
DISCUSSION

Coffee in Class: An Alternative to Animal Experiments in Pharmacology?

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The stimulant effect of coffee on psychomotor performance was introduced as a potential alternative clinical pharmacology experiment for medical and pharmacy students

Animal experiments have been designed and standardised to demonstrate the effects of certain drugs on body organs, as part of undergraduate health professional education. However, the logistics of animal availability, the expenses incurred, increasing awareness of concerns about animal welfare¹⁻³ and the 'Three Rs' concept (i.e. *Replacement, Refinement and Reduction*),⁴ have often either reduced these experiments to tutor demonstrations or have resulted in their complete withdrawal from the undergraduate curriculum.⁵

As an alternative to satisfy the ethical concerns of animal rights activists, Computer Assisted Learning (CAL) was introduced.⁶⁻⁸ Although CAL is an effective means of fulfilling the educational objectives of laboratory sessions, the lack of hands-on experience with living tissues, the lack of practical experience to facilitate the future application of the procedures in research, as well as the absence of biological variation, are the major limitations of CAL.⁹

In view of the current scenario, we considered it necessary to investigate alternative exercises which would expose the students to experimental methodology with scientific explanation. Clinical pharmacology experiments, such as dosage calculations, rational drug selection, evaluation of drug information, and the analgesic effect of NSAIDs, have been used to supplement CAL.¹⁰ In an effort to identify alternatives to animal experiments and CAL at the undergraduate level, the Department of Pharmacology, Gulf Medical University, Ajman, United Arab Emirates, introduced a new experiment in the teaching curriculum of Bachelor of Medicine/Bachelor of Surgery (MBBS) and Pharm D (Doctor of Pharmacy) programmes. The aim of the experiment was to demonstrate the stimulant effect of coffee on psychomotor performance in students, by using simple paper and pencil tests, namely, the *Six-Letter Cancellation Test* (SLCT) and the *Digit/Letter Substitution Test* (DLST). These tests objectively assess the psychomotor functions of an individual, and integrate different mental functions, such as per-

ception, recognition, integration and reaction, in the assigned task. These tests are not meant for assessing memory or intelligence. Since they are speed tests, performance is influenced by mental alertness, concentration and coordination abilities. Both tests consist of three sections: instructions, the key (target) letters, and the working-out part. In the SLCT, the subject identifies the key letters in the working-out part, whereas in the DLST, the numbers in the working-out part have to be substituted by the corresponding letters given in the key. The duration of each test is 90 seconds. In both the tests, the extent of the working-out part exceeds the potential for completion in the stipulated time. The maximum and minimum scores for these tests vary in different subgroups. Parallel worksheets (with a different key) are used on each occasion (Figure 1 and Figure 2), to nullify the effect of memory.¹¹

Minimal materials are required

The equipment required for the experiment is readily available at low cost. It comprises three sets of parallel worksheets for the SLCT, three sets of parallel worksheets for the DLST, a stop watch, an office bell, and standard hot coffee (2g instant coffee/200ml).

The protocol

The experimental protocol is divided into five individual stages:

1. *The practice session:* The tutors familiarised themselves with the tests and planned the experiment to ensure smooth implementation. Ethical approval was granted from the Institutional Ethics Committee prior to the conduct of the experiment. The tests were administered during the pharmacology laboratory sessions to seven batches of 25-30 medical and pharmacy students.

Figure 1: The six-letter cancellation test

SIX-LETTER CANCELLATION TEST (SLCT)

Name: _____ Course: _____ Date: _____ Session: _____

Target letters: R L F T O Z

Cancel the above six letters with a slash in the given text, at your maximum speed.
Time allowed: 90 seconds

Q W E R T A Y U I O P A S D F G H L J K M Z X C V B N T M Y S Q C
 B M C Z K L J G D A P I Y B R W Q E T U O L N J G D X V N O M J B
 P H L O K M I J N U H B I Y G V T F C R D X E S Z C W A Q W I X E
 L P M K O N J R I B H U V G Y C F T X D N Z S E A Q P W K E V F K
 P O I D U Y T R E V W Q Z X C V B N M L K J H G F D S F A B P G O
 A M P N O B I V U C Y X T I Z G R E W Q L K J H F X D S E R U C H
 A D S F G J H K L Z C X V B W M N Q J E W R T U Y I O P M H N F Z
 Z P L K O M J I N Y H U B G Y V F T C D R X S E Z A Q W Y A Z G V
 Q P W O E I R U T Y A L S K D J F H G Z M X N C B V D H U P A R W
 Z X C V B N M A S D F G H J K L Q W E R T Y U I O P Q L R F S U X
 S Q A Z W S X O E D C R F V T G B Y H Q N U J M I K L O P K L T S T
 M N B V C X Z L K J H G F D S A P O I U Y T R E W Q A E I O U R A

Total attempted:
Incorrect:
Net score:

- The students were told about the importance and relevance of the tests, and were issued with the instructions necessary for performing the tests. Written consent was obtained from those who volunteered to participate in the experiment. One practice session was organised, in order to familiarise the participants with both the tests.
- The pre-coffee session:* The worksheet for the SLCT were distributed, and the students were asked to write their names on the back of the sheet. This was followed by the first bell, indicating the beginning of the ‘working-out time’, which ended with a second bell after 90 seconds. The students were asked to start and stop immediately when the bell rang, and strict monitoring of time was ensured. The sheets were randomly exchanged among the students for score calculations. The second test, the DLST, was administered in a similar manner, after an interval of 5 minutes.

