

**IMMEDIATE EFFECT OF TRATAKA ON PERFORMANCE IN  
STROOP COLOR WORD TEST**

*Dissertation submitted by*

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*Towards the partial fulfillment of*

**Masters of Science (YOGA)**

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## **D E C L A R A T I O N**

I, hereby declare that this study was conducted by me at Swami Vivekananda Yoga Anusandhana Samsthana (S-VYASA), Bengaluru, under the guidance of Dr. Raghavendra Bhat, S-VYASA University Bengaluru.

I also declare that the subject matter of my dissertation entitled IMMEDIATE EFFECT OF TRATAKA ON PERFORMANCE IN STROOP COLOR WORD TEST has not previously formed the basis of the award of any degree, diploma, or similar titles.

Date:

Place: Bengaluru

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(Candidate)

## **A C K N O W L E D G E M E N T**

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Finally I salute the supreme consciousness, with whose guidance and blessing I have accomplished this work.

Date:

Place: Bengaluru

**Prashanth Kumar Singh**  
**CERTIFICATE**

This is to certify that Mr. Prashanth Kumar Singh is submitting this literature review “**Concept of Trataka in Hatha Yoga Pradipika**” and Experimental Research on “**Immediate effect of trataka on performance in stroop color word test**”, towards the partial fulfillment of the requirement for the Master of Science in Yoga By Swami Vivekananda Yoga Anusandhana Samsthana (SVYASA) and this is a record of work carried out by him in this Institute.

Place: Bangalore

Date:

Dr. Raghavendra Bhat

Guide

**STANDARD INTERNATIONAL TRANSLITERATION CODE USED TO  
TRANSLITERATE SANSKRIT WORDS**

a	=	अ	ña	=	ड	pa	=	प
ā	=	आ	ca	=	च	pha	=	फ

i	=	इ	cha	=	छ	ba	=	ब
ī	=	ई	ja	=	ज	bha	=	भ
u	=	उ	jha	=	झ	ma	=	म
ū	=	ऊ	ñ	=	ञ	ya	=	य
ṛ	=	ऋ	ṭa	=	ट	ra	=	र
ṝ	=	ॠ	ṭha	=	ठ	la	=	ल
e	=	ए	ḍa	=	ड	va	=	व
ai	=	ऐ	ḍha	=	ढ	śa	=	श
o	=	ओ	ṇa	=	ण	ṣa	=	ष
au	=	औ	ta	=	त	sa	=	स
m̐	=	अं	tha	=	थ	ha	=	ह
ḥ	=	अः	da	=	द	kṣa	=	क्ष
ka	=	क	dha	=	ध	tra	=	त्र
kha	=	ख	na	=	न	jña	=	ज्ञ
ga	=	ग						
gha	=	घ						

## ABSTRACT

Ancient Indian yoga text, *Haṭha Yoga Pradīpikā* describes six cleansing techniques, which purifies and prepares our body, for the practice of yoga postures, breath regulation and meditation. Yogic visual concentration (*trāṭaka*) is one of those. A previous study showed increase in critical flicker fusion (CFF) following yogic visual concentration (*trāṭaka*). Hence, present study was planned to assess the immediate effect of yogic visual concentration on cognitive performance. Performance on Stroop color-word test was assessed in thirty healthy male volunteers with ages ranging from 18 to 31 years (group mean age  $\pm$  S.D.,  $22.57 \pm 3.65$ ) before and after (*trāṭaka*) and control session on two separate days. There was a significant improvement in the performance in Stroop color- word test after *trāṭaka* compared to control session (RM ANOVA with Bonferroni adjustment  $P < 0.001$ ). Performance on Stroop color-word test was better after *trāṭaka* compared to control session suggesting increased selective attention, cognitive flexibility and response inhibition following *trāṭaka*.

**Keywords:** yoga, *trāṭaka*, attention, stroop color-word test, cognitive performance

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## CHAPTER 1

### INTRODUCTION

*Trāṭaka* (yogic visual concentration practice) is one of the six cleansing techniques mentioned in the ancient Indian yogic text, *Haṭha Yoga Pradīpikā*. These six cleansing techniques are, *dauti*, *basti*, *neti*, *trāṭaka*, *nauli*, and *kapālabhāti*. The literal meaning of the *sanskṛata* word *trāṭaka* is “to gaze steadily”. Looking intently with an unwavering gaze at a small point until tears are shed is known as *trāṭaka* (*Haṭha Yoga Pradīpikā*, Ch: 2, V: 31). *Haṭha Yoga Pradīpikā* mentions that practice of *trāṭaka* eradicates all the eye diseases, fatigue and lethargy (*Haṭha Yoga Pradīpikā*, Ch:2, V: 32). Though *trāṭaka* is known as a cleansing technique, the final stage of *trāṭaka* induces a meditative mental state (Nagarathna & Nagendra, 2000). When meditation is practiced over a period of time it improves perception, attention and cognition (Brown, 1977). A large number of research studies has shown improvement in performance in attentional tasks following meditation.

