



Practice and order effect of 5 alternate forms of Colour Word Stroop Test: A Pilot Study

Shweta Shenoy^{1✉}, Prachi Khandekar², Abhinav Sathe³

¹Head and Dean, MYAS- GNDU, Department of Sports Sciences and Medicine, Guru Nanak Dev University, Amritsar, Punjab, India

²Research Fellow, MYAS- GNDU, Department of Sports Sciences and Medicine, Guru Nanak Dev University, Amritsar, Punjab, India

³Research Fellow, MYAS- GNDU, Department of Sports Sciences and Medicine, Guru Nanak Dev University, Amritsar, Punjab, India

✉Corresponding author

Head and Dean, MYAS- GNDU, Department of Sports Sciences and Medicine, Guru Nanak Dev University, Amritsar, Punjab, India;

Email: drshweta.sportsmed@gmail.com

Article History

Received: 17 May 2020

Reviewed: 18/May/2020 to 05/July/2020

Accepted: 06 July 2020

E-publication: 09 July 2020

P-Publication: July - August 2020

Citation

Shweta Shenoy, Prachi Khandekar, Abhinav Sathe. Practice and order effect of 5 alternate forms of Colour Word Stroop Test: A Pilot Study. *Medical Science*, 2020, 24(104), 2760-2766

Publication License



This work is licensed under a Creative Commons Attribution 4.0 International License.

General Note



Article is recommended to print as color digital version in recycled paper.

ABSTRACT

Introduction: The aim of this study was to evaluate the practice effect of 5 repetitions of alternate forms of Colour Word Stroop test (CWST) and effect of order. This was aimed at determining the number of efforts required to attenuate the practice effect. **Material and methods:** 5 alternate versions of the CWST were administered to 43 young healthy adult males and female who were divided into 5 different groups randomly on the basis of the sequence of administration of 5 different versions of CWST. **Results:** Repeated measure ANOVA revealed that practice effect occurred on consecutive administration of the test, but its effect diminished after 4

repetitions. No significant difference between orders of administration of 5 versions was found. *Conclusion:* Minimum 4 sessions of practice should be given with the alternate forms of CWST to diminish the effect of learning.

Keywords: Practice effect; Stroop test; Neuropsychological; Cognitive interference; Colour word test

1. INTRODUCTION

Brain is a dynamic organ and it responds to each stimulus uniquely. The Color Word Stroop Test (CWST) is a neuropsychological test widely used to assess the ability of brain to attend selectively and hinder cognitive interference that occurs when dealing with a specific element of the stimulus, obstructing the simultaneous processing of a second element of the stimulus, known as the Stroop Effect (Scarpina and Tagini, 2017). The test is named after John Ridley Stroop, who designed it (Stroop, 1935) and since then it is being extensively used in variety of fields ranging from psychological assessment to brain research. Several ongoing researches (Laguë-Beauvais et al., 2013; Huang et al., 2019; Harrison et al., 2005) have used CWST along with newer technologies like functional near infrared spectroscopy (fNIRS), functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) scan to understand neuro-physiological response of the brain but the studies are lacking to explain that how the practice effect changes the individual's response if the alternate versions of paper and pencil version of CWST is used repeatedly in short succession of time.

When the psychological tests are performed repeatedly in short period of intervals the sequence, pattern and performance is learned by the participants and the performance of the test is improved on subsequent administration (McCaffrey et al., 1992) which is known as practice effect. CWST is also subjected to practice effect when it is administered repeatedly (Ellis et al., 1989; MacLeod, 1998). To reduce the practice effect the authors (Lemay et al., 2004) suggested that paper pencil version of psychological tests must incorporate alternate forms to decrease the effect of learning. Authors have postulated that during repeated psychological testing practice effect persist for 3 sessions of repeated exposure (Claus et al., 1991), 4-5 sessions (Watson et al., 1994) and 4 sessions (Benedict and Zgaljardic, 1998). No clear information was found to explain the number of sessions for which the practice effect persisted, specifically for CWST and its alternate versions. Thus there was a scope to further explore this field and to address this lacuna.

