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ORIGINAL PAPER

Comparison of anticipation skills and reaction time in normal adults using a constructed anticipation timer

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Background: In the realm of sports, the ability to navigate accurately through a dynamic environment is an important factor for the coordination of speed and balance. Athletes engaged in sports that involve the swift movement of balls or targets, such as catching a baseball or hitting a tennis ball, rely on a complex interplay of perceptual abilities to succeed.
Purpose: Construction of a visual anticipation timer to assess and train the anticipatory skills and reaction time.
Methods: We conducted a prospective experimental study. Fifty-one subjects were recruited and informed consent was obtained. They underwent a comprehensive eye examination. We excluded subjects with the best corrected visual acuity worse than 6/6, N6, and those with ocular and systemic diseases. We constructed an anticipation timer with LED lights, push buttons, a resistor, and an Arduino board. The lights are placed vertically at a gap of 2.5cm. The participants were asked to anticipate a time when the last LED light would be on and press the button accordingly. The discrepancy between the "exact time" and the participants' "anticipated time" was quantified as an error. We measured the error count for each participant before and after the training. The same anticipation task was given as training for 15 min. The participants were given a break of 5 min after the training session and before the post-training measurement.
Results: The mean age of the 51 participants was 18.51 $\pm$ 1.41 years. The Shapiro-Wilk test showed that the data were not normally distributed ($W = 0.758$; $P < 0.001$). We performed the Wilcoxon signed-rank test to find the difference in error counts between pre- and post-training sessions. This showed a significant reduction in error count in the post-training values compared to pre-training values. ($p = 0.002$; $z = -3.044$). The mean error count for pre- and post-training sessions was 2.22 and 0.90, respectively.
Conclusion: The error counts have been significantly reduced in post-training sessions using a constructed anticipation timer. This study shows that repeated task of anticipation improves the accuracy of the anticipation. Anticipation training makes the person react faster and more accurately.
Future scope: The constructed instrument is planned for validating different professions and age groups to understand the importance of anticipation and its cognitive involvement.

Keywords: anticipation, anticipatory skills, anticipation timer, reaction skills, sports, perceptual abilities

1. Introduction

In the realm of sports, the ability to navigate accurately through a dynamic environment is an important factor for the coordination of speed and balance. A successful game is about good agility, specifically in a wider environment where tasks can be presented in different forms and locations. Sports that involve the dynamic movement of balls or targets, such as catching a baseball or hitting a tennis ball, require a higher perceptual ability. Among the various perceptual abilities, reaction speed and anticipatory skills are considered core skills required for a game play. These skills help the athlete to react more quickly and precisely to the unpredictable path of moving targets.

Researchers are constantly seeking innovative ways to train and assess these skills, as they have been considered advantageous for a successful performance. Visual skills are sport-specific and differ from player to non-player, expert and novice. Analyzing the skills required for each sport and training them serves as a predictor of success. The ability to foresee the moment is very crucial not only in sports but also in other professional disciplines (1).

Visual reaction time among athletes is described as how rapidly an athlete reacts to a visual stimulus, while anticipatory skills involve the ability to predict the future position or trajectory of a moving object accurately, such as to foretell when an object or image would arrive at a designated target point in time and space. These skills are the major predictors which can decide a player's success or defeat. Supportive evidence has shown that training anticipatory skills has a positive impact in football, tennis, and cricket, where projectiles are hurled at high speeds. Visual skills are more utilized in these fields to anticipate the movement of the ball and make timely actions (2).

Understanding the scientific importance of the visual skills, we designed and developed an instrument "visual anticipation timer"—to assess and train anticipation skills and reaction time. By measuring the effectiveness of this instrument, the need for the anticipatory training in the realm of sports and other disciplines can be segmented.

1.1. Introduction

Kuo et al. aimed at designing and developing an affordable visual reaction system to train and monitor the badminton players, which showed that the agility and visual reaction time (VRT) for the players are effectively improved. The developed instrument induces competitive environments to monitor, evaluate, and train skills like agility and the response time (3).

Kuan et al. found that athletes have faster visual reaction time scores compared to non-athletes. Accuracy in visual anticipation time was found to be consistent and higher in athletes (4).

Bhabhor et al. compared visual reaction time (VRT) between sports players (table tennis – TT) and healthy controls, in which study it was found that reaction time was faster in the players group as compared to controls. This study suggests that playing table tennis can enhance eye-hand reaction time, concentration, and alertness. It emphasizes the potential benefits of participating in sports (5).