The Stroop color-word test (Stroop, 1935) is a useful and reliable assessment tool in psychology (Lezak, Howieson, & Loring, 2004). It was first described by John Ridley Stroop in 1935. It measures selective attention, cognitive flexibility and reaction time. A study used the Stroop color-word Test to examine the differences in various domains of attention between long-term concentrative meditators versus matched controls. The performance in the Stroop test was significantly higher following long-term *vihāṅga* meditation practice, suggesting an increase in selective attention, cognitive flexibility and processing speed (Prakash et al., 2010).



Recently, a study has been conducted to evaluate the immediate effect of *trāṭaka* on critical flicker fusion (Mallick & Kulkarni, 2010). Thirty healthy volunteers were assessed in two types of session viz. *trāṭaka* and control session. The critical flicker fusion (CFF) is defined as the frequency at which a flickering stimulus is perceived to be continuous. There was a significant increase in CFF following *trāṭaka* suggesting changes at the cortical level in the processes that mediate fusion.

However, there were no studies evaluating the effect *trāṭaka* on cognitive performance. Hence, the present study was designed to assess the immediate effect of *trāṭaka* on performance in Stroop color-word test.

## **CHAPTER 2**

### **LITERARY RESEARCH ON TRATAKA: CONCEPT OF TRĀṬAKA ACCORDING TO HAṬHA YOGA PRADĪPIKĀ**

#### **2.1 Introduction**

*Trāṭaka* is a very simple but powerful technique. *Trāṭaka* means 'to gaze steadily at a fixed point' and there are two forms of the practice. One is '*bahiraṅga*' or external *trāṭaka* and

the other is *antarāṅga* or internal *trāṭaka*. *Bahirāṅga* is easier to practice because one has to simply gaze at an object or a symbol. Whereas, *antarāṅga trāṭaka* involves clear and stable inner visualization of an object.

In the practice of *trāṭaka* an object is gazed at until its subtle form manifests in front of the closed eyes. The point of concentration is usually a symbol or object which activates the inner potential and can absorb the mind. The most commonly used symbol is a candle flame. The purpose of focusing the eyes on an external object is to arouse the internal vision and make it absolutely steady by stopping the eye movements. *Trāṭaka* is a process of concentrating the mind and limiting its oscillating tendencies. The one-pointed concentration of mind is termed '*ekāgratā*'.

There are many symbols for *trāṭaka* apart from the candle flame, such as a crystal ball, a *śiva liṅga*, *yantra maṇḍala*, the full moon, a star, the rising or setting sun (when it is orange, not yellow), a *cakrā*, the symbol Om or your own shadow. These are the most effective, but *trāṭaka* can also be done on a rose, a tree, a mountain, the sea, the sky, a rock, a black dot or any object of your choice. However, one should be careful when selecting the *trāṭaka* symbol. If for example, you concentrate on the form of *kālī* you will arouse that aspect of your inner being if you are not beyond it. You may even manifest *kālī* and be terrified by her fearsome form. A steady flame of light is the most practical and safest, unless your guru advises you otherwise.

## **2.2 Aim and Objectives**

The present literary review was conducted to compile the authentic information on *trāṭaka* from *Haṭha Yoga Pradīpikā*.

## 2.3 Materials and Methods

### 2.3. A - Source material

#### I. *Haṭha Yoga Pradīpikā*

### 2.3. B Methods

The above mentioned traditional text was studied to compile the authentic information on *trāṭaka*. The verses related to the present topic were collected and compiled and presented in a systematic way.

## 2.4 Descriptions of *trāṭaka* in *Haṭha Yoga Pradīpikā*

*Trāṭaka* is one of the six cleansing technique mentioned in the ancient Indian yogic text, *Haṭha Yoga Pradīpikā*. These six cleansing techniques are *dauti*, *basti*, *neti*, *trāṭaka*, *navli*, and *kapālabhāti*. These cleansing techniques should be practiced before the practice of *asana*, *prāṇāyāma* and meditation.

मेदप्लेष्माधिकः पूर्व षट्कर्माणि समाचरेत् ।

अन्यस्तु नाचरेत्तानि दोषाणां समभावतः ॥

*medaṣṣeṣmādhikaḥ pūrova ṣaṭhakarmāṇi samācaret|  
anyastu nācarettāni doṣāṇāṃ samabhāvataḥ|| (HYP Ch 2.21)*

When fat or mucus is excessive, *ṣaṭhakarmā*: the six cleansing techniques should be practiced before the *prāṇāyāma*. Other in whom the *doṣā*. i.e. phlegm, wind and bile, are balanced should not do them.

According to Ayurveda body is made up of *tridoṣāviz.*, *Kapha*(mucus)*Pitta*(bile)*Vata* (wind). A balance proportion of these three facilities body functions, but if there is an excess of one and a shortage of another, ailments develop. Before commencing *prāṇāyāma*, any imbalance in the *tridoṣā* should be removed. Excess body fat should be reduced, mucus blocking the respiratory track should be removed, gas in stomach and intestines eliminated, etc. There are six particular practice designed for this purpose they are called *ṣaṭhakarmā*.

