of perceptual–motor ability they examine, for example perception, information management or psychomotor, although often there are no clear-cut distinctions and there is much overlapping.4 Many psychometric tests have been validated as reliable predictors of technical skill performance and they appear to have practical applications in personnel recruitment in many spheres of everyday life.5 In the Armed Services, batteries of psychometric tests, in conjunction with personality questionnaires, curriculum vitae analyses and formal interviews are used to select candidates who are likely to be successful in pilot training.6 7 Psychomotor tests, for example adaptive tracking tasks, which measure eye–hand co-ordination, are particularly relevant here, but increasingly, as flying systems become more complex and aircrews need to monitor and control computer-based systems, information management ability is also expedient. In the UK, a fully automated selection testing system, MICROPAT (MICROcomputerized Personnel Aptitude Tester), which assesses both psychomotor and information management ability patterns, has been developed and validated.4 7 In the field of anaesthesia, learning fibreoptic endoscopy demands that anaesthetists develop new types of practical skills.8 It may be that eye–hand co-ordination and other psychomotor abilities are among the primary aptitudes on which flexible endoscopy skills are based. However, there is no information on whether psychometric test scores can predict endoscopy skills. In this study, we have investigated if there were significant correlations between the scores obtained by anaesthetic trainees on MICROPAT psychomotor and information management tests and the times taken for the trainees to perform their first 15 fibreoptic nasotracheal endoscopies.

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Subjects and methods

The study was approved by the South Birmingham Local Research Ethics Committee. Sixteen consecutive anaesthetic trainees appointed to the Birmingham School of Anaesthesia who had no previous experience in fibreoptic techniques performed three computerized psychometric tests, ADTRACK 2 (AD2), ADTRACK 3 (AD3) and MAZE from the MICROPAT testing system. The anaesthetic trainees were tested in the morning, having not been on duty the night before. Normal caffeine ingestion and tobacco consumption were allowed before psychometric testing and during fibreoptic training, as the training programme often took many days to complete and it may have been impractical to restrict the intake of these items during the whole of this period. None of the trainees were computer game enthusiasts. The trainees performed the MICROPAT tests with their dominant hand controlling the joystick (and they similarly held the fibrescope controls in the dominant hand when they embarked on the fibreoptic training programme).

AD2 and AD3 are joystick-controlled, one-dimensional adaptive pursuit tracking tasks designed to test eye–hand co-ordination. Adaptive refers to the task becoming more difficult as the candidate’s performance improves. In AD2, the computer displayed a block surrounded by two bars. The computer moved the bars from side to side and the trainee was required to keep the block as close to the bars as possible using the joystick. A number on the screen told the candidate how well he or she was doing. The lowest possible score was 1 and the highest, 17. AD3 is similar to AD2 except that the trainee could control the adaptation. The screen showed the current difficulty level and an indication of the amount of error in performance at that level. Difficulty level or adaptation was increased by pressing one key and decreased by pressing another. The adaptation increased automatically in AD2 and AD3 by speeding up the pursuit. In AD3, difficulty level could be increased further by making the trajectory less predictable.

MAZE was designed to test information management abilities. Candidates were required to direct nine separate targets around a square maze on the computer screen until they reached the middle (home). The targets moved in straight lines and the operator had to tell them to turn corners by pushing a button. The targets set off at equally timed intervals, so that it was possible to have nine targets requiring direction at any one time. If a target failed to turn a corner and “crashed”, then that target was lost. The final score was calculated on the overall distance travelled by the targets. Full instructions were displayed on the screen for all tests so that no intervention by an instructor was required. Typical time for instructions, practice and testing for each of the three tests was 10 min. To avoid any possibility of bias, neither instructors nor trainees were made aware of any psychometric scores—all test data were stored on the computer hard disk and no scores were compiled until all trainees had completed their fibreoptic training programmes.