- The post-coffee session:* A 200ml cup of standard coffee was served to each student. After 20 minutes, the two tests were re-administered as before, with parallel worksheets, i.e. a new key was used in each session, to nullify the effect of memory.
- Interpretation of scores:* The students were asked to record the scores of the two tests in the three sessions (practice, pre-coffee and post-coffee) in their record books, and to draw conclusions based on a pharmacological explanation. The mean scores of both the tests for the practice, pre-coffee and post-coffee sessions were expressed as the mean ± standard deviation (SD). Comparison of scores was done by using the Wilcoxon signed-rank test. The significance level was set at 0.05.
- Student feedback:* Feedback on the experiment was obtained by using a structured, content-validated and pre-tested questionnaire on a five-point Likert-

Table 1: Mean psychomotor scores before and after coffee

Paper and pencil tests	Mean ± SD scores (n = 162)		
	Practice session	Pre-coffee session	Post-coffee session
Six-letter cancellation test (SLCT)	36 ± 7	38 ± 5	45 ± 6*
Digit/letter substitution test (DLST)	54 ± 10	60 ± 6	76 ± 8*

*p < 0.05.

Figure 2: The digit/letter substitution test

DIGIT/LETTER SUBSTITUTION TEST (DLST)

Name: _____ Batch: _____ Date: _____ Session: _____

KEY:

1	2	3	4	5	6	7	8	9
S	W	B	N	P	L	A	F	C

Substitute the number in each box with the corresponding letter.
Time allowed: 90 seconds

2	4	7	9	1	5	6	4	1	4	6	9	5	7	3

7	8	9	1	4	5	3	2	6	7	4	1	5	1	2

2	5	8	7	4	6	9	1	4	5	6	7	1	3	9

3	9	7	5	4	1	2	3	8	5	7	3	6	4	9

4	5	9	6	2	7	8	1	3	6	4	2	7	9	3

7	6	9	1	2	3	5	4	7	5	2	3	8	9	6

Total Attempted:
Incorrect:
Net Score:

like scale (strongly agree to strongly disagree). The statements enquired about the ease of understanding and performing of the tests, the appropriateness of the time allowed and the methodology, the understanding of the concepts and the generation of links between theory and actual effects of CNS stimulants, the interest levels generated, and the willingness to perform similar experiments in the future. In addition, open-ended responses about the students' experiences were also encouraged. Voluntary participation was emphasised, and full confidentiality of the data was ensured to all the participants.

Results

Of a total of 180 medical and pharmacy students, 162 participated in the experiment (response rate

90%). The mean scores (\pm SD) of the SLCT for the practice, pre-coffee and post-coffee sessions are given in Table 1. Although there were no significant differences between the practice and pre-coffee session scores for both the tests, a statistically significant difference ($p < 0.05$) was observed between the pre-coffee and the post-coffee scores. Furthermore, a small number of students obtained a low score (5%), or had no change in their scores after coffee intake (6%).

The students gave a very good feedback on the experiment, as reflected in the questionnaire (Table 2). However, in the free responses, a few students (12%) reported that they lost interest by the third session, due to the simplicity and repetitive nature of the test, and that, as a result, they felt that they did not perform at their best.

Table 2: Student feedback on the experiment (n = 162)

Statement	Strongly agree (%)	Agree (%)	Unsure (%)	Disagree (%)	Strongly disagree (%)
The objectives of the experiment were specified	100	N/A	N/A	N/A	N/A
The tests were easy to understand	98	2	N/A	N/A	N/A
The tests were easy to perform	98	2	N/A	N/A	N/A
The time required for administering each test was appropriate	96	4	N/A	N/A	N/A
I found the experiment interesting and enjoyable	100	N/A	N/A	N/A	N/A
I was satisfied with the methodology employed	95	4	1	N/A	N/A
I was able to understand the CNS stimulant effects of coffee through this experiment	94	4	2	N/A	N/A
The experiment helped me to link theory to actual effect	95	2	3	N/A	N/A
This experiment is a welcome change to routine Computer Aided Learning (CAL) sessions	100	N/A	N/A	N/A	N/A
I would like to have more sessions of similar experiments	98	1	1	N/A	N/A

N/A = not applicable, as no response in this category for this statement.

Discussion

We have endeavoured to introduce a clinical pharmacology experiment as an alternative to CAL and animal experiments, for use in undergraduate health professional education. This experiment has very few requirements, and can be easily performed within laboratory session time-frames. The experiment also reinforces the concept of the mild stimulant effect of coffee. However, test performance is affected by various factors, including motivation, understanding, interest, mood, environment, quality of the worksheet, and personality type, so scores obtained may vary for different groups and sub-groups. Moreover, a clear understanding of the principle of the paper and pencil test among the faculty is important, in order to plan the experiment in an organised manner.

Although these tests had been used earlier as a teaching tool among medical students, the perceptions of the students had not been obtained.¹¹ The experiment was reintroduced in our setting with certain modifications, and student feedback was obtained with regard to its acceptability and relevance. This experiment had been introduced for the first time in the Pharm D curriculum to demonstrate the effects of the drug.

The test scores of both the tests (SLCT and DLST) showed a significant increase in psychomotor performance after coffee intake, suggesting a stimulant effect. However, a number of sources of variation were identified: differences in quantity of coffee consumed, loss of interest due to repetitive nature of the test, and anxiety after coffee intake. The latter is a known side-effect of coffee in certain individuals. Students who did not show an increase in score stated that they frequently consumed coffee during the day.

The student feedback revealed that the majority found the experiment interesting and informative. This could probably motivate them to learn more about the drugs and their effects. However, in the open-ended responses, a few students felt that the tests were too simple and that a higher degree of complexity was necessary to keep up their interest.

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