धौतिर्बस्तिस्तथा नेतिस्त्राटकं नौलिकं तथा ।

कपालभातिश्चैतानि षट् कर्माणि प्रचक्षते ॥

*dhautirbastistathā netistrāṭakaṃ naulikaṃ tathā|  
kapālabhātīśacaitāni ṣaṭ karmāṇi pracakṣate|| (HYP Ch 2.22)*

*Dhauti, basti, neti, trāṭaka, nauli and kapālabhati; these are known as ṣaṭhakarmā or six cleansing processes.*

Hatha yoga is famous for these six cleansing techniques. Although only six in number each has a variety of practice. The fourth karma *istrāṭaka*, which is steady and continuous gazing at a point of concentration it has two practice *antara* (internal) and *bāhira*(external)*trāṭaka*.

कर्मषट्कमिदं गोप्यं धटशोधनकारकम् ।

विचित्रगुणसंधायि पुज्यते योगिपुंगवैः ॥

*karmaṣaṭkamidam gopyam dhataśodhanakārakam |  
vicitraguṇasandhāyi pujyate yogipuṅgavaiḥ | (HYP Ch 2.23)*

These shatkarma which effect purification of the body are secret. They have manifold, wondrous result and are held in high esteem by eminent yogis.

The *ṣaṭhakarmā* specifically increase the vital capacity of the practitioner. They were never designed for therapy alone, but to create harmony in body and mind and to prepare for further practices as they bring about smooth and perfect functioning of the bodily systems, it is inevitable that through their practice the mind will become free from turbulence and disturbances and thus be better able to concentrate and move towards *dhyāna*.

निरीक्षेन्निशलदृशा सुक्ष्मलक्ष्यं समाहितः ।

अश्रुसंपातपर्यन्तमाचार्यैस्त्राटकं स्मृतम् ॥

*nirīkṣenniśaladr̥śā suksmalakṣyam samāhitaḥ |  
āśrusampātaparyantamācāryaiṣṭrāṭakam smṛtam | (HYP Ch 2.31)*

*Trāṭaka mean to gaze steadily and looking intently with an unwavering gaze at a small point until tears are shed is known as trāṭaka by the acharyas (teachers).*

There are two form of practice, one is *bahiraṅga* or external *trāṭaka* and the other is *antaraṅga* or internal *trāṭaka*. *bahiraṅga* is simple to practice because you just have to gaze at an object or symbol. However *antaraṅga* *trāṭaka* involves clear and stable inner visualization of an object. Swatmarama says to gaze at a small point or *sukṣman lakṣyaṁ*. *Sukṣman* can mean ‘small’ or ‘subtle’. In the practices of *trāṭaka* an object is gazed at until its subtle form manifests in front of the closed eyes.

The point of concentration is usually a symbol or object which activates the inner potential and can absorb the mind. The object most commonly used is a candle flame, because even after closing the eyes, the impression of the flame remains in mind for some time and *antaraṅga* *trāṭaka* can be easily practiced. The purpose of focusing the eyes on an external object is to arouse the internal vision and to make that vision steady by stopping the eyes movements.

मोचनं नेत्ररोगाणां तन्द्रादीनां कपाटकम् ।

यत्नतस्त्रातकं गोप्यं यथा हाटकपेटकम् ॥

*mocanaṁ netrarogaṅāṅāṁ tandrādīnāṁ kapāṭakam |*  
*yatnatastrātakam gopyam yathā hāṭakapeṭakam || (HYP Ch 2.32)*

*Trāṭaka eradicates all eyes diseases, fatigue and sloth and the close the doorway creating these problems. It should be carefully kept secret like a golden casket.*

*Trāṭaka* benefits not only eyes, but a whole range of pshychological and mental functions. It is theraputic in dipression, insomnia, allergy, anxiety, postural problems, poor concentration and memory. *Trāṭaka* is the process of concentration of mind by limiting its oscillating tendencies. The purpose is to make the mind completely one-pointed and arouse inner vission. One pointed concentration of mind is called *ekāgratā*. Generally, the eyes constantly move. When the eyes are focused on a single object thoughts in the mind reduces. The mind will be focused on the object chosen for *trāṭaka*.

## **2.5 Benefits of *trāṭaka***

### **Physical**

It keeps away the eyestrain by improving the stamina of eye muscles and by giving deep relaxation to them. It makes the eyes clear, bright and radiant. It cleanses the tear glands and purifies the optical system.

### **Therapeutic**

Errors of refraction get corrected. It strengthens the ability of the lens to adjust better to distance. It balances the nervous system relieving nervous tension, anxiety, depression and insomnia.

### **Spiritual**

It helps to develop intense concentration and improves memory. It helps to develop a strong will-power. It is an excellent preparation for meditation.