Each anaesthetic trainee then embarked on a standardized graduated fibreoptic training programme, described previously. Initially, the set-up of the videoendoscope system was demonstrated to the trainee, as were the fibrescope controls and the correct way to manipulate the instrument. Trainees then had a structured, video-controlled practice session on a bronchial tree model, after which they viewed a videotape recording showing details of airway anatomy and good endoscopy technique. Each trainee then performed 15 fibreoptic nasotracheal endoscopies and intubations with the videoendoscope under the supervision of an experienced trainer. Patients were ASA I or II, aged 16–70 yr, undergoing elective oral surgery requiring nasotracheal intubation.

Trainees were required to perform fibrescopy only in patients who were expected to present uncomplicated fibreoptic intubations. Hence patients were not obese, had no history of oesophageal reflux, no evidence of nasal obstruction and no significant abnormality of the airway. Electrocardiogram, indirect arterial pressure, arterial oxygen saturation and carbon dioxide concentrations were monitored and patients’ lungs were preoxygenated. Anaesthesia comprised glycopyrrolate, fentanyl, propofol and atracurium. The patient’s lungs were hyperventilated with isoflurane in oxygen using a face mask attached to a Bain breathing system, after which endoscopy was conducted in a standard manner. The trainee performed endoscopic anterior rhinoscopy in both nostrils, selected the most patent, moved the fibrescope forward either underneath or alongside the inferior turbinate, identified structures in the nasopharynx, then advanced the instrument through the pharynx, larynx and trachea to the carina. Finally, the tracheal tube was railroaded over the fibrescope which guided it into the trachea to complete the intubation. The importance of continually seeing the airway and identification of airway anatomy was emphasized. The instructor gave demonstrations, advice, feedback guidance and assistance as necessary. Videotape recordings of the first five endoscopies were made following General Medical Council guidelines, and were subsequently reviewed by trainee and instructor during a debriefing session. Endoscopy time was taken as the time required to move the fibrescope from the first nostril examined to the carina and was recorded for every intubation.

The mean of each trainee’s 15 endoscopy times was paired with his or her AD2, AD3 and MAZE scores, and the correlation between endoscopy times and psychometric test scores were analysed using Pearson correlation coefficients and linear regression. The mean times for the first seven endoscopies and last seven endoscopies and the ratios of the mean times for the last seven endoscopies to the mean times for the first seven endoscopies were also studied. \( P<0.05 \) was considered statistically significant.

Results

Age, professional status and sex of the 16 trainees studied are given in table 1.

<table>
<thead>
<tr>
<th>No. of Trainees</th>
<th>Age (yr)</th>
<th>Professional status</th>
<th>Sex (M/F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>30.06 [26–36]</td>
<td>7 Specialist Registrars</td>
<td>12/4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 Senior House Officers</td>
<td></td>
</tr>
</tbody>
</table>
All trainees improved with fibreoptic intubation practice and mean endoscopy times decreased progressively during the first 15 endoscopies (fig. 1).

There were significant correlations between mean endoscopy times for the 15 endoscopies and AD2 scores (table 2, fig. 2) and AD3 scores (table 2, fig. 3). Mean times for the first seven endoscopies (Nos 1–7) and for the last seven endoscopies (Nos 9–15) were also significantly correlated with AD2 and AD3 scores (table 2). Correlations between mean times for the 15 endoscopies, the first seven endoscopies and the last seven endoscopies and MAZE scores were not statistically significant (table 2, fig. 4).

The rates at which individual trainees improved varied considerably. The ratios of mean endoscopy times for the last seven endoscopies to mean endoscopy times for the first seven endoscopies varied from 0.46 to 0.79 (table 2). However, improvement ratios were not significantly correlated with AD2, AD3 or MAZE scores (table 2).

In order to minimize some of the effects resulting from trainees’ encountering patients’ airways of varying degrees of difficulty, the statistical analyses were repeated on the data when each trainee’s fastest and slowest endoscopy times were omitted. Similar correlations to those above were found (table 3).