This study would help to bridge the gap that how an individual alters his response to the altered colour and sequence of CWST administered on consecutive days. We hypothesised that practice effect would occur with the alternate versions of CWST and practice effect would be attenuated after 3 to 4 sessions but there would be no difference between the effects of alternate versions of CWST. Thus we conducted a study to determine: (1) practice effect of repeated testing of alternate forms of CWST; (2) effect of order of repeated testing of alternate forms of CWST and (3) number of consecutive sessions after which the practice effect diminishes.

2. MATERIALS AND METHOD

Participants

This study was a 5 days repeated measure observational study. 43 healthy young adult participants (mean age 23.93 ± 2.07 , mean BMI 22.86 ± 4.07 , 28 females and 15 males) were included in the study. The sample size was calculated for effect size of 0.562, level of significance was kept at 5% and power of test was 80%. The participants were university post graduate students and reported normal or corrected normal vision and no colour blindness. They were all matched on the basis of their IQ (using Multi- Dimensional Aptitude Battery II) and sleep quality (using Pittsburgh sleep quality index). Kenemans et al., 1999 stated that caffeine intake can affect the scores of Stroop testing. Thus participants were asked to abstain from tea/ coffee/ soft drinks. The subjects were randomized into five different group using lottery method. The duration of the study was from October 2019 to January 2020.

Standardization of alternate forms of colour and word Stroop test

4 alternate versions (1 original version; total 5 versions) of the test forms were prepared. All the alternate versions of paper- pencil version of CWST had either different sequence or different colour. Form 2 had three colours (red, green and blue) as that of original form but the sequence of colours and words differed from the original version form. Both form 3 and 4 had three colours (purple, brown and yellow) but the sequence of colour and word was different in form 3 and 4. Form 5 had three colours (pink, green and yellow).

The font style was chosen as Calibri (Body) with font size as 12 and in upper case word format. The distance between the rows and columns were kept similar to the original test form. Every alternate form of CWST had 4 test pages with 100 items: Word page, colour page, colour- word page and inhibition/ switching page (Parsons et al., 2013).

Procedure

After a brief practice of one row, the participants were instructed to read the words down the column, starting with the first word. They were instructed to completely read the pages as fast as possible without any error. For the first page they were asked to read the words in black ink, for the second page they read the name of the colour by which 'XXXX' were printed, for the third page the colour of the ink was read instead of the word and for the fourth page they were instructed to read in the similar manner as that of third page but the box highlighted word was to be read, ignoring its ink colour. Each participant completed all five forms of the test on 5 successive days between 9-11 am. The 5 groups which were created randomly followed different sequence of test administration on 5 different days (Table 1).

Table 1 Test Administration sequence across 5 groups.

	Day 1	Day 2	Day 3	Day 4	Day 5
Group 1	Form 1	Form 2	Form 3	Form 4	Form 5
Group 2	Form 2	Form 4	Form 3	Form 5	Form 1
Group 3	Form 3	Form 1	Form 5	Form 2	Form 4
Group 4	Form 4	Form 5	Form 1	Form 3	Form 2
Group 5	Form 5	Form 4	Form 3	Form 2	Form 1

The above table 1 shows the sequence of administration of 5 different forms of CWST in 5 different groups. Raw data was recorded as the time taken(seconds) to complete the task and errors during each task, later which were converted into the outcome measures of average reaction time (seconds), time interference scores (seconds) and error interference scores which were calculated as follows:

Average reaction time = Total time / 400.

Total time is the summation of time taken to read 100 items on 4 sheets.

Time interference score was calculated by the formula:

Time interference score = CWS- [(CS+WS)/2]

Where, CWS- Colour word score, CS- Colour score and WS- Word Score

Error interference was calculated as:

Error interference score = CWE-[(WE+CE)/2]

Where, CWE- number of Colour word error, CE- number of Colour error and WE- number of Word error

Statistical analysis

The data was analysed using IBM SPSS statistics version 23 (IL, USA). Repeated measure Analysis of Variance (ANOVA) test was used to determine the practice effect of 5 consecutive days and between the 5 groups. Statistical level of significance was set at the level 0.05. Pair-wise comparison within group was done using Bonferroni's multiple comparison procedure.