### **Limitations**

Epileptics should avoid gazing of flickering candle flames. They can, however, choose a totally steady object to gaze on. If you are a sensitive person who has insomnia this practice at night make your mind too widely awakened and difficult to go to sleep; hence *trāṭakā* can be practiced one hour before going to bed. In case of tension headache, one may avoid this practice, as it may tend to aggravate the pain.

## **CHAPTER 3**

### **REVIEW OF SCIENTIFIC LITERATURE**

#### **3.1 Research studies on *trāṭakā***

An early study showed that, combination of focusing and defocusing through *yoga* reduces optical illusion more than focusing alone (Telles et al., 1997). The yoga training



consisted of *trāṭaka*, meditation and yoga postures. There was a significant decrease in the degree of optical illusion perceived using Muller Lyer Lines.

A study was conducted (MSc Project at S-VYASA) to assess the immediate effect of *trāṭaka* on visual perception in children and adults using Muller Lyer Lines (Jojo, 2008). There was a significant decrease in the degree of optical illusion in children whereas adults showed no change.

A study was conducted to evaluate the efficacy of *trāṭaka* and eye exercises in the management of Timira (Ammetropia & Presbyopia) (Gopinathan, Dhiman & Manjusha, 2012). Group A practiced eye exercises and Group B was subjected to *trāṭaka*. After the enrolment of patients for this study, signs and symptoms were assessed both subjectively and objectively before, during, and after treatment. The study indicates that subjectively there are significant results in both the groups but objectively there is not much improvement.

Recently, a study has been conducted to evaluate the immediate effect of *trāṭaka* on critical flicker fusion (Mallick & Kulkarni, 2010). Thirty healthy volunteers were assessed in two types of session viz., *trāṭaka* and control session. The critical flicker fusion (CFF) is defined as the frequency at which a flickering stimulus is perceived to be continuous. There was a significant increase in CFF following *trāṭaka* suggesting changes at the cortical level in the processes that mediate fusion.

### **3.2 Research studies on Stroop color word test and Yoga**

A study used Stroop color-word Test to examine the differences in various domains of attention between long-term concentrative mediators versus matched controls. The performance in Stroop test was significantly higher following long-term *vihaṅgam* meditation practice suggesting increase in selective attention, cognitive flexibility and processing speed (Prakash et al., 2010).

In a subsequent study, the same authors evaluated the effect of Long-term concentrative meditation on cognitive performance among older adults (Prakash et al., 2011). Long-term *vihaṅgam* Yoga meditators showed better performance on attention tasks compared to non-meditators.

A study was conducted to assess (MSc Project at S-VYASA) the performance on Stroop color-word test immediately after *bhrāmarī* and breathe awareness (Mohanty 2013). There was a significant increase in the Stroop test scores after the practice of *bhrāmarī* as well as breath awareness.

### **3.3 Yoga and attention**

The performance in a letter cancellation task was assessed in 69 male volunteers before and after cyclic meditation, supine rest and control session (Sarang&Telles, 2006). The net score significantly increased after cyclic meditation and supine rest while magnitude was more after cyclic meditation compared supine rest. There was a reduction in the scores for wrong cancellations after cyclic meditation but not after supine rest. The

efficiency of executive processing was assessed using Stroop task in long-term meditators (Chan & Woollacott, 2007). The results showed a reduction in interference on the Stroop task following meditation, suggesting an increase in the efficiency of the executive attentional network. The Stroop interference and the d2-concentration & endurance test were measured in an experienced mindfulness mediators and non-meditators (Moore & Malinowski, 2009). The results showed better performance in all measures of attention in meditators whereas no change in non-meditators.

Performance on psychomotor tasks following Cyclic Meditation and Supine Rest was assessed in 57 male volunteers (Subramanya & Telles, 2009). Cyclic Meditation and Supine Rest both showed improvement in digit letter substitution test scores and scores for letter-copying and scores for circle-dotting tasks. A subsequent study assessed the performance in a six-letter cancellation task in 35 male volunteers following four mental states viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* (Kumar & Telles, 2009). There was a significant increase in the net scores after *dhāraṇā* whereas significant decrease after *cañcalatā* suggesting better attention following *dhāraṇā*. In another study, immediate effects of Cyclic Meditation (CM) and Supine Rest (SR) on attention in school children were assessed using letter cancellation task (Pradhan & Nagendra, 2010). The results showed a significant increase in total score and net score after both the practices; although the magnitude of change was more after CM than after SR in the net scores (14.5 versus 11.31%).

More recently, a study evaluated the performance of regular meditators and non-meditators during an fMRI adapted Stroop color-word task, which requires attention and

impulse control (Kozasa et al., 2012). The findings suggested that, meditation training improves efficiency, possibly via improved sustained attention and impulse control.

## **CHAPTER 4 AIM AND OBJECTIVES**

### **Aim and objectives of the study**

- To study the immediate effect of *trāṭaka* on cognitive performance using Stroop color-word test
- To compile the concept of *trāṭaka* from *Haṭha Yoga Pradīpikā*

### **Rationale for the study**

A recent study has shown increase in critical flicker fusion following *trāṭaka* suggesting changes at the cortical level in the processes that mediate fusion (Mallick & Kulkarni, 2010).