**Discussion**

We have shown that there was a significant negative correlation between mean times required by anaesthetic trainees to perform their first 15 fibreoptic endoscopies and scores on psychomotor tracking tests. This confirms the impression that manual dexterity, eye–hand co-ordination and other motor abilities are important determinants of an individual’s initial level of endoscopy skill and performance. However, there appeared to be no correlation between MAZE, an information processing test from the MICROPAT system, and endoscopy times. This suggests that the ability to process and use a sequence of fast-moving information, as tested by MAZE, is not a key aptitude when performing fibreoptic endoscopy. Further studies are required to determine the extent to which other information processing abilities are pertinent to fibreoscopy. MICROPAT embraces tests relevant to two of the three stages of Schmidt’s closed-loop model for perceptual–motor skills, but does not examine perception, the first stage. It is conceivable, however, that spatial orientation, complex visuospatial organization and other perceptual abilities are intimately involved in the skilful performance of

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**Table 2**  Correlations coefficients ($r$) between AD2, AD3, MAZE and fibreoptic nasotracheal endoscopy time variables (for 15 endoscopies).

<table>
<thead>
<tr>
<th>Endoscopy time variable</th>
<th>Mean of means</th>
<th>Range of means</th>
<th>Psychometric test</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean endoscopy times for 15 endoscopies (s)</td>
<td>86.3</td>
<td>66–122</td>
<td>AD2</td>
<td>$-0.599^*$</td>
</tr>
<tr>
<td>Mean endoscopy times for first 7 endoscopies (1–7) (s)</td>
<td>106.1</td>
<td>72–140</td>
<td>AD3</td>
<td>$-0.589^*$</td>
</tr>
<tr>
<td>Mean endoscopy times for last 7 endoscopies (9–15) (s)</td>
<td>68.2</td>
<td>48–108</td>
<td>MAZE</td>
<td>$-0.102$</td>
</tr>
<tr>
<td>Mean endoscopy times for last 7 endoscopies (9–15) (s)</td>
<td>68.2</td>
<td>48–108</td>
<td>AD2</td>
<td>$-0.530^*$</td>
</tr>
<tr>
<td>Ratios of mean endoscopy time for last 7 endoscopies (9–15)</td>
<td>0.64</td>
<td>0.46–0.79</td>
<td>AD3</td>
<td>$-0.091$</td>
</tr>
<tr>
<td>to mean endoscopy time for first 7 endoscopies</td>
<td></td>
<td></td>
<td>MAZE</td>
<td>$-0.085$</td>
</tr>
</tbody>
</table>

* Both $P<0.05$
fibreoptic endoscopy. Perceptual processing has been shown to be necessary for laparoscopic manipulations, and Schueneman and colleagues have demonstrated that perceptual and information processing abilities were more accurate predictors of operative skill among surgical residents than psychomotor aptitude. Academic achievements, incidentally, were found not to correlate, or even to correlate negatively, with surgical skill in Schueneman’s studies, as in others. Sivarajan and colleagues studied anaesthetic residents as they learned spinal anaesthesia and also found that their academic knowledge of the technique did not correlate with their criterion-referenced clinical performance of it.

It is important to note, however, that the rates at which trainees’ times improved during their first 15 intubations were not significantly correlated with psychomotor scores. Hence, psychomotor abilities do not appear to be good predictors of the individual’s rate of learning of fibreoptic skills during early training. One possible reason for this is that the study was designed to examine the initial stages of fibreoptic training, not the whole endoscopy learning process. There is evidence that the mean half-life for fibreoptic nasotracheal endoscopy learning is approximately nine endoscopies, and this implies that the average trainee needs to perform at least 45 endoscopies before he approaches his asymptote or “expert time,” when the learning process may be considered almost complete. Hence endoscopy records collected over a much longer period than in this study would be required to confirm or refute an association between psychomotor abilities and the rate of learning of fibreoscopy from novice to expert. When acquiring complex motor skills, beginners need first to go through the verbal–cognitive stage of learning. Here, the main concern is to analyse what needs to be done, explore different strategies and elaborate the most effective and efficient technique for performing the task. Hence cognitive abilities may be more important during the early stages of motor learning, and psychomotor abilities may become more relevant in later stages, when cognitive problems have been solved.