Abbreviations: LED, light emitting diode; VRT, visual reaction time; SPSS, statistical package for social sciences; PRT, pre-training session; PST, post-training session; VMRT, visuo motor reaction time; DAIO, Dr. Agarwals Institute of Optometry.

The purpose of this study was to construct and validate a visual anticipation timer, which is specifically designed to assess and enhance the anticipatory and reaction skills among various athletes. By utilizing this instrument, we aimed to determine whether targeted training can lead to improvements in these critical perceptual abilities.

2. Methodology

2.1. Apparatus

The apparatus utilized in this study consist of ten LED lamp runways at a gap of 2.5 cm connected and mounted on a tabletop. The system operates by presenting a moving stimulus through a sequence of LED bulbs that illuminate sequentially on a runway. The participants were tasked with pressing the handheld response button precisely when the moving lights reached a target. The speed of light is kept constant.

To assess the accuracy of visual anticipation, the direction of error (whether participants responded too early or too late) after each trial was meticulously recorded in milliseconds using a mobile timer.

1. **LED light runway:** It is the key component of the constructed anticipation timer, where a linear series of Red LED (Light Emitting Diode) lights are placed as a runway on a metal board. These lights serv as a visual stimuli for the participants. When the device is switched on, the lights ran at a series of constant speed intervals (**Figure 1**).
2. **Mounting surface:** The LED lights incorporated into a metal board is mounted on a flat surface like tabletop or a stable surface. This minimizes the disturbance and provides a comfortable position to perform the test.
3. **Handheld button:** A button is connected to the device. The participants were instructed to use the handheld response button if they anticipated the arrival of the LED lights at the target point. The time taken to anticipate and press the button is calculated.
4. **Phone timer:** The Android phone timer is used as a separate device (not connected to the instrument) and operated by the examiner. This records the time taken for the participant to anticipate and respond to the visual stimulus.
5. **Participant's response:** Participants were instructed to use a handheld response button if they anticipated the arrival of the LED lights at a target point. The time taken to anticipate and press the button was calculated. The timer is started when the LED lights are presented to the participants and stopped when the participant respond. (**Figures 1**, **2**).

FIGURE 1 | Working of constructed anticipation timer.

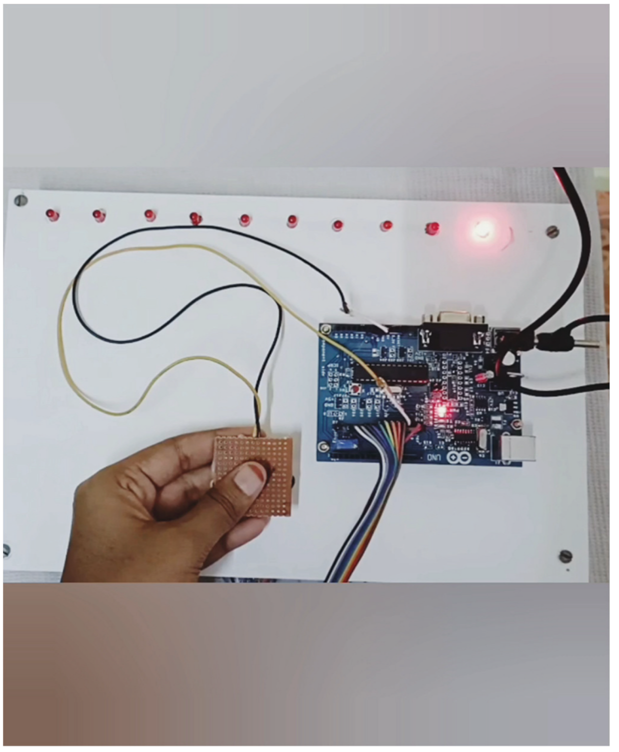


FIGURE 2 | Working of constructed anticipation timer.

6. **Control electronics:** Inside the device, there are control electronics that manage the sequencing of the LED lights and synchronize them. These electronics ensured that the LED lights move in a controlled and consistent manner.
7. **Power source:** The device typically requires a power source, often in the form of batteries or an electrical outlet, to operate the LED lights, and to control electronics.
8. **Settings and adjustments:** The anticipation timer has settings and adjustments to control factors such as the speed of the moving lights and the interval between stimuli. These settings allow researchers to customize the testing conditions.

