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The Effect of Martial Arts Training on Task Switching Behavior in Adults

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Abstract:

Martial Arts is known to be associated with enhanced cognitive control in younger children. Nevertheless, there has not been sufficient evidence of its effects being tested in adults. With a focus on this, the current research aims to measure switching costs and mixing costs to know of their cognitive abilities. The experiment conducted made use of a task switching paradigm and collected information from 28 participants. Two groups were made – Experienced (Martial Artists) and Non-Experienced (Non-Martial Artists). The reaction time of experienced group was lesser than the non experienced group. Physical fitness which is commonly associated with Martial Arts is shown to affect reaction times by making it faster.

Keywords: *Martial Arts, Executive Functioning, Task Switching Behavior, Switching costs, Mixing Costs*

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I. INTRODUCTION

Physical fitness is paramount in today's world. It must be noted that we have advanced from nomadic ancestors who invested all their time and energy in moving around to find food and shelter. They would traverse long distances consistently. Henceforth, our bodies are designed and evolved to be robust and active. With the advancement of various transport systems, it is not possible to walk for such long distances anymore and that is why exercising is crucial for a healthy life. In addition to keeping one calm and composed, several Martial Arts techniques are known to enhance the overall adaptability of the body and is considered a through body workout. Furthermore, it is also a great stress buster, much like other forms of exercise. Mental benefits of Martial Arts are also multifold. It helps in improving executive functions such as concentration, memory, alertness, emotion-regulation, self awareness and problem solving. The executive function most relevant to the present study is Task Switching Behavior.

II. REVIEW OF RELATED LITERATURE

Martial Arts comprises of elements similar to physical exercise and mindfulness meditation. It covers a wide range of activities which include self-defense measures, physical activities and techniques for mental control along with combating sports such as boxing, taekwondo, judo, karate, kickboxing etc. is also known to help improve cognitive abilities such as problem solving (Diamond 2012), attention and processing speed (Douris & Douris 2015). Whenever an individual performs exceptionally well with respect to these cognitive capacities, he/she is portrayed as having a very strong grip over executive control (Miller & Wallis, 2009).

Previous studies have shown that benefits associated with Martial Arts are multifold. (Woodward, 2009). For example, children with training in martial arts have shown improvements in their concentration and listening skills, self-control and decision making. When children are given chances to enhance executive functioning and self regulation attitudes, it can improve their school achievements, positive behavior, health and well being, and success at work (Fuhs & Farran, 2014).

Executive Functioning are the cognitive processes that facilitate us to blend our thinking patterns, behaviors and activities in a way that encourages and leads us to goal achievement (Miller & Wallis, 2009). It combines together elements of working memory, flexible thinking, which is being able to think about something in more than one way, inhibitory control, self-monitoring, being attentive, planning and organizing (Blume & Marlett, 2009). Importance of these functions can be seen in our day to day lives as they enable us to juggle between various tasks of routine efficiently (White & Williams, 2017)

When situations change, one needs to be reactive and adjusting. This is defined by their task switching ability (Kiesel et al, 2010). In our daily errands, such procedures are integral to making us consistently adjust to the complex and changing social environment. This is because an individual can have different goals in his mind at the same time and working simultaneously upon it is a way of reaching completion in a short time (Philip & Kalinich, 2008). To achieve this, one must 'switch' or move their attention from one task to another. For example- completing a report and alongside scrolling through instagram and checking up on other social medias. According to Monsel (2003)'s study, it is having the ability to shift one's focus from one task to another and it is essential because everyday life is a constant shift between various tasks thereby requiring a good executive control. According to Lindenberger and Eber's study (2004), task switching is often calculated with the help of a computerized behavioral task also known as a task switching paradigm. It consists of two types of experimental blocks – single task blocks or pure blocks and mixed task blocks. In the pure task block, the participants are expected to complete one

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task, either A or B, for the entire block. A pure block will follow the pattern of 'AAAA'. This is often succeeded by another pure block of a different task such as, 'BBBB'. The mixed task block is a combination of both the blocks and is presented as 'AABBAABBAA'. It has two types of trials associated with it called repeat trials and switch trials. Repeat trials occur when the same task appears consecutively, such as AA or BB and switch trials occur when there is a switch or change in the task such as the 'AB' portion of the block (refer to Figure 1.)

