Introduction

Sepak takraw is a ballistic open skill sport which is similar to tennis in order to win a point. This sport is considered a Malaysian national game. Like other team games, *sepak takraw* consist of two major elements, which are attack and defense. The main purpose of this game is to terminate a rally into the opponent's court. This is usually achieved through superior ball control. The service, volley pass and spike are offensive skills. The server's role is assumed to be the most crucial to the team's overall performance because a good service is sometimes sufficient in starting and terminating rallies in order to gain point. The serve initiates a rally, and may be very effective in enabling teams to win easy point. Due to its obvious significance, serving is regarded as *sepak takraw* first dimension of offence. A good serve will score a point directly, whilst an accurate and well-placed pass is essential to set up the spike.

An important characteristic of *sepak takraw* skills is the production of finely timed actions geared to approaching objects. This situation advocates that strategies to use early advance cues from the opponent's service action, as well as the effective co-ordination of head, eye and postural movements during ball flight would appear to be the pre-requisites for a successful performance. From the given information, players in *sepak takraw* must have the ability to visually detect, early in the flight, the ball's trajectory and the velocity after being served. The receiver has extra time to process the information in order to make the most appropriate response, if the players were successful to detect invaluable information prior to contact.

Visual perception in *sepak takraw*

In open skill sports, the receiver awaiting a service is facing with multifaceted problem-solving tasks. A decision must be reached, often in a very severe time constraint as where to anticipate the ball. In *sepak takraw*, the receivers can only anticipate the direction and depth of the ball. Receivers at highest level of competition have very limited time period in which to view their opponents' action before having to engage in some decisions about their own response selection. Receivers have to react to the high ball velocities, and varieties of service deliveries. This phenomenon is similar to other fast ball games in which the players have to conduct decision-making processes under severe time constraints. At the initiation of every point in a match, a player is immediately placed in a time-constrained situation, where they must return the serve. Players must be prepared to react to the service placement and velocity, without any prior knowledge of the opponent's intention. To facilitate an effective return, players must be able to anticipate the depth, direction, and types of the service as precisely as possible. Experts in sports which deal with severe time constraints and environmental uncertainty have developed a range of extremely efficient decision-making strategies which have the net effect of reducing reaction time by decreasing the total amount of information to be processed (Abernethy, 1991). In order to make an efficient decision making strategy, players have to learn how to anticipate their opponent's shot in advance, prior to ball-foot contact. This requires an alert mind and awareness. Singleton (1988) suggested that the players should anticipate opponent's responses by understanding the opponent's habits along with the body movements.

There are many varieties of service, for example drop service, lob and spin (top, bottom and side) service in *sepak takraw*. Majority of servers utilize the "instep kick" to produce higher post-contact ball velocity. A well-executed serve puts the opposing team on the defensive. Accurate placements, unpredictable movement, high ball velocities, or a combination of these factors are crucial elements for effective serving. In 1995, a different technique called *kuda* service was introduced. This technique requires plantar flexion of the foot and ball-foot contact occurs at the upper region of the service foot, whereas traditional service imposes dorsi flexion of the foot and ball-foot contact occurred at the inside region of the serving foot. The kinematics of *kuda service* is different from the traditional (*sila*) service in term of ball-foot contact and angle of radius gyration. Receivers should be able to apply different perceptual strategies due to different technique used to execute *kuda* service.

Service in *sepak takraw* is a projectile motion. In this situation, it is generally agreed that the greater the time available to evaluate the trajectory of the ball, the better the coincidence-anticipation will be (Whiting & Sharp, 1974). However, in a game situation, time available to evaluate ball trajectory is very limited. In order to shorten the time needed to solve the task, players must use only the most relevant information. Essential kinematics information may come from the server's movements, as well as their position in court (Bard & Fleury, 1981; Salmela & Fiorito, 1979). This information helps the receiver to build specific predictions about the event outcome. Although such information helps players to shorten reaction times, it is possible that, within a particular time constraint, the higher the predictions for a particular event are, the better the performance will be. Such is the case if the subject's predictions are accurate. An example from baseball reveals that a fast ball pitched at 145km/hr will reach the home plate in approximately 375 milliseconds (ms). Batters must complete their perceptual processes in approximately 10ms (Radlo, Janelle, Barba, & Frehlich, 2001). Conversely, a slower pitch such as curveball is typically thrown between 110-120km/hr, and allows batters slightly more time to 'process' the pitch. Unfortunately, misjudging the speed of a pitched ball by just 2ms will likely result in a foul ball (Adair, 1994). Findings showed that ball velocities and varieties of the pitch are crucial factors in enabling points to be scored in these types of sports.