3. RESULTS

Table 2 Demographic Representation of the participants:

Variable	Mean	Standard deviation
Age (years)	23.93	2.07
Height (m)	1.63	0.09
Weight (Kg)	60.20	9.49
BMI (kg/m ²)	22.54	3.03
Sleep Quality (Pittsburgh Sleep Quality index score)	3.90	1.80
IQ (Multi- Dimensional Aptitude Battery- II Score)	93.18	11.93

The above table 2 shows mean and standard deviation values of demographic data of the participants. The results of this study showed that the interference score was decreased 20.45% from day 1 to day 2, decreased 0.19% from day 2 to day 3, decreased 17.3% from day 3 to day 4 but it was increased 3.89% from day 4 to day 5. Average reaction time decrease was large 8.31% between day 1 and day 2. But subsequent decreases were 0.8% and 8.3% between day 2 and day 3 and between day 3 and day 4. Total time and average reaction time were increased by 1.32% from day 4 to day 5.

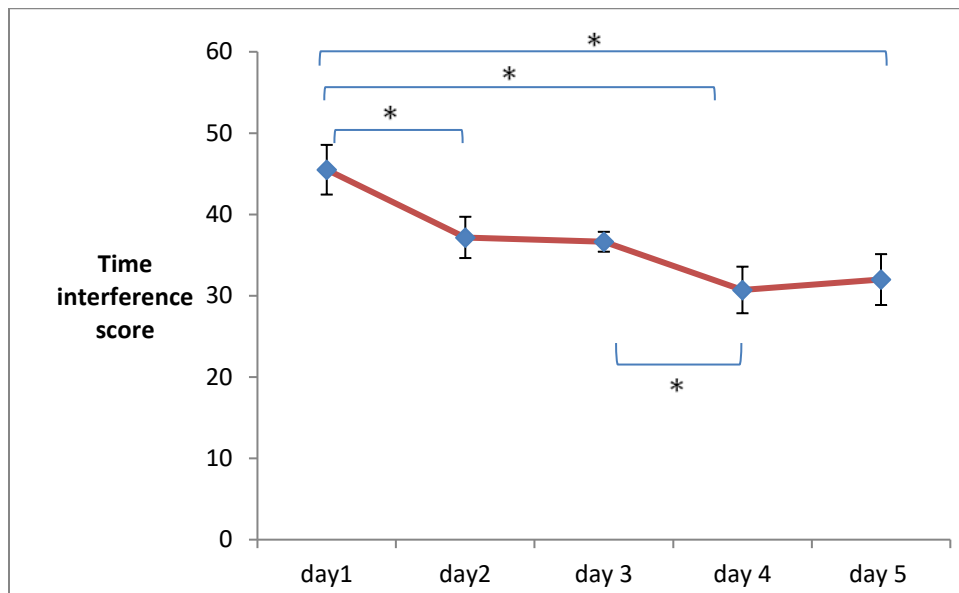


Figure 1 Variation of time interference scores across the 5 days administration of alternate versions of CWST.

The above figure 1 shows mean values of time interference scores (sec.) of 5 different versions of CWST administered on 5 consecutive days. Error bars show standard deviation values. It was found that there was a significant difference between following pairs of administration: day 1- day 2, day 1- day 4, day 1- day 5 and day 3- day 4.