The basic blueprint of the paradigm therefore involves three conditions – Pure, repeat and switch trials. The paradigm provides with two measures of task switching called mixing costs and switching costs, which are the markers of costs in various multitasking situation. Switching costs are the performance costs which are connected to switching between consecutive tasks and is obtained from comparing the switching and repeat trials in the mixed block (Koch, Alport, 2005; Los, 1996). The mixing costs as the name suggests are obtained from mixing different tasks such as comparing repeat trials to the pure trials (Kray & Lindenberger, 2004). Therefore, switch cost refers to the performance of an individual when he has to switch between two tasks presented simultaneously while mixing cost refers to the performance when two different tasks are mixed (Strobach 2012). In this way, mixing costs is clearly separated from switching costs.

The costs in these tasks are effective as increased Reaction Times (RT). Thus, a smaller mixing cost or switching cost is indicative of a stronger executive control.

Figure 1. Diagram showing the mixing costs and switching costs trials.

A study was carried out by Kray and Lindenberg (2000) where they used a task switching paradigm on 118 people aged between 20 to 80. It was found that the younger participants displayed a smaller mixing cost than the older ones.

III. OBJECTIVE OF THE STUDY

To find out the impact of Martial Arts training on task switching behavior in adults by measuring their Reaction Times (RT).

IV. METHODOLOGY

Two groups were made – Martial Artists and Non Martial Artists. On both the groups, a task switching paradigm was administered to determine their switching costs and mixing costs.

The sample consisted of 28 people (15 Martial Artists and 13 Non Martial Artists). The age range was 19-45 years. It was made sure that none of the participants reported having any kind of memory deficit or some other cognitive dysfunction. They all reported to have normal or corrected-to-normal vision.

The stimuli presented was either a square or a circle of the same size and it was displayed in Blue colour (0R 0G 55B) or Red colour (204R 0G 0B) against a white background. Before presenting the stimuli, a cue (length = 4.3 cm, width = 4.5cm) would be given in which either the word 'SHAPE' or 'COLOUR' would appear written in black words on the white background at a visual angle of 0.8 degrees. (refer to Figure 2). The signal showed up on screen for 500ms followed by a 500ms clear screen interval. Next, the stimuli appeared for 1000ms or until the participant responded to it, and then a 250ms blank screen interval shall have finished the trials (refer to Figure 2).

They were asked to press the 'F' button on the computer keyboard if their response was either 'blue' or 'square', and the 'J' button if their response was either 'red' or 'circle'. There was a total of three blocks shown to the participants, one in which they would simply have to respond to the shape of the figure, another in which they would respond to the colour of the figure and lastly, in the mixed block they were instructed to respond to either the shape or the colour of the figure depending on the cue card shown before the appearance of the stimuli. Each of the pure blocks consisted of 192 trials out of which 96 were congruent trials and 96 were incongruent. The mixed block consisted of 384 trials out of which 192 (half) were repeat trials while the other 192 were witch trials. Again, out of the 192, 96 were congruent and 96 were incongruent trials for both repeat and switch conditions.

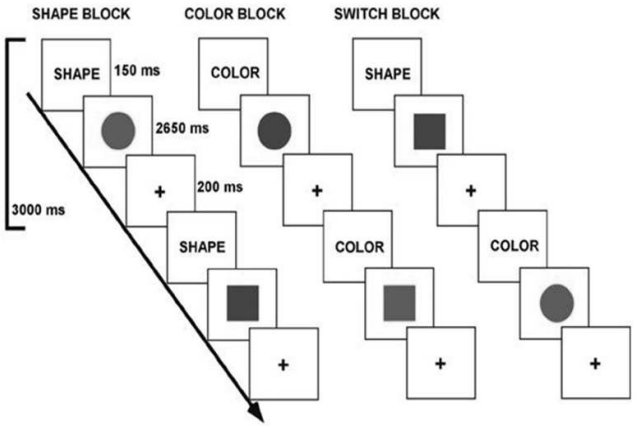

Figure 2. Visual representation of arrangement of blocks in the task switching paradigm

V. RESULTS

First, the data for Reaction Time (RT) was analysed, where all the errors were excluded and only the correct ones were considered. The average RT of each participant in each condition was then submitted to a global Analysis of Variance (ANOVA) for a 2 (Martial Arts Group: Martial Artists, Non-Martial Artists) x3 (Switching condition: Pure, Repeat,

Switch) x 2 (Congruency: Congruent, Incongruent) mixed design with Martial Arts as a group variable and Switching and Congruency as repeated measures.