In *sepak takraw*, a well-placed and accurate drop service usually can deliver a point to the team. Thus, such a change in the ball speed of the ball can have an effect on the time allocated towards such perceptual processes as stimulus identification, pattern recognition and memory template matching. Studies in baseball, cricket, tennis, and other sports which require similar perceptual decision making demands have supported the idea that when players use advanced cues extracted from their sporting environment, faster decision-making occurs (Ripoll, 1991; Bard & Fleury, 1981). Prediction outcome events have a negative effect if the predictions are incorrect. As a result, predictive efforts are engaged only with appropriate provocation, and only when it appears profitable to do so. Players must seek advance cues to predict, with some degree of precision beyond the level of chance in the situation of combating time-pressure to reduce the negative risk.

Perceptual strategy demands for superior anticipatory skills in ballistic sports include that the opponent's intent must be clearly known. In the anticipation of a *sepak takraw* service, such intent is revealed through kinematic properties of the serving action. This study was based on the premises that: (i) kinematics serving action are governed by simple biomechanical principles, (ii) all movement patterns in sport have quantifiable kinematics (Kreighbaum & Barthels, 1996), and (iii) kinematics involve progressive proximal-to-distal summation across relevant joint segments (Lundin, 1989).

The above assumptions necessitate the receivers to understand the biomechanical principles of the service kinematic sequences. Receivers should also be able to pickup advance essential perceptual information from server preparatory kinematics. This ability will enable receivers to elude potential time constraints through early prediction of the server's forthcoming action. Given the proximal-to-distal development of service, a fundamental link should exist between perceptual expertise and basic biomechanics of action being viewed. Literature posits that expert players should be able to extract more information from early advances cues than novices and in terms of cue sources they utilize in making anticipatory judgments.

Sepak takraw serving techniques

The *sila* serving techniques had been utilized in international *sepak takraw* competitions until the introduction of the *kuda* service technique in 1995. Prior to 1995 Malaysia won all the *sepak takraw* gold medals contested at the Asian Games tournaments. Malaysian dominance ended with the implementation of the new serving technique during the 1995 SEA Games. Previous studies (Sidthilaw, 2000; Juliana, Noor Azuan, Azmin Sham, & Wan Abu Bakar, 2002) showed the speed of foot at impact is a contributing factor in the speed of the ball in *kuda* service. Sidthilaw (2000) conducted a three dimensional kinematic analysis of the *sepak takraw* serve during the 13th Asian Games to evaluate six international servers from Thailand, Myanmar, Malaysia, Indonesia, Singapore and Brunei Darussalam. It revealed that mean foot velocities at impact of *sepak takraw* serve were 11.07, 9.00, 8.99, 7.62, 8.87 and 8.57m/s respectively. This study showed that *kuda* service performed by servers from Thailand and Myanmar produced greater velocities from other countries. Due to a higher ball velocity resulting from *kuda* service, information processing time of the receiver will be limited, which leads to difficulty in predicting outcomes of the serve. Viewing time will also decrease when the receivers have to respond to the *kuda* service, should they rely only upon ball flight information.

The purpose of this study was to determine perceptual behaviour of receivers in anticipating the *kuda* and *sila* service techniques in *sepak takraw*. It was hypothesized that experts would be more intelligent of extracting valuable information than novices. This hypothesis was tested through visual simulation experiment on temporal anticipatory cue usage.

Methodology

The research employed quasi-experimental design, which involved two groups based on *sepak takraw* skill levels (experts and novices), and two types of *sepak takraw* service techniques. Research participants were required to view visual stimulation depicting both the temporal events that occurred during the execution of *sila* and *kuda* services. Participants were required to predict the outcomes of both services.

Participants

Twelve male *sepak takraw* experts and twelve male novices participated voluntarily in this study. Expert participants' age ranged from 21 to 25 years old. They were randomly selected from a group of Malaysian national *sepak takraw* team. Novice participants were randomly selected from a group of undergraduates at University College of Science and Technology Malaysia, enrolled in co-curriculum activity programme. Age range of novices was similar to the expert group. Novice participants possess basic *sepak takraw* skills and have been involved in the sport at recreational levels. They have also observed high-level *sepak takraw* matches being played.

