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Application of Inner Speech in the Motor Learning Context: A Validation Study

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ABSTRACT

This study addresses the absence of suitable tools for evaluating the frequency and content of inner speech during the acquisition of new motor skills by adapting the Learning-Specific Inner Speech Scale (Xiang et al., 2020) for a motor learning context. We assessed the modified scale, termed the Motor Learning-Specific Inner Speech Scale (MLISS), focusing on its factor structure, internal consistency, and content validity among young adults in Study 1. A total of 325 university students (145 females) participated, completing the MLISS, which comprises 16 items across four dimensions of inner speech: self-criticism, self-reinforcement, self-management, and social assessment. In Study 2, 149 university students (58 females) completed the MLISS and executed three basketball skills: shooting, passing, and dribbling. Data analysis employed confirmatory factor analyses and structural equation modeling, which confirmed the proposed scale structure. Notably, the self-reinforcement and self-management dimensions of the MLISS showed significant correlations with basketball performance, affirming the measure's construct validity. These findings indicate that the MLISS is a valid tool for assessing inner speech frequency in motor learning, marking the first extension of an existing inner speech measure into this domain.

Keywords: *Inner speech, motor learning, self-talk, scale, motor performance*

1. Introduction

Motor skills refer to the ability to engage specific muscle groups to achieve particular objectives. These skills can be broadly categorized into gross motor skills, which involve large muscle movements and whole-body actions such as standing, walking, running, and jumping, and fine motor skills, which require the coordination of smaller muscle groups for tasks like picking up small objects or using scissors (1). While it is commonly believed that motor skills are developed through physical practice and repetition, research indicates that cognitive strategies can also facilitate motor skill acquisition, regardless of physical engagement. One prevalent cognitive strategy is self-talk, which encompasses verbalizations directed at oneself, either spoken aloud or internally. In sports, self-talk can serve various functions, including motivational or instructional purposes, and can be framed positively or negatively, thus influencing performance outcomes (see (2-9)).

Research has extensively explored the impact of self-talk on both motor performance, which refers to temporary motor behavior observed during practice sessions, and motor learning, characterized by more stable improvements in the ability to execute motor tasks through practice and targeted interventions (10-15). A meta-analysis by Hatzigeorgiadis et al. (2011) revealed that instructional self-talk, such as cues like "ball … step … swing," is more beneficial for precision and outcome-oriented skills, including dart throwing and golf putting, whereas motivational self-talk, like "I can do this," is more effective for skills that demand physical conditioning, endurance, and strength, such as cycling and long-distance running (11). The literature suggests that self-talk influences various cognitive and motivational processes, including information processing, self-efficacy, emotional regulation, and the execution of movement patterns, thereby enhancing overall performance (6).

The timing and rationale behind novices' use of self-talk during the motor learning process remain ambiguous. One potential explanation for this uncertainty is the lack of suitable tools to evaluate the frequency and content of internal dialogue while acquiring new motor skills. Although self-talk has been extensively researched among athletes, with validated instruments like the Self-Talk Use Questionnaire (16) and the Automatic Self-Talk Questionnaire for Sports (17) that explore various dimensions of self-talk in sports contexts, there appears to be a significant gap in research and assessment tools focused on inner speech in the context of learning new motor skills.

Intrapersonal communication manifests in various forms, including self-talk and inner dialogue. Research in this domain emphasizes the self-regulatory roles of inner speech, as noted by some scholars (18-20). The Self-Talk Scale (STS), developed by Brinthaupt et al. (2009), evaluates individuals' typical self-talk in response to everyday situations, focusing on four key functions: self-criticism, self-reinforcement, self-management, and social assessment (21). Self-criticism involves negative self-talk during discouraging experiences, while self-reinforcement pertains to positive self-dialogue following favorable events. Self-management relates to regulating one's behavior, and social assessment addresses self-talk about social interactions. Although the STS gauges the frequency of self-talk in general contexts, researchers have adapted the scale for specific scenarios, such as public speaking (22).

Recently, Xiang et al. (2020) introduced the Learning-specific Inner Speech Scale (LISS), designed to evaluate self-talk among students across various age groups. This scale adopts a functional perspective on inner speech, measuring the prevalence of self-critical, self-reinforcing, self-managing, and social-assessing inner dialogues within distinct learning and academic settings (23). Through three studies involving children, adolescents, and young adults, the authors established that the LISS possesses satisfactory psychometric properties, including internal consistency, test-retest reliability, and both construct and content validity. Furthermore, the LISS is sensitive to age differences and shows promising predictive validity regarding students' actual learning outcomes. Xiang et al. concluded that the LISS serves as a valuable instrument for researchers and practitioners interested in examining verbal cognition and its connections to learning strategies and academic performance. However, it is important to note that the academic learning environment differs from that of motor skills acquisition, as the latter primarily depends on learners' motor and cognitive abilities, while academic skills are predominantly cognitive in nature (1).