It was found that Martial Artists were 57ms faster than the non Martial artists [$F(1,26)=4.60$; $p=.041$; $\eta^2=.15$]. there was also found to be significant effect of the type of switching condition used $F(1, 26)=48.21$;$p<.001$; $\eta^2=.65$], further evidenced in a significant overall mixing cost (responses in Pure condition were 51 ms were faster than in Repeat trials, $p<.001$). Overall, it was found that the congruent trials were 26ms faster than the incongruent trials [$F(1,26)=80.14$; $p<.001$; $\eta p^2=.76$]. It was also found that switching conditions had an impact on congruency meaning that it changed with congruency [$F(2,52)=13.79$;$p<.001$; $\eta p^2=.35$] (refer to Figure 3.). There was also found to be a significant interaction between the three variables [$F(2,52)=3.32$;$p=.044$; $\eta p^2=.11$]. To analyze this further, mixing costs and switching costs was looked at separately. A simple main effects analysis was conducted on switching costs and mixing costs separately to explore the global interaction.

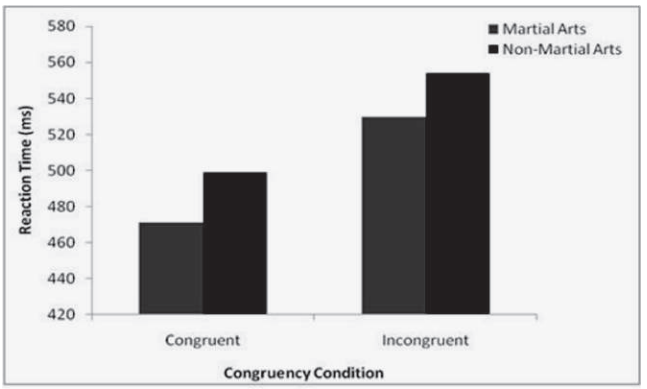

Figure 3. Bar Chart showing the average RTs of both Martial Arts and Non-Martial Arts Group for Congruent and Incongruent conditions.

VI. MIXING COSTS

A new 2 (Martial Arts Groups) x2 (Mixing Costs: Repeat, Switch) x2 (Congruency) was conducted on RT data. Overall, it was found that the effects of congruency were 17ms [$F(1,26)=35.01$;$p<.001$; $\eta p^2=.57$], which changed with the mixing costs [$F(1,26)=5.30$;$p=.03$; $\eta p^2=.17$]. The effects of congruency had increased in the repeat condition from the mixed block ($t(27) = 4.28$, $p<.001$), which contrasted with the smaller (9ms) although still significant congruency in the pure block ($t(27) = 3.26$, $p=.003$), as was expected. One of the reasons this was seen was because in the pure block, the participants are only doing one condition and while they are doing just one task, there is no interference from a previous task.

The size of the mixing cost very minutely changed between the two groups [$F(1,26)=2.98$;$p=.096$; $\eta^2=.10$]. It was significantly smaller in the Martial Artist Groups (31 ms, $t(14) = 2.59$; $p=.021$) as compared to the non-Martial Artists group (72ms, $t(12)=3.30$, $p=.006$). While the two groups were clearly different in the repeat condition from the mixed block, ($t(26) = 2.73$, $p=.016$), they did not differ in the pure block.

Finally, the modulation of congruency effects across the mixing costs conditions changed with the martial arts group [$F(1,26)=5.53$;$p=.026$; $\eta^2=.176$]. In the Congruent condition, Martial Artist showed a significant reduction of 63 ms of mixing costs compared to the non-Martial Artists [$F(1,26)=5.05$;$p=.03$; $\eta^2=.16$]. Non-Martial Artists showed the same amount of mixing costs for congruent and incongruent conditions ($F<1$)

VII. SWITCHING COSTS

In the analysis of switching costs, a pattern of 34 ms of congruency was observed [$F(1,26)=66.11$;$p<.001$; $\eta p^2=.72$] that altered with the switching costs [$F(1,26)=6.95$; $p=.014$; $\eta p^2=.21$]. importantly, in the Martial Arts group, this modulation changed [$F(1,26)=3.36$;$p=.078$; $\eta p^2=.11$]. The two groups differ in the switching costs observed with the congruent conditions [$F(1,26)=6.83$;$p=.015$; $\eta p^2=.21$], while they remained the same with the incongruent ones ($F<1$).