Visual Simulation Construction and Design

For construction of the visual display, the camera was placed in front of the server at two metres from the baseline of the receiver’s court. *Two servers* were randomly selected from a pool of Malaysian national players to execute the *kuda* and *sila* services. The visual simulation consisted of several series of temporal occlusion of *kuda* and *sila* services. Twelve *kuda* services and 12 *sila* services replication consisted of six directional (left) services and six directional (right) services were selected for the visual displays. Server being in ready position to serve the ball was the common starting event in each of the occlusion conditions. The action sequence included the player tossing the ball to the server and the complete action of the service. A randomized order of 168 trials of visual display presentation (12 traditional services x seven occlusion conditions + 12 *kuda* services x seven occlusion conditions) was created with a five-second inter-trial interval (ITT). Rationale for the rather rapid inter-trial interval was to simulate the actual game situation where responses have to be made within a short period of time. Seven time windows that represented the occlusion conditions were as follows:

Time-window 1 (T1)	occlusion of display occurred at 240ms prior to ball-foot contact.
Time-window 2 (T2)	occlusion of display occurred at 160ms (4 frames) prior to ball-foot contact.
Time-window 3 (T3)	occlusion of display occurred at 80ms (2 frames) prior to ball-foot contact.
Time-window 4 (T4)	occlusion of display occurred at the point of ball-foot contact.
Time-window 5 (T5)	occlusion of display occurred at 80ms (2 frames) after to ball-foot contact.
Time-window 6 (T6)	occlusion of display occurred at 160ms (4 frames) after to ball-foot contact.
Time-window 7 (T7)	no occlusion – control condition.

Procedures

Specifically, participants were subjected to the following conditions: (i) seated two metres in front of the visual display, provided with pencil and response card, (ii) visual presentation displayed at the overall chin-level height, (iii) server's action was displayed with the first five displays serving as a guideline to accommodate the participants with the real experiment, (iv) visual presentation displayed when participants were ready, and (v) participants mark their response card based on their prediction of the service direction. A score of one will be given for prediction error and score of zero for a correct prediction. Total scores were then converted into percentage errors.

Analysis of Data

A priori comparison was used to determined significant difference between experts and novices. Two-way ANOVAs were used to determine the effects of the factors of skill level, service groups and temporal occlusion upon each measure of prediction error.

Results and Discussion

Confidence Interval Analysis (CIA) of the data was done to determine if the accurate anticipation of the service was by chance or by the utilization of advanced perceptual information. As there were only two alternatives (i.e. left or right) provided on the response card; the probability of an accurate prediction was 0.5 for every visual simulation presented. Table 1 and Table 2 present the results of the confidence interval analysis of the participants for every time frame; from t1 to t7.

At t1, the prediction error of expert participants for both the *kuda* service and *sila* service was below 50% of the probability level. This finding shows that experts were able to utilize visual information 80ms after ball toss. On the other hand, the prediction error for novice player at the similar time frame was above 50% of the probability level. This shows that novices were unable to utilize visual information during the same time period.

As more visual information was presented, at t2, t3, t4, t5, t6 and t7, the prediction error was reduced. CIA showed that experts were able to utilize visual information with the prediction error for all time frames below 50%. This finding indicates that experts were able to utilize all visual information presented. However, the prediction error of novices was above 50% of the probability level for t2 and t3. This finding shows that novices were unable to utilize information between 80ms and 160ms after ball toss to anticipate the final location of the ball for both the types of services. Table 1 summarizes the CIA findings.

Table 1: Confidence Interval Analysis of novice at t1 to t7 time frame for both services.