In conclusion, current tools for evaluating inner speech in the context of motor skill acquisition are inadequate. Recognizing the significance of inner speech in sports (5, 6, 9), our studies aimed to adapt the LISS for motor learning and assess the modified scale's quality by analyzing its factor structure, internal consistency, and content validity among young adults (Study 1). Following the establishment of the measure's psychometric properties, we proceeded to evaluate whether the revised LISS could predict motor performance in learners (Study 2).

2. Study 1

2.1. Participants

This research involved 325 university students, comprising 145 women, aged between 19 and 22 years, from national universities in Tehran, Iran. All participants provided written informed consent prior to their involvement in the study. They completed the assessment materials in a quiet classroom setting using paper and pencil.

2.2. Measure

In this study, we adapted the LISS (23) to better suit the context of motor learning. The original LISS assesses the

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frequency and content of inner speech during specific learning situations, such as academic assessments and interactions with peers or educators. It comprises 16 items that evaluate four dimensions of inner speech—self-criticism, self-reinforcement, self-management, and social assessment—each represented by four items rated on a 5-point frequency scale (1 = never, 5 = very often), beginning with the prompt "I talk to myself silently when…" To tailor the LISS for motor learning, we rephrased the items relevant to each dimension. For instance, the self-criticism item "I should have done differently in solving a problem or reading a book" was modified to "I should have done differently in performing a motor skill." The new items were developed based on insights from various motor learning studies (24-26), resulting in the creation of the Motor Learning-specific Inner Speech Scale (MLISS).

The research adhered to the protocol established by Wild et al. (2005) for the translation and validation of the MLISS (27). Initially, the MLISS was translated into Persian by two proficient translators fluent in both English and Persian. Their translations were subsequently compared, analyzed, and synthesized into a single cohesive version. To ensure clarity and comprehension, the Persian MLISS was then piloted with a sample of young adults (n = 41, aged 18-24 years), leading to minor adjustments in the wording of certain items. Ultimately, all items were deemed understandable and suitable for students aged over 18. In the subsequent phase, the finalized Persian MLISS was translated back into English by two skilled translators who had no prior interaction with the initial translators. A lead translator then compared these translations with the original MLISS to confirm their accuracy.

The final iteration of the MLISS, detailed in the Appendix, comprises 16 items that evaluate the same four dimensions as the LISS: self-criticism (e.g., feelings of shame or guilt regarding motor skill performance), self-reinforcement (e.g., positive feelings about motor skill learning), self-management (e.g., a desire to explore methods for learning a motor skill), and social assessment (e.g., consideration of feedback from instructors or teammates). Additionally, we updated the instructions for administering the measure to better align with the context of motor learning.

2.3. *Data analysis*

Internal consistency reliability was evaluated through Cronbach's alpha, while the relationships between subscales were examined using the Pearson correlation test. To assess the construct validity of the MLISS, confirmatory factor analyses (CFA) were conducted with Lisrel® version 10.2, employing maximum likelihood estimation to evaluate model fit. A range of fitness indices, as suggested in the literature, were utilized, including Chi-square, SRMR, NNFI, CFI, IFI, and RMSEA. Prior to performing the CFA, we ensured that the assumptions of maximum likelihood estimation were met.

2.4. *Results*

Table 1 presents the MLISS subscales along with the total score, highlighting the correlations between the subscales. Notably, all subscales exhibited positive and significant correlations with each other, as well as with the total score (all ps < 0.001). Additionally, the reliability analysis indicated that Cronbach's alpha values exceeded the acceptable threshold of 0.70, as detailed in Table 2.

Table 1

Descriptive statistics and correlation between subscales

Measure	M	SD	1	2	3	4	5
1. Total score	52.89	12.2	-	0.77**	0.78**	0.78**	0.76**
2. Self-criticism	12.92	4.02	-	-	0.38**	0.34**	0.66**
3. Self-reinforcement	13.03	3.76	-	-	-	0.69**	0.36**
4. Self-management	14.7	4.1	-	-	-	-	0.37**
5. Social assessment	12.22	3.82	-	-	-	-	-

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Table 2

Cronbach's alpha results

Measure	Cronbach's Alpha
Self-criticism	0.79
Self-reinforcement	0.84
Self-management	0.89
Social assessment	0.81

We performed a confirmatory factor analysis involving four latent variables and 16 items. The findings, detailed in Table 3 and illustrated in Figure 1, indicated that the initial model comprising four factors—self-criticism, self-reinforcement, self-management, and social assessment—exhibited a good fit.