### **Hypothesis of the study**

- The practice of *trāṭaka* may increase performance in Stroop color-word test

### **Null hypothesis**

- The practice of *trāṭaka* may not influence performance in Stroop color-word test

## **CHAPTER 5**

### **METHODS**

#### **5.1 Participants**

##### **5.1.1 Sample size:**

Thirty normal healthy male volunteers were studied.

##### **5.1.2 Age range and gender:**

Normal healthy male volunteers with ages ranging from 18 - 31 years (group mean age  $\pm$  S.D;  $22.57 \pm 3.65$ ) were studied. Male volunteers alone were selected as the mental state is known to vary with the phases of the menstrual cycle (Little & Zahn, 1974).

##### **5.1.3 Source:**

The students undergoing different yoga courses at Swami Vivekananda Yoga Anusandhana Samsthana, Bengaluru were recruited for the study.

#### **5.1.4 Inclusion criteria:**

- (i) Normal healthy male volunteers with ages ranging from 18 – 35 years.
- (ii) Willingness to participate in the trial

#### **5.1.5 Exclusion criteria:**

- i. Any kind of chronic illness and vision deformity
- ii. Color blindness

#### **5.1.6 Ethical consideration:**

The study protocol was explained to the participants and their signed consent was obtained.

### **5.2 Assessment**

The Adult's version of the Stroop color and word test (Golden, 2003) was used to assess cognitive function of the participants. The test consists of 3 pages. The first page tests how fast the participant can read the words, the second page tests how fast the participants can name the colors on the page, and in the third page the participants were asked to name the color of the ink the words were printed in, ignoring the word that was printed for each item. The task was administered individually. For any mistake the participants were asked to stop and proceed after correcting the mistake. The participants were given 45 seconds for each page. Detailed instructions were given to the participants before starting the test. A stop-watch was used to record the time taken to complete the task.

### **5.3 Design**

Self as control design was used in the present study. Each participant was assessed in two sessions (*trāṭaka* and control session) on two separate days. Half the subjects practiced *trāṭaka* on first day and control session on second day. The other half was having the order of the session reversed. The duration of the both the sessions were 25 minutes. Participants were assessed before and immediately after the sessions.

#### **5.4 Intervention**

##### ***Trāṭaka:***

Subjects were given 15 days of training in *trāṭaka*. Theoretical aspects of *trāṭaka* were explained by a qualified yoga teacher on the first day. The pre-recorded audio instruction for *trāṭaka* was played during the session. *Trāṭaka* practice consists of two distinct stages. The first stage, consisted of eye exercises, which is a preparatory practice for *trāṭaka*. The eye exercise includes eyeball movements in the horizontal, vertical, and diagonal direction and circular movements. These were performed with eyes open, in a well-lit room. This was followed by the practice of palming to relax the eyes. Palming consisted of putting slightly cupped palms over the eyes, so that the eyes perceive complete darkness. First stage lasted for 10 minutes. Second stage was *trāṭaka*, and it was practiced

in dark room. Subjects were asked to fix the gaze on the flame of the candle for about 2 to 3 minutes, suppressing the urge to blink as far as possible. Then visualize the candle flame in between the eyebrows. This process repeats for 2 – 3 rounds. Finally, subjects were asked to defocus and the practice ended with silence and then prayer. The second stage lasted for 15 minutes. The duration of the whole practice was 25 minutes.

### **Control session**

During control session participants were practiced the first stage (eye exercise) for 10 minutes and then for next 15 minutes they sat quietly with closed eyes without doing any concentration or meditation.

### **5.5 Data extraction**

Scoring the Stroop test gives three types of raw scores (i) raw word scores, (ii) raw color scores, and (iii) raw color-word scores. To get the pure interference score of the color-word page independent of the participants' reading or color naming ability, interference raw scores (I) were derived by subtracting color raw scores from color-word raw scores.

### **5.6 Data analysis**

Statistical analysis was done using SPSS (Version 19.0). Since the same individuals were assessed in repeat sessions on separate days (i.e., *trāṭaka* and control), repeated measures analysis of variance was used (ANOVA). Repeated measures analysis of variance (ANOVA) was performed with two 'within subjects' factors, i.e., Factor 1: Sessions; *trāṭaka*& control and Factor 2: States; “Pre”, and “Post”. This was followed by *post-hoc* analyses with Bonferroni adjustment comparing ‘Post’ with ‘Pre’ values.



## CHAPTER 6 RESULTS

The group mean and standard deviation for scores obtained in Stroop color-word test is presented in **Summary Table 1**.

### **Repeated measures analysis of variance (ANOVA)**

Repeated measures ANOVA were conducted where subjects were measured before and after *trāṭakaas* well as *control* session.