Expertise / Time Frame	**Min *Kuda***	**Min *Sila***	**Low Interval *Kuda***	**Low Interval *Sila***	**Upper Interval *Kuda***	**Upper Interval *Sila***	**Sig. *Kuda***	**Sig. *Sila***
Novice at t1	54.89	46.38	47.56	40.09	63.89	53.51	0.21	0.18
Novice at t2	41.22	41.83	35.80	36.37	47.14	47.81	*	*
Novice at t3	38.61	33.23	33.37	28.36	44.19	38.39	*	*
Novice at t4	22.33	17.01	17.70	12.65	27.06	21.72	*	*
Novice at t5	14.77	2.23	12.18	-0.27	17.40	4.70	*	*
Novice at t6	0.00	0.00	0.00	0.00	0.00	0.00	*	*
Novice at t7	0.00	0.00	0.00	0.00	0.00	0.00	*	*

*$p < 0.05$

Table 2: Confidence Interval Analysis of experts at t1 to t7 time frame for both services.

Expertise / Time Frame	**Min *Kuda***	**Min *Sila***	**Low Interval *Kuda***	**Low Interval *Sila***	**Upper Interval *Kuda***	**Upper Interval *Sila***	**Sig. *Kuda***	**Sig. *Sila***
Expert at t1	32.96	27.06	27.65	22.02	38.61	32.41	*	*
Expert at t2	17.10	14.36	12.71	10.02	21.53	18.72	*	*
Expert at t3	13.83	8.22	9.55	4.01	18.18	12.47	*	*
Expert at t4	3.32	0.00	-0.97	-4.30	7.64	4.30	*	*
Expert at t5	0.00	0.00	-2.52	-2.52	2.52	2.52	*	*
Expert at t6	0.00	0.00	0.00	0.00	0.00	0.00	*	*
Expert at t7	0.00	0.00	0.00	0.00	0.00	0.00	*	*

*$p < 0.05$

Descriptive analysis for prediction of service direction is presented in Table 3. The pattern of prediction for the *kuda* service was almost similar for both groups. The gradient of the graph for the *kuda* service between t2-t3 was small for both groups. The gradient of the graph between t1-t4 for the *sila* service was quite regular, indicating a similar perceptual strategy was used by both expert and novice athletes. At t4, prediction by the experts for the *sila* service was 100% accurate; while for the *kuda* service it was 96.67% accurate. Novices were only able to perfectly anticipate at t6 i.e. 160 ms after ball contact.

The analysis revealed that experts were able to reduce the prediction error between t1 and t2 for the *kuda* service by 17.78%. For the similar time frame in *sila* service, error reduction rate was 12.82%. Although the reduction in prediction error for *kuda* service was higher, the prediction error for t1 for the *kuda* service was relatively higher than the prediction error at t1 for the *sila* service. As such, the data shows that experts faced more difficulties in accurately anticipating *kuda* service when compared to *sila* service.

At t3, *kuda* service prediction error (13.89 ± 6.03%) by the experts was relatively higher for *sila* service prediction error (8.33 ± 8.91%). This also shows that experts found it more difficult to accurately anticipate the *kuda* service than the *sila* service. Prediction error reduction for t2-t3 for *sila* services was higher (6.07%) when compared to *kuda* services (3.33%). A similar pattern of anticipatory performance was seen for t4. Prediction error for the *kuda* service (3.33 ± 4.22%) was relatively higher compared to the *sila* service. At t4, experts were able to accurately anticipate the location of the *sila* service. Experts were also able to anticipate accurately for both types of services at t5, t6 and t7.

Table 3: Prediction error for both services at t1 to t7

Time frame	Experts		Novices	
	Kuda	**Sila**	**Kuda**	**Sila**
t1	35.00 ± 18.40 %	27.22 ± 5.86 %	55.56 ± 7.50 %	48.89 ± 16.33 %
t2	17.22 ± 7.36 %	14.40 ± 7.40 %	42.22 ± 11.98 %	43.33 ± 13.80 %
t3	13.89 ± 6.03 %	8.33 ± 8.91 %	39.44 ± 11.56 %	33.89 ± 10.67 %
t4	3.33 ± 4.22 %	0.00 ± 0.00 %	22.78 ± 11.12 %	17.78 ± 14.39 %
t5	0.00 ± 0.00 %	0.00 ± 0.00 %	15.00 ± 9.55 %	2.22 ± 3.81 %
t6	0.00 ± 0.00 %	0.00 ± 0.00 %	0.00 ± 0.00 %	0.00 ± 0.00 %
t7	0.00 ± 0.00 %	0.00 ± 0.00 %	0.00 ± 0.00 %	0.00 ± 0.00 %