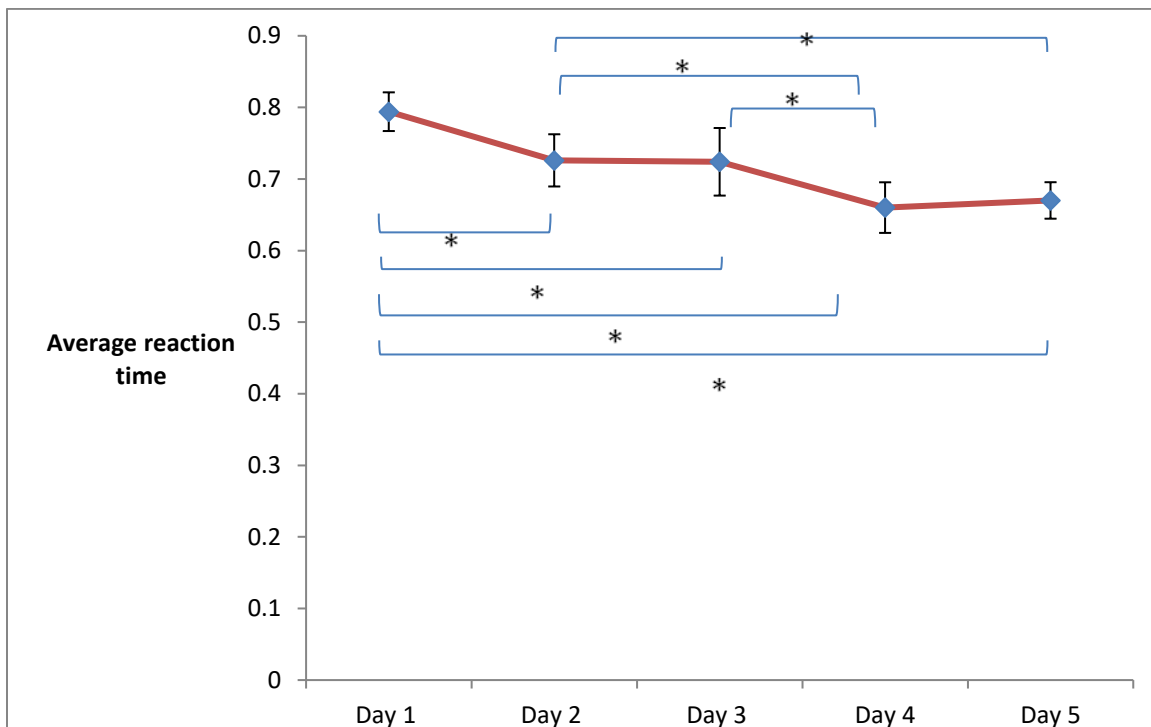


Figure 2 Variation of average reaction time across the 5 days administration of alternate versions of CWST.

The above figure 2 shows mean values of average reaction time (sec.) of 5 different versions of CWST administered on 5 consecutive days. Error bars show standard deviation values. It was found that there was a significant difference between following pairs of administration: day 1- day 2, day 1- day 3, day 1- day4, day1-day 5, day 2- day 4, day 2- day 5 and day 3- day 4.

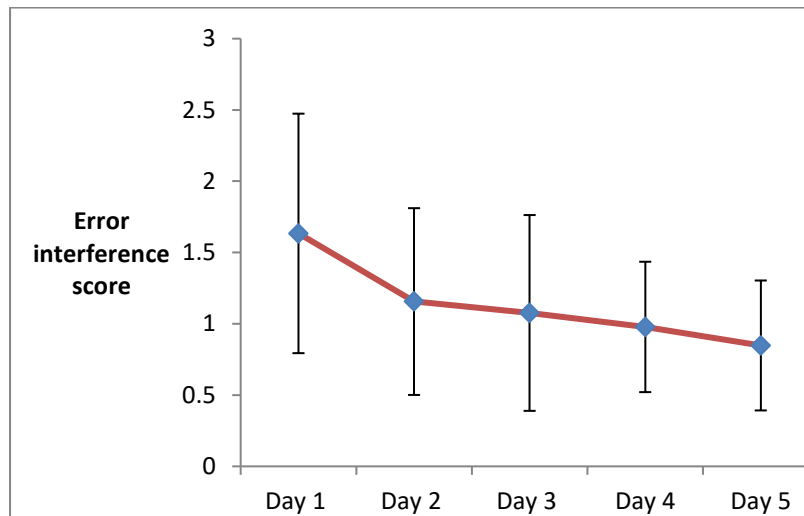


Figure 3 Variation of error interference score across the 5 days administration of alternate versions of CWST.

The above figure 3 shows mean values of error interference scores of 5 different versions of CWST administered on 5 consecutive days. Error bars show standard deviation values. It was found that there was no significant difference between error interference scores of 5 days of administration.

Practice effect

Repeated measure ANOVA across 5 sessions revealed that there was no significant difference between error interference score, and significant difference in at least one session of time interference score, total time and average reaction time of 5 sessions on 5 consecutive days. Plots of mean scores are shown in fig. 1, fig. 2 and fig.3. On multiple comparisons it was shown that day 1 time interference score, total time and average reaction time scores differed significantly ($p < 0.05$) from the scores of day 2, day 3, day 4 and day 5. Whereas the scores of day 2 and day 3 were not significantly different ($p > 0.05$) from each other and scores of day 4 and day 5 were not significantly different ($p > 0.05$) from each other. The scores of day 2 and day 3 were significantly different from the scores of day 4 and day 5.