There was a significant difference between Sessions for (i) Word score  $F(1, 29) = 21.57$ ,  $P < 0.001$ ; (ii) Color score  $F(1, 29) = 9.65$ ,  $P < 0.01$ . There was a significant difference between States for (i) Word score  $F(1, 29) = 163.42$ ,  $P < 0.001$ ; (ii) Color score  $F(1, 29) = 195.30$ ,  $P < 0.001$ ; (iii) Color-word score  $F(1, 29) = 435.24$ ,  $P < 0.001$ . There was also a significant interaction between Session and State for (i) Word score  $F(1, 29) = 55.69$ ,  $P < 0.001$ ; (ii) Color score  $F(1, 29) = 29.61$ ,  $P < 0.001$ ; (iii) Color-word score  $F(1, 29) = 54.90$ ,  $P < 0.001$ .

### **Post hoc analyses with Bonferroni adjustment**

There was a significant difference between the 'post' session of *trāṭaka* and control ( $P < 0.001$ ). There was a significant increase in the word score ( $P < 0.001$ ), color score

( $p < 0.001$ ), color-word score ( $p < 0.001$ ) after *trāṭaka* compared to before *trāṭaka*. There was also, a significant increase in the word score ( $p < 0.01$ ), color score ( $p < 0.001$ ), color-word score ( $p < 0.001$ ) after control session compared to before. There was no significant difference in the interference score.

Scores in stroop color word test following control and *trāṭaka* session has been presented in **Summary Table 1** and changes have graphically presented in **Graphs 1 - 4**.

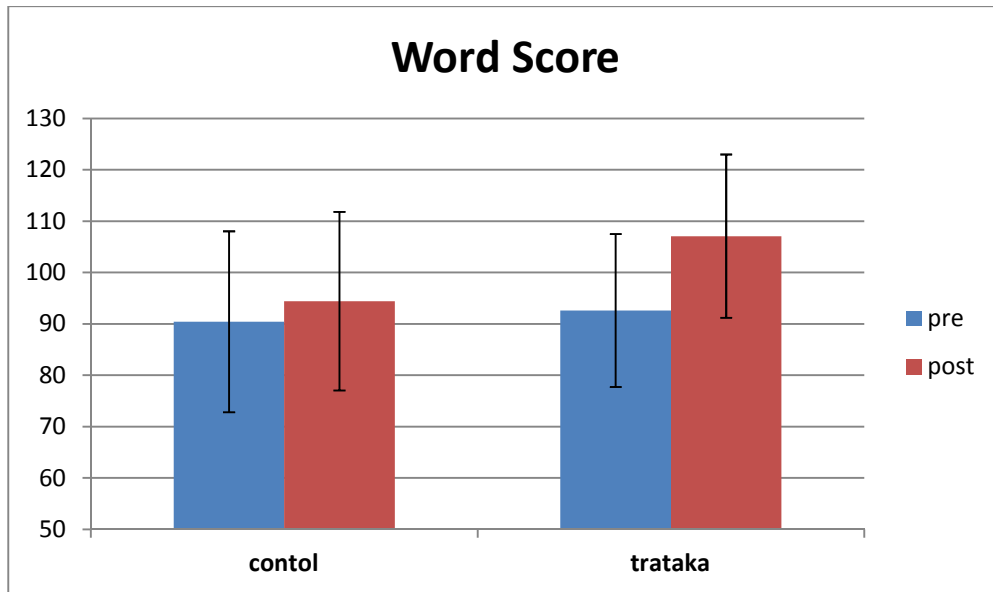
**Summary Table 1. Scores in stroop color word test following control and *trāṭaka* session**

Variables	Control		<i>Trāṭaka</i>	
	Pre	Post	Pre	Post
Word Score (W)	90.40 ± 17.62	94.40±17.37**	92.60±14.88	107.07±15.90***†††
% Change		4.42 %↑		15.63%↑
Color Score (C)	59.53 ± 9.23	63.67±8.77***	60.47±9.19	71.10±9.83***†††
% Change		6.95 %		17.58 %
Color-Word Score (CW)	39.60 ± 7.49	43.83±7.23***	38.77±6.55	48.87±6.94***††
% Change		10.68 %↑		26.05 %↑
Interference Score (CW-C)	19.93 ± 5.95	19.83±6.69	21.70±6.40	22.23±6.90