Novices showed an almost similar pattern as the experts in the anticipation accuracy of the *kuda* service and *sila* service. At t1, *kuda* service prediction error was (55.56 ± 7.50%) which was relatively higher than the *sila* service prediction error (48.89 ± 16.33%). Interestingly, at t2, the data showed a reversal in service prediction error; *sila* service prediction error was (43.33 ± 13.80%) higher when compared to *kuda* service prediction error (42.22% ± 11.98%). Prediction error for the *kuda* service at t4 (22.78 ± 11.12%) and t5 (15.00 ± 9.55%) was also higher than the prediction error for *sila* service at t4 (17.78 ± 14.39%) and t5 (2.22 ± 3.81%). In sum, novices faced more difficulties in accurately anticipating *kuda* service compared to the *sila* service.

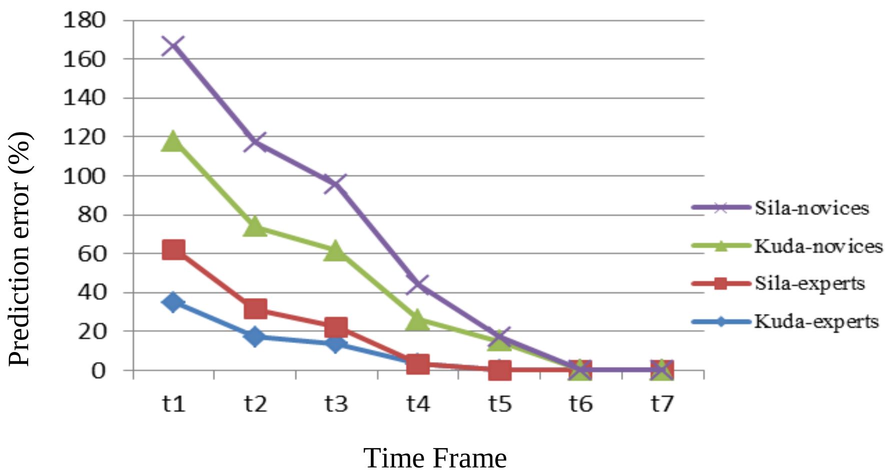

Figure 1: Prediction error comparison for both group and both services

Data were further analyzed to investigate the prediction error of experts in anticipating the *kuda* service and *sila* service for each time frame. Repeated measures ANOVA showed a significant difference among expert players in anticipating both services at t1 [F (14, 180) = 2.37; $p < 0.05$], t2 [F (14, 180) = 5.60; $p < 0.05$], t3 [F (14, 180) = 3.81; $p < 0.05$] and t4 [F (14, 180) = 2.00; $p < 0.05$]. There were no significant differences at t5 through t7. Anticipatory performances were consistent in both the *kuda* and *sila* service from t1 to t7. Significant difference among experts was evident in anticipating the *kuda* service at t1 [F (14, 154) = 2.23, $p < 0.05$]. No significant differences among experts in anticipating the *kuda* service were found at t2 through t7. Perceptual strategies among experts were found to be more consistent when anticipating the *sila* service.

Reduction in experts' prediction error

There were reductions in prediction error among experts in anticipating the *kuda* service between t1 and t2; t2 and t3; and t3 and t4. However the differences were only significant between t1 and t2 [F (1, 28) = 9.03, $p < 0.01$]; and t3 and t4 [F (1, 28) = 83.63, $p < 0.01$]. For the *sila* service, there were significant differences between t1 and t2 [F (1, 28) = 27.24, $p < 0.01$]; t2 and t3 [F (1, 28) = 4.29, $p < 0.05$] and between t3 and t4 [F (1, 28) = 13.38, $p < 0.01$].

Comparison between experts and novices

A priori comparison showed significant differences at t1 [F (1, 28) = 18.75, $p < 0.05$], t2 [F (1, 28) = 50.79, $p < 0.05$], t3 [F (1, 28) = 62.66, $p < 0.05$], t4 [F (1, 28) = 45.09, $p < 0.05$], and t5 [F (1, 28) = 38.12, $p < 0.05$] for the *kuda* service. Expert-novice differences were also significant for the sila service at t1 [F (1, 28) = 29.91, $p < 0.05$], t2 [F (1, 28) = 61.52, $p < 0.05$], t3 [F (1, 28) = 54.79, $p < 0.05$], t4 [F (1, 28) = 25.57, $p < 0.05$] and t5 [F (1, 28) = 5.09, $p < 0.05$]. Statistical power analysis produced a high level of 0.8.