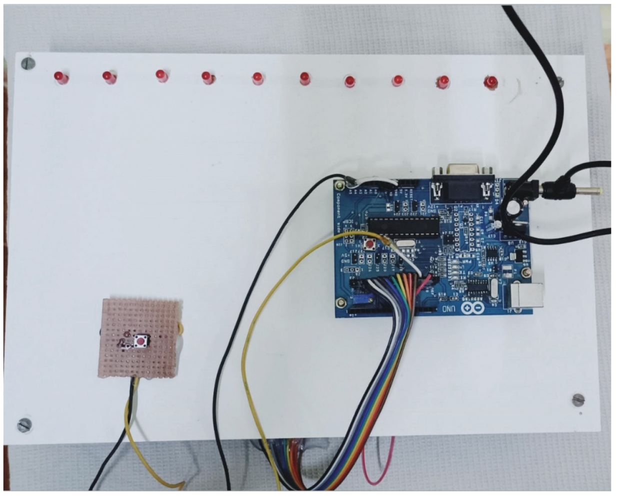


FIGURE 3 | Constructed anticipation timer.

2.2. Methods

Following the construction of our device (**Figure 3**), we conducted a prospective experimental study with a convenient sample of 51 participants, each of whom underwent a comprehensive eye examination. We excluded subjects with the best corrected visual acuity worse than 6/6, N6, and those with ocular and systemic diseases, one-eyed Participants were also excluded from our study. All the subject included were non-athletes. They were asked to anticipate the arrival (Anticipatory skill) of LED lights to the target point and react (Reaction time) immediately to stop the light at the target point.

The training sessions were given for 15 min and were designed to facilitate the acquisition of anticipatory skills, a critical component of our study. These sessions involved the use of our specialized device.

After the training session, the study subjects were once again subjected to the same anticipatory timer test. During this post-training phase, their response times in seconds and error counts were documented for further analysis.

Patient informed consent: Informed consent was obtained from all individuals included in this study.

2.3. Statistical methods

Descriptive statistics were used to summarize the baseline characteristics and task performance data in milliseconds and error counts. This included calculating the mean, standard deviation, and minimum and maximum values.

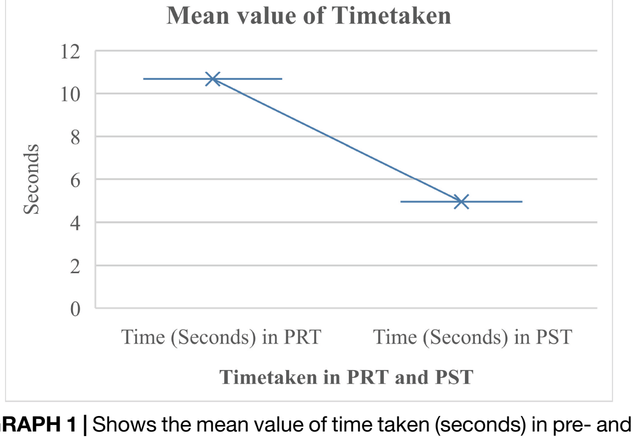
We used the Shapiro-Wilk test to assess normality and found that the data distribution deviated from normality. Therefore, we employed non-parametric tests, including the Wilcoxon signed-rank test and Spearman correlations. Wilcoxon signed-rank test was used to analyze pre- and post-performances. Spearman correlations were used to explore potential relationships within the dataset.

3. Results

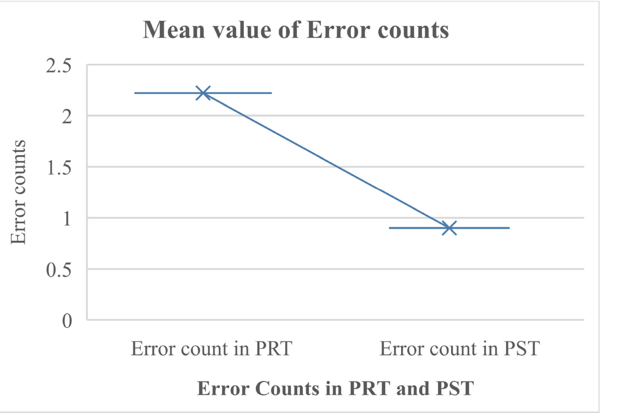
In this study, a total of 51 students participated. The mean age of participants was 18.51 ± 1.41 years with maximum and minimum of 22 years and 17 years, respectively. All participants had good static visual acuity, scoring equal to or better than 0.1 log MAR (equivalent to 6/7.5 on the Snellen chart), and they exhibited no color vision deficiencies. Additionally, they were free from ocular diseases and systemic illnesses. Refractive errors were corrected to ensure the best possible visual acuity before conducting the assessments.