MICROPAT psychomotor tracking tests were designed primarily as measures of eye–hand co-ordination and control precision for the selection of UK Army Air Corps pilots. The initial validation study used a sample of 243 pilot trainees and found that the correlation coefficient between MICROPAT

<table>
<thead>
<tr>
<th>Table 3 Correlations coefficients (r) between AD2, AD3, MAZE and fibreoptic nasotracheal endoscopy time variables for 13 endoscopies (each trainee’s fastest and slowest times omitted). *P&lt;0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endoscopy time variable</strong></td>
</tr>
<tr>
<td>Mean endoscopy times for 13 endoscopies (s)</td>
</tr>
<tr>
<td>Mean endoscopy times for first 6 endoscopies (1–6) (s)</td>
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<tr>
<td>Mean endoscopy times for last 6 endoscopies (8–13) (s)</td>
</tr>
<tr>
<td>Ratios of mean endoscopy time for last 6 endoscopies (8–13) to mean endoscopy time for first 6 endoscopies (1–6)</td>
</tr>
</tbody>
</table>
Fibreoptic nasotracheal endoscopy performance and psychomotor aptitude

691

tests and the criterion task of pilotry was 0.57 and thus MICROPAT measured approximately 33% \((r^2 \times 100)\) of the abilities underlying pilotry skills. The correlation coefficients between MICROPAT psychomotor tests and early endoscopy performance found in our study were remarkably similar. Thus psychomotor abilities may account for up to one-third of the variations in early endoscopy performance. It necessarily follows that psychomotor aptitude is by no means the only factor required for success in fibreoptic endoscopy, nor is it necessarily the most important factor. Cognitive and perceptual abilities are also likely to be crucially important. It is also essential to be well motivated, to have a positive mental attitude and to be able to focus one’s attention. It is important to learn an effective endoscopy technique and to receive quality feedback guidance from an experienced instructor. Hence there is no reason why a low psychomotor test score should disqualify an anaesthetist from fibreoptic training; all trainees should have the opportunity to receive instruction in this technique.

Although none of the trainees in our study were computer games or arcade games devotees, most had access to personal computers and some recouted playing computer games on infrequent occasions while scholars or students. It is important to know if regular practice on such games significantly affects the scores obtained in psychometric tests. In general, it is believed that transfer between two similar skills tends to be small, and Harvey has stated that there are two reasons for this. First, skills that appear similar are often based on different combinations of abilities. Second, practice at a skill reduces the proportion of variance that can be explained by specific motor abilities and increases the proportion of variance that is specific to the skill itself. Hence there is proportionately less of a highly practised skill that is available for transfer. Instructors should thus be aware of the possibility that psychomotor scores achieved by computer games experts may, to a limited extent, reflect some transfer of learning, and this may also apply to trainees with other highly developed motor skills, for example experienced pilots or musical instrument players. There is no information on whether or not these skills are also correlated with fibreoptic endoscopy performance.

Although it is not essential for a trainee to undergo psychometric tests before embarking on a fibreoptic training programme, there may sometimes be advantages in having an objective evaluation of the individual’s psychomotor aptitude. The information could be fed back to the trainee, in a constructive manner, as knowing one’s strengths and weaknesses can provide an effective tool for optimizing progress and personal development. A particularly high psychomotor score might reinforce a recommendation for further endoscopy training. An awareness of an anaesthetist’s psychomotor abilities may help instructors to tailor training programmes more effectively for the individual, for example by indicating which trainees may benefit from more extensive practice on airway simulators before embarking on treating patients.

Acknowledgements

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References