Expertise, types of service and time frame interactions

Factorial ANOVA showed a significant difference between experts and novices in the anticipation test [F (1, 392) = 370.43, $p < 0.05$]. The results show that the visual perception skills can be used to validate the skill level of *sepak takraw* players. Analysis between *kuda* and *sila* service yielded a significant difference [F (1, 392) = 22.79, $p < 0.05$]. The time frames for between both type of services was also found to be significantly different [F (1, 392) = 283.14, $p < 0.05$].

Comparisons of expertise level and time frames yielded a significant difference [F (29,392) = 8.08, $p < 0.05$]. This shows that the participants of the study utilized the visual cues presented to anticipate the final location of the ball. Data was further analysed to investigate the interaction between time frames and type of service. The analysis showed a significant difference between service groups and time frames [F (1, 392) = 20.25, $p < 0.05$]. This finding reiterates the kinematic differences between the two services.

Interaction analysis between expertise level, time frame and type of service showed a significant difference [F (1, 392) = 283.14, $p < 0.05$], hence confirming the earlier analyses that players of different levels (experts/novices) anticipate different types of services at different time frames. It also shows that the *kuda* service and *sila* service have significantly different time phases. While expert players were able to effectively utilize cues as early as 80ms of ball toss, novice players were only able to anticipate accurately 240ms after ball toss. Experts also found it more difficult to anticipate the *kuda* service than the *sila* service at 80ms of ball toss (t1). The findings of the study showed a significant difference in the ability of experts to accurately anticipate the *kuda* service and the *sila* service during earlier parts of the action. Experts were more accurate in anticipating the *sila* service compared to the *kuda* service. These differences can be attributed to the differences in the kinematic patterns of both the services (*kuda* and *sila*). Experts were more accurate in anticipating the final location of the ball for the *sila* service compared to the *kuda* service.

The expert-novice differences were evident in all conditions of the *sila* and the *kuda* service. In line with the findings of previous studies (Abernethy, 1996; Williams & Starkes, 2002); the expert's ability to accurately anticipate the services can be attributed to the superior *visual software* acquired by the experts through the experience of training and playing *sepak takraw*. This experience has enhanced their ability to extract relevant information from the performing environment. The experts' ability to extract information early in the preparatory phase contributed to the higher accuracy in anticipation by the experts (Williams & Starkes, 2002). Relevant information here refers to optical flow from the kinematics of the *tekong* in the preparatory phase of service execution. As such the findings of this study are consistent with Gibson's (1966) Ecological Theory that proposes the visual perception is a direct process.

Expertise in *sepak takraw* is influenced by domain specific cognitive processes. As this study has shown, although the lower body dominates action in *sepak takraw*, expert *sepak takraw* participants are able to detect early cues replicating findings in earlier studies on anticipation (William & Burwitz, 1993; Williams & David, 1998; Savelsberg, William, Kamp, & Ward, 2002). Understanding and possessing in-depth knowledge on movement patterns enable players to anticipate accurately in less than ideal conditions. Experts are able to recognize movement patterns by identifying critical cues early. Identifying movement patterns enables players to understand and categorize information that appears in their visual field. In this context, the ability of experts to extract and consequently organize and classify essential information as meaningful cues in complex actions is related to the understanding and in-depth knowledge possessed by experts in their respective domains.

This study has shown that players utilize different perceptual strategies to anticipate the *kuda* and *sila* service. Based on the temporal phases it is evident that the mechanical patterns of the *kuda* service differ from the *sila* service, thus *sepak takraw* players need to utilize different perceptual strategies in anticipating the different types of service. Further studies utilizing different methods (e.g. spatial occlusion) need to be carried out, before concrete conclusions can be made. It is also recommended that visual search techniques and point light display need to be combined in future studies. Utilization of life sized visual simulations of the server's action and with participants required to produce leg action in response to the visual simulation could be essential to provide better insight with regards to actual relationship between perception and action. High definition visual recording and display equipment should be used to enhance visual acuity due to the speed of limb movement during the execution of service. A more elaborate time frame would shed light on the temporal parameters in identifying critical cues in the course of anticipation of service in *sepak takraw.*

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