Order effect

There was no significant difference ($p > 0.05$) between the time interference score, total time and average reaction time of the 5 groups which were given random different order of 5 alternate forms of CWST.

Minimum number of practice sessions before testing

Our results indicated that minimum 4 practice sessions must be given in order to reduce the practice effect of paper and pencil version of CWST.

4. DISCUSSION

The current study aimed to see the practice effect and order effect of administration of 5 alternate forms of colour and word Stroop test over a five days period. Our results showed that the use of alternate forms of CWST was not sufficient to reduce practice effect. Our results are consistent with the results of Beglinger et al., 2005, who showed that practice effects cannot be minimised with the use of alternate forms., consistently our results also suggested that practice effect are evident even after administration of alternate forms of CWST on different trails days. Our results showed that time interference scores decreased across the consecutive administration but the decrease was not significantly different between day 2 - day 3 and day 4- day 5. This suggests that administration of alternate forms produce equivalent interference effect after the first administration. After 4th administration the interference and time scores slightly increase. This may be due to over-practice and lack of interest to carry out similar task.

The result of the current study suggests that learning occur largely between first and second administration day and subsequently it decreases afterwards but it requires at least 3- 4 successive administrations with alternate versions of CWST. Our results were consistent with the results of Bell et al., 2018 who showed that strongest practice effect appeared between trail 1 and 2 even when computerized version of Stroop test was used. The reduction in the total time and reaction time might have occurred due to automatic response produced due to similar patterns of the colour -words and task patterns. Through these results we

suggest that maximum familiarization occur after one trial but minimum four pre trials must be given in order to have stable scores. In our study we had given a randomized sequence of testing to every group, after comparison it was seen that there is no significant difference between orders of testing suggesting that all the five forms were equivalent.

This study was conducted as a part of major study where the authors intend to see the effect of exercise intervention on CWST scores on successive days in a week. In order to see the effect of exercise exclusively it is essential to identify the number of familiarization sessions required before the actual session is begun for minimizing the practice effect. Successive CWST testing has been done in the field of exercise and cognition but researchers have used computerised version of Stroop task (Byun et al., 2014; Hyodo et al., 2012; Kujach et al., 2018). They have typically conducted the test to see the effect only in two sessions. The computerized version is also said to have lesser practice effect than paper and pencil version (Parsons et al., 2013). There were some limitations of the study. Dulaney and Rogers 1994 suggested that young and older adults have difference in development of practice effect during CWST. The subjects chosen for our study were healthy young adults so the results cannot be generalized for other populations such as middle aged and older adults and population having psychological disorders. However, our study can provide the baseline to see the changes in other populations.

5. CONCLUSION

We concluded that the performance of CWST improves due to practice effect. To eliminate this practice effect and have a plateau score; minimum four familiarization sessions of alternate test sheets must be given before the actual testing. The test version forms can be given in any order. Although practice effect is difficult to eliminate even after administration of alternate form, our study can be useful to guide future researchers to make strategies for reducing the practice effect of CWST. These results will be helpful to implement CWST in exercise and cognition studies.

Acknowledgement

We thank our participants for taking part in the study.

Funding

The study was supported by grant received from Ministry of Youth Affairs and Sports, Government of India. Equipments, tests and Research Fellows were all funded by this grant.

Conflict of Interest

The authors declare no conflict of interest.

Informed Consent

All the subjects gave written informed consent prior to inclusion in the study.

Ethical Approval

The study was approved by Institutional Ethical committee of Guru Nanak Dev University, Amritsar, Punjab (No. 158/ HG; Dated 01/10/2019).

REFERENCE

1. Beglinger LJ, Gaydos B, Tangphao-Daniels O, Duff K, Kareken DA, Crawford J, Fastenau PS, Siemers ER. Practice effects and the use of alternate forms in serial neuropsychological testing. *Archives of Clinical Neuropsychology*. 2005; 20(4):517-29.
2. Bell L, Lamport DJ, Field DT, Butler LT, Williams CM. Practice effects in nutrition intervention studies with repeated cognitive testing. *Nutrition and healthy aging*. 2018; 4(4):309-22.
3. Benedict RH, Zgaljardic DJ. Practice effects during repeated administrations of memory tests with and without alternate forms. *Journal of clinical and experimental neuropsychology*. 1998; 20(3):339-52.
4. Byun K, Hyodo K, Suwabe K, Ochi G, Sakairi Y, Kato M, Dan I, Soya H. Positive effect of acute mild exercise on executive function via arousal-related prefrontal activations: an fNIRS study. *Neuroimage*. 2014; 98:336-45.
5. Claus JJ, Mohr E, Chase TN. Clinical trials in dementia: learning effects with repeated testing. *Journal of Psychiatry and Neuroscience*. 1991; 16(1):1.
6. Dulaney CL, Rogers WA. Mechanisms underlying reduction in Stroop interference with practice for young and old

- adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 1994; 20(2):470.
7. Ellis NR, Woodley-Zanthos P, Dulaney, CL, & Palmer RL. Automatic effortful processing and cognitive inertia in persons with mental retardation. *American Journal on Mental Retardation*. 1989
 8. Harrison BJ, Shaw M, Yücel M, Purcell R, Brewer WJ, Strother SC, Egan GF, Olver JS, Nathan PJ, Pantelis C. Functional connectivity during Stroop task performance. *Neuroimage*. 2005; 1;24(1):181-91.
 9. Huang T, Gu Q, Deng Z, Tsai C, Xue Y, Zhang J, Zou L, Chen Z, Wang K. Executive Function Performance in Young Adults When Cycling at an Active Workstation: An fNIRS Study. *International journal of environmental research and public health*. 2019; 16(7):1119.
 10. Hyodo K, Dan I, Suwabe K, Kyutoku Y, Yamada Y, Akahori M, Byun K, Kato M, Soya H. Acute moderate exercise enhances compensatory brain activation in older adults. *Neurobiology of aging*. 2012; 33(11):2621-32.
 11. Kenemans JL, Wieleman JS, Zeegers M, Verbaten MN. Caffeine and stroop interference. *Pharmacology Biochemistry and Behavior*. 1999; 63(4):589-98.
 12. Kujach S, Byun K, Hyodo K, Suwabe K, Fukuie T, Laskowski R, Dan I, Soya H. A transferable high-intensity intermittent exercise improves executive performance in association with dorsolateral prefrontal activation in young adults. *Neuroimage*. 2018; 169:117-25
 13. Laguë-Beauvais M, Brunet J, Gagnon L, Lesage F, Bherer L. A fNIRS investigation of switching and inhibition during the modified Stroop task in younger and older adults. *Neuroimage*. 2013 1; 64:485-95.
 14. Lemay S, Bédard MA, Rouleau I, Tremblay PL. Practice effect and test-retest reliability of attentional and executive tests in middle-aged to elderly subjects. *The Clinical Neuropsychologist*. 2004; 18(2):284-302.
 15. MacLeod M. Training on integrated versus separated Stroop tasks: The progression of interference and facilitation. *Memory and Cognition*, 1998; 26 (2), 201-211.
 16. McCaffrey RJ, Ortega A, Orsillo SM, Nelles WB, Haase RF. Practice effects in repeated neuropsychological assessments. *The Clinical Neuropsychologist*. 1992; 6(1):32-42
 17. Parsons TD, Courtney CG, Dawson ME. Virtual reality Stroop task for assessment of supervisory attentional processing. *Journal of clinical and experimental neuropsychology*. 2013; 35(8):812-26.
 18. Peterson BS, Skudlarski P, Gatenby JC, Zhang H, Anderson AW, Gore JC. An fMRI study of Stroop word-color interference: evidence for cingulate sub regions subserving multiple distributed attentional systems. *Biological psychiatry*. 1999 15;45(10):1237-58.
 19. Phillips LH, Bull R, Adams E, Fraser L. Positive mood and executive function: Evidence from Stroop and fluency tasks. *Emotion*. 2002;2 (1):12.
 20. Scarpina F, Tagini S. The stroop color and word test. *Frontiers in psychology*. 2017; 12;8:557.
 21. Stroop JR. Studies of interference in serial verbal reactions. *Journal of experimental psychology*. 1935; 18(6):643.
 22. Watson FL, Pasteur MA, Healy DT, Hughes EA. Nine parallel versions of four memory tests: An assessment of form equivalence and the effects of practice on performance. *Human Psychopharmacology: Clinical and Experimental*. 1994; 9(1):51-61.