It was also seen that the Non Martial artists produced a very small difference between the repeat and switch conditions (26 ms, $p=.007$) as compared to the Martial Artists (70 ms, $p<.001$).

VIII. ACCURACY

Accuracy (Acc) rates for each participant in condition was computed and analysed following the same mixed 2 x 3 x 2 global design as for the RTs. The results showed main differences in switching conditions [$F(2,52)=28.26$;$p<.001$; $\eta^2=.52$], with an increase of 6% in accuracy in the pure block compared to the repeat condition from the mixed block (mixing costs, $p<.001$) and a reduction of 3% accuracy in the switch trials compared to the repeat ones (switching costs, $p<.001$). Likewise, Congruent trials were 6% more accurate than incongruent ones [$F(1,26)=77.13$;$p<.001$; $\eta^2=.75$]. There were no differences across the Martial Arts groups and no interactions with the previous effects (refer to Figure 4).

IX. IMPLICATIONS AND CONCLUSION

Martial Arts and exercises with regards to previous research is known to improve attention, memory, focus and emotional well being (Witte et al., 2015). In the task switching paradigm used in this study to assess the RTs of the Martial Arts and the Non-Martial Arts group. The results from the global ANOVA showed that Martial Artists showed a smaller mixing and switching cost as compared to the Non-Martial Artists. Low switch costs in task switching have been reported to be an indicator of strong cognitive flexibility (Whitson et al., 2014), meaning the person is better able to switch between various tasks without it costing them a lot in terms of performance.

It was also found that Martial Artists were more accurate. Studies have shown that training in Martial Arts helps one to be more alert at all times as it is a part of learning self defense against attacks. Due to this a certain predictability factor comes into play where they are better able to predict or expect a stimulus. In this study, the Martial Artists performed better with lower reaction times representing that they were able to see a pattern in the mixed block which was

'CCSSCCSSCCSS… ' which others were not able to see. This could be because they are trained to be aware of everything around them which keeps them in a state of constant alertness, specially to distractors or changes. The other Non-Martial Artist participants were improvising with each trial but not predicting. This is one very important element which differentiates the Martial Artists from the rest. In the pure condition, the performance is carried out in an 'autopilot' mode which requires very little active participation. However, in the mixed block which requires frequent task switching this luxury is lost (Egner, 2007). This is evidenced as the performance of both groups is better in pure blocks as compared to the mixed block. Participants in the task switching paradigm are required to hold in mind two sets of information.

		PURE	REPEAT	SWITCH
Martial Arts	Congruent RT	437.91	452.	522.26
	SD Acc	58.70 0 .724	55.41 0.670	89.13 .708
	Incongruent RT	442.57	489.07	564.45
	SD Acc	51.50 .723	67.08 0.646	0.946 .564
Non-Martial Artists	Congruent RT	472.73	544.95	571.12
	SD Acc	67.59 .712	104.78 .677	99.09 .687
	Incongruent RT	486.62	558.50	617.42
	SD Acc	68.99 .706	86.79 0.615	90.06 .543

Figure 4. Table showing the RT (Reaction Time), standard deviation (SD), and Accuracy Rates (Acc) across all conditions for the Martial Arts and Non-Martial Arts group.

Due to the awareness training, Martial Artists find it easier to switch between tasks as per the given instructions as compared to the Non-Martial Artists. Other studies have shown that Martial Artists are more ready to respond to distractors as they have a wider attention span. It has also been found that Martial Artists are more sensitive to interference which is why they have better performance in the second pure block which has interfering elements from the first pure block. Even if the interference seems to slow them down a little, they seem to still perform better.

The congruency effects are observed more in the second condition of the pure block. This is because the second block is slightly contaminated due to the learning in the first block and applying it in second as well. Therefore, the congruency effect is only in the second block and it is very less in case of Martial Artists. There is a big difference in the congruent and incongruent conditions in the mixed block of the two groups. Even in the incongruent condition, Martial Artists are faster.

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