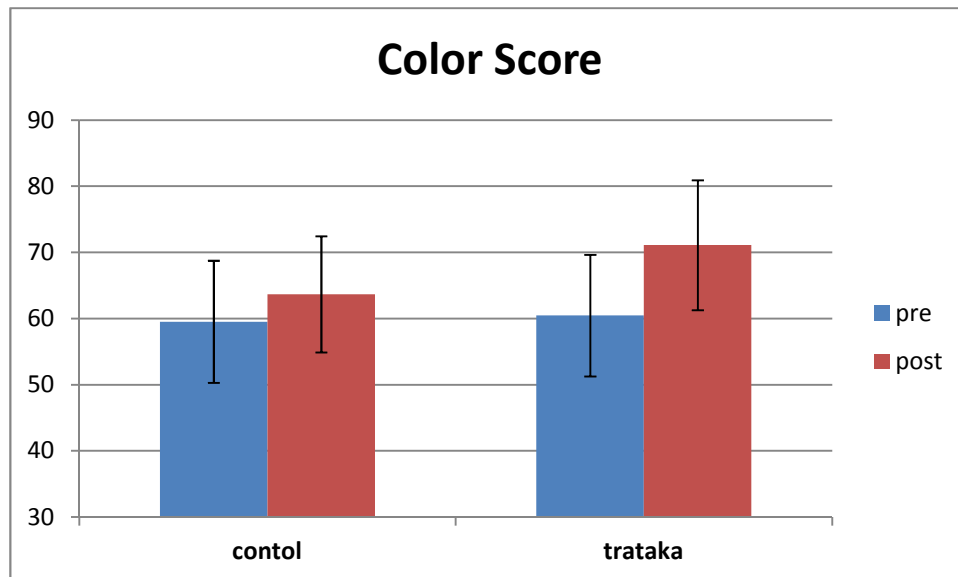
\*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$ ; RM ANOVA with Bonferroni adjustment comparing Post values with Pre values.

††  $P < 0.01$ ; †††  $P < 0.001$ ; RM ANOVA with Bonferroni adjustment comparing Post of *trāṭaka* with Post of control session.

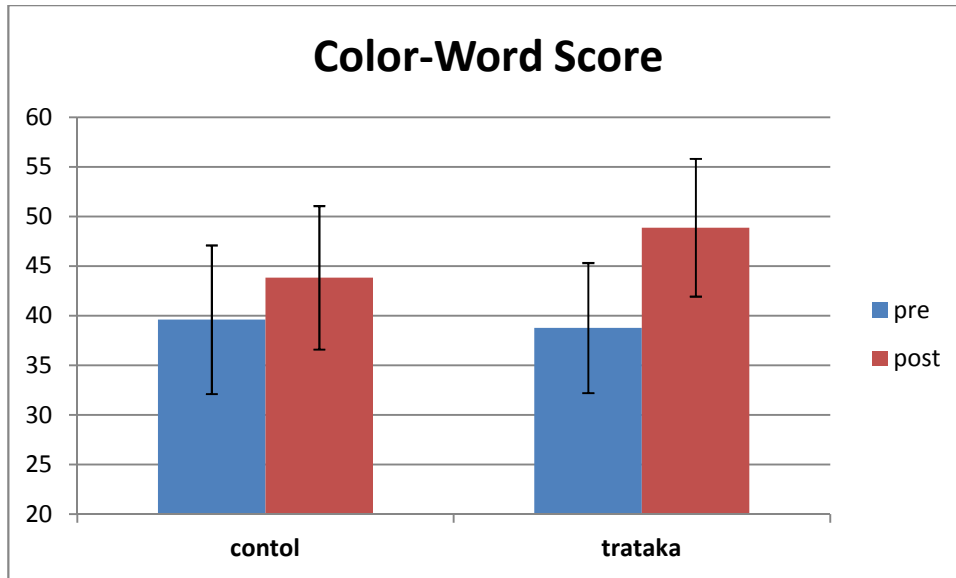
**Graph 1. Word score (W) before and after control session and *trāṭaka***



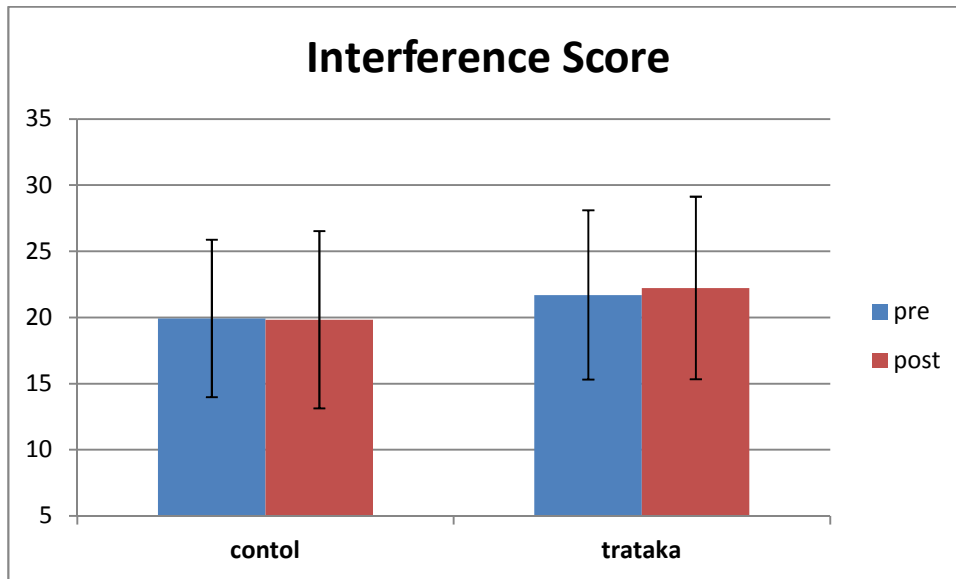
**Graph 2. Color score (C) before and after control session and *trāṭaka***