The second model incorporates two hidden factors: a positive function, which encompasses items related to self-reinforcement and self-management, and a negative function, which includes items associated with self-criticism and social evaluation of inner speech. The results from the confirmatory factor analysis (CFA) indicated that this model demonstrates an excellent fit. Additionally, a second-order CFA was conducted, revealing four first-order factors—self-criticism, self-reinforcement, self-management, and social assessment—culminating in a second-order factor representing overall inner speech. The findings confirmed that the final model also exhibits a strong. Consequently, the MLISS is validated as having appropriate construct validity and structural integrity.

Table 3

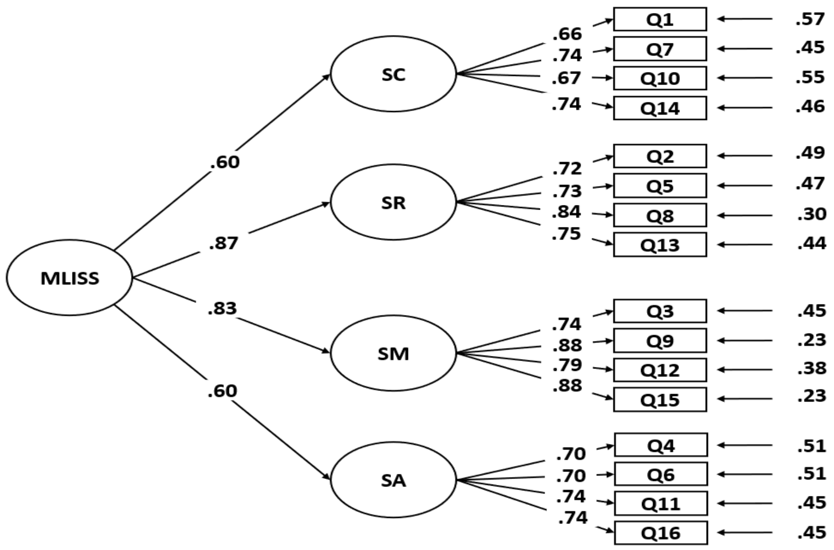
Results of fitting structural questionnaire models

	X^2	df	RMSEA	CFI	IFI	NNFI	SRMR
Final model (two-order)	303.59	100	0.079	0.92	0.92	0.90	0.090
Two-factor model (one-order)	349.10	103	0.086	0.90	0.90	0.88	0.051
Four-factor model (one-order)	175.1	98	0.049	0.97	0.97	0.95	0.03

Notes. df = Degree of Freedom; RMSEA = Root Mean Square Error of Approximation; CFI = Comparative Fit Index, IFI = Incremental Fit Index; NNFI = Non-normed Fit Index; SRMR = standardized root mean square residual.

Figure 1

b-Values



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2.5. Discussion

This study was initiated to address the absence of suitable tools for evaluating the frequency and content of inner speech during the acquisition of new motor skills. To this end, the researchers adapted the LISS (23) for the motor learning context, resulting in the development of the Motor Learning Inner Speech Scale (MLISS). The study then assessed the modified scale's factor structure, internal consistency, and content validity among young adults, with findings indicating that the MLISS demonstrates both reliability and validity. The subsequent discussion will explore potential applications of the MLISS in future research endeavors.

The subscales of the MLISS, which include self-criticism, self-reinforcement, self-management, and social assessment, represent dimensions that have not been previously explored within the realm of motor learning. While earlier self-talk instruments, such as the Self-Talk Use Questionnaire (16) and the Automatic Self-Talk Questionnaire for Sports (17), focused on various elements of self-talk in athletic contexts, the MLISS subscales introduce novel insights into inner dialogue specific to motor skill acquisition. During the early phases of learning new motor skills, individuals often encounter mistakes that can trigger self-critical thoughts, leading to a reduced sense of self-worth and emotional distress. Research by Brinthaupt (2019) indicates that the frequency of self-talk tends to rise in response to cognitive or emotional challenges, a phenomenon likely to occur when mastering new motor tasks (18).

It is essential to analyze the role of self-criticism in inner speech during the acquisition of new motor skills. Learners often practice these skills in the presence of peers, which can create significant pressure, especially when they make mistakes. This environment may lead to an increase in self-critical inner dialogue as they reflect on their performance errors. Conversely, the self-reinforcement aspect of inner speech emphasizes positive outcomes when learners successfully execute a new motor skill. This encouraging self-talk is particularly prevalent among novices who experience gradual improvement in their practice, reinforcing their confidence and motivation.

The role of inner speech in self-management is crucial for self-regulation and guiding a learner's behavior, particularly when acquiring new motor skills. Research indicates that self-talk significantly enhances cognitive and motor self-regulation, as evidenced by studies on motor learning and sports performance (6). This suggests that inner speech is particularly beneficial for novices as they navigate the complexities of learning new motor tasks. Given its self-regulatory capabilities, the self-management aspect of inner speech emerges as a vital component in the motor learning process.

Social assessment, which encompasses a learner's interactions with others—such as recounting comments made to peers or envisioning their reactions to the learner's performance—occurs frequently during the practice and execution of motor skills. Novice learners often receive feedback from instructors and fellow learners, and they may also engage in silent reflections on the feedback related to their teammates' performances. Consequently, examining the social assessment aspect of inner speech is crucial in the context of motor skill acquisition. The Motor Learning Inner Speech Scale (MLISS) thus emerges as a pioneering and validated instrument for measuring the prevalence of four functional dimensions of inner speech throughout the motor learning process.

3. Study 2

3.1. Participants

In the second study, we recruited 149 university students, comprising 58 women, aged between 19 and 22 years from national universities in Tehran, Iran. All participants had successfully completed a three-credit semester-long basketball course, ensuring they were familiar with the shooting technique and capable of executing it correctly, irrespective of the outcome of their shots. Written informed consent was obtained from each participant prior to their involvement in the study.

3.2. Measures

MLISS: Participants engaged in the MLISS as outlined in Study 1. This assessment took place in a quiet room within

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a sports hall, where they utilized paper and pencil before proceeding to the basketball skills testing.

Basketball skills: In this research, we employed three established and dependable basketball skills—shooting, passing, and dribbling—that are frequently utilized in studies on self-talk (2, 13). Each participant completed the skill assessments individually, without the presence of others. An experienced coach documented the scores on personal scorecards. The subsequent paragraphs will detail the skill tests conducted.

1) Shoot: We conducted a three-minute shooting test, which was adapted from methodologies established by Chroni et al. (2007) and Weinberg et al. (1991) (28, 29). In this assessment, participants attempted to make as many shots as possible from various positions within a designated perimeter of 366 cm radius around the hoop over a duration of 90 seconds. Participants were tasked with both shooting and retrieving the basketball independently. Each successful shot was awarded one point, and the test-retest reliability for this procedure has been reported at 0.91, as noted by Chroni et al. (2007) and Weinberg et al. (1991) (28, 29).

2) Pass: The Stubbs' Ball Handling Test was employed as referenced in Chroni et al. (2007). This test involved a vertical wall on which three adjacent circles, each measuring 30 cm in diameter, were marked at intervals of 160 cm apart. The circles were positioned at varying heights: the first at 151 cm, the second at 121 cm, and the third at 136 cm above the ground. The athlete began the test from a line painted 450 cm away from the wall. Upon receiving the verbal cue "Ready, … Go," the participant executed a chest pass to the first circle, retrieved the ball, and then passed to the second circle, followed by the third. This sequence was repeated, with the athlete continuously passing the ball among the three circles for a duration of 30 seconds. Points were awarded for each successful bounce within or on the edge of the circles, with a validity coefficient of 0.74 established by correlating the scores with the best results from two trials (28).

3) Dribble: The dribbling test, part of the Harrison Basketball Battery (Chroni et al., 2007), required participants to navigate through a series of cones while dribbling a basketball for a duration of 30 seconds. Each cone successfully maneuvered around awarded the participant one point. This task has demonstrated a high test-retest reliability coefficient of 0.95, indicating its consistency and reliability in measuring dribbling skills (28).

3.3. *Data analysis*

In this phase of the study, we employed regression analysis and structural equation modeling through Smart-PLS to assess the predictive validity of the MLISS concerning motor performance. This involved correlating the dimensions of the MLISS with the outcome scores from participants' shooting, passing, and dribbling tests, which served as manifest variables. Basketball performance was identified as the dependent variable in our prediction models.

3.4. *Results*

The descriptive statistics, including the mean and standard deviation of basketball skills, are summarized in Table 4.

Table 4

Mean and standard deviation of basketball skills

	Mean	SD
Shoot	7.40	4.07
Pass	6.71	