The participants demonstrated significantly lower mean values in the error counts in post-training sessions (0.9 ± 1.118) when compared to pre-training sessions (2.22 ± 2.9), which is graphically shown in **Graphs 1**, **2**.

The normality of the data was evaluated using the Shapiro-Wilk test, resulting in the following statistical findings: $W = 0.785$, $p < 0.001$; $W = 0.758$, $p < 0.001$; $W = 0.861$, $p < 0.001$; and $W = 0.758$, $p < 0.001$, for time taken before training, error count before training, time taken after training, and error count after training, respectively. These results suggest that the data are not normally distributed.



GRAPH 1 | Shows the mean value of time taken (seconds) in pre- and post-training sessions, PRT: Pre-training session, PST: Post-training session.



GRAPH 2 | Shows the mean value of error counts in pre- and post-training sessions, PRT: Pre-training session, PST: Post-training session.

We conducted a Wilcoxon Signed-Rank Test to evaluate the difference in time taken (in milliseconds) between the pre- and post-training sessions. The results showed $Z = -3.3130$; $p = 0.002$ indicating a significant difference between the pre- and post-training sessions, based on positive ranks.

The results of the Wilcoxon Signed-Rank Test indicate a significant difference between pre-training error count and post-training error count $z = -3.044$; $p = 0.002$. Consequently, we observed a substantial decrease in the error count following the training.

4. Discussion

The study found that, after a 15-min training session using the anticipation timer, there was a significant reduction in error counts in the post-training measurements compared to the pre-training measurements. This improvement indicates that anticipation training can enhance the accuracy of anticipatory skills and make individuals react faster and more accurately.

The significant reduction in error counts post-training aligns with previous research highlighting the adaptability of the human perceptual system. Anticipation and reaction skills are critical in dynamic sports environments, where athletes must quickly process visual information and respond accordingly.

It is worth noting that this study's sample size was relatively small, and the participants were all of a similar age range. Future research could explore the effects of anticipation training in larger and more diverse populations to assess whether age, gender, or other factors influence training outcomes. Additionally, the long-term retention of improved anticipation skills should be investigated to determine the lasting impact of such training.

In a study conducted by Caires et al., the impact of a single training session on visual choice reaction time in individuals following mild stroke was explored. Seven participants engaged in reaching tasks on both affected and unaffected sides in both ipsilateral and contralateral spaces. After training involving a randomized sequence of six circles presented in five blocks, a significant reduction in choice reaction time was observed for the unaffected side in the ipsilateral space ($p = 0.041$). While other conditions lacked statistical significance, they displayed clinical relevance in Cohen's d ($d > 0.60$). This suggests that even a single training session can improve reaction times in stroke survivors (6).

In a study involving football players, Wilkerson et al. investigated visuomotor reaction time (VMRT) as a predictor of injury. A pre-participation VMRT cut-off of $\leq$ 85 hits ($\geq$ 705 ms) was associated with a 2.30-fold increased injury risk. Those slow players who completed a 6-week VMRT training program exhibited significant performance improvement, while untrained players experienced a small performance decrement, highlighting VMRT as a modifiable injury risk factor. Hence the study gives evidence that improved VMRT reduces injury incidence (7–10).

5. Conclusion

The results of this study support the idea that anticipation training using a constructed anticipation timer can enhance anticipatory and reaction skills. The reduction in error counts post-training suggests that this form of training may be beneficial for individuals involved in sports or activities requiring quick and accurate responses to visual stimuli. Further research is warranted to explore the broader applicability of anticipation training and its potential benefits in various contexts.

Author contributions

MN: Conceptualization, Formal analysis, Validation, Writing – Original draft, Supervision, Project administration. MS: Data curation, Writing – Original draft preparation, Writing – Review and Editing, Visualization, Supervision, Project administration. PS: Methodology, Resources, Software, Validation, Investigation. AS: Formal analysis, Visualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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