**Graph 3. Color-Word score (CW) before and after control session and *trāṭaka***



**Graph 4. Interference Score (CW-C) before and after control session and *trāṭaka***



## CHAPTER 7 DISCUSSION

In the present study, Stroop color-word test was assessed before and after the practice of *trāṭaka* and control session in 30 male volunteers. The Stroop color-

word test is an index of executive functioningsuch as interference control (van Mourik et al., 2005), selectiveattention and cognitive flexibility (Homack&Riccio, 2004), and response inhibition(Pocklington&Maybery, 2006).*Trāṭaka* showed better performance on Stroop color-word test compared to control session.

Stroop color-word test consists of four basic scores viz., word score, color score, color-word score, and interference score. The word score is the number of items completed on the word page and it reflects basic reading sped (Golden, 2003). Word score significantly increased following *trāṭaka* (15.63%) compared to control session (4.42%) suggesting better reading speed after *trāṭaka*. Naming of a color takes more time than naming the word, it needs conscious effort to choose and say the name of the color (Golden, 2003). Color score is the number of items completed on the color page and it involves selective attention (Golden, 2003). Color score significantly increased after *trāṭaka* (17.58%) compared to control session (6.95%) suggesting better selective attention following *trāṭaka*. Color-word score is the number of items completed on the color word page which involves naming the color of the ink the words are printed in, ignoring the word that is printed for each item (i.e., RED printed in GREEN ink). Scores on color-word page was significantly higher following *trāṭaka* (26.05%) compared to control session (10.68%) suggesting better selective attention, cognitive flexibility and response inhibition after *trāṭaka*.

*Trāṭaka* involves intense focusing on a candle flame. It is somewhat similar to a focused meditative state (*dhāraṇā*) which is described in ancient yoga text, *patañjali yoga sutra* (Taimini, 1986). A study compared performance on a cancellation task following four mental states (Kumar & Telles, 2009) viz., *canalata* (random thinking), *ekāgratā* (non-meditative concentration), *dhāraṇā* (focused meditation) and *dhyāna* (effortless meditation or meditative expansiveness). Following *dhāraṇā* there was significant increase in the scores on cancellation task suggesting better selective attention, visual scanning, and concentration.

Earlier study on *trāṭaka* showed significant increase in critical flicker fusion (CFF) suggesting changes at the cortical level in the processes that mediate fusion (Mallick & Kulkarni, 2010). In the current study, performance on Stroop color-word test increased after *trāṭaka*. The performance on Stroop color word test is related to pre frontal cortex (Adleman et al., 2002). Hence, improved performance on Stroop color word test after *trāṭaka* is may be due to increased activity at the pre frontal cortex.

Though there was a better performance after *trāṭaka* compared to control session there was significant increase after control session compared to pre scores. Control session consisted of 10 minute eye exercise and next 15 minutes they were asked to sit quietly with closed eyes without meditation. Participants might have done focused thinking or meditation during control session because of which there

is an increase in the scores. However this just a speculation and there was no objective measurements to confirm this.

One of the main limitations of the study is that there is no guarantee that participant did not practice meditation or any focused thinking during control session. It would have been ideal to have a simultaneous assessment of the physiological measures to assess the level of autonomic arousal during the two sessions. This is particularly of interest as attention is known to modulate sympathetic activation (Moses et al, 2007).

In summary, *trāṭaka* showed better performance in Stroop color-word test compared to control session suggesting increased selective attention, cognitive flexibility and response inhibition following *trāṭaka*. Further studies using other objective measurements would substantiate these findings would help to understand the mechanisms involved.

## **CHAPTER 8 APPRAISAL**

### **8.1 Summary and Conclusion**



In the present study, Stroop color-word test was assessed before and after the practice of *trāṭaka* and control session in 30 male volunteers. The Stroop color-word test is an index of executive functions such as interference control, selective attention and cognitive flexibility, and response inhibition. *Trāṭaka* showed better performance on Stroop color-word test compared to control session. There was significant increase in word score (15.63%), color score (17.58%), and color-word score (26.05%), following *trāṭaka*. There was no change in interference scores. In summary, *trāṭaka* showed better performance on Stroop color-word test compared to control session suggesting increased selective attention, cognitive flexibility and response inhibition following *trāṭaka*.

## **8.2 Implication of the study**

*Trāṭaka* can be useful in the management of attention deficit disorders. *Trāṭaka* can be taught to school children to improve attention.

## **8.3 Limitations of the study**

One of the main limitations of the study is that there is no guarantee that participant did not practice meditation or any focused thinking during control session. It would have been ideal to have a simultaneous assessment of the physiological measures to assess the level of autonomic arousal during the two sessions.

## **8.4 Suggestions for the future**

Further studies using other objective measurements may help to understand the mechanisms involved in the current findings. Studying autonomic changes during *trāṭaka* may be helpful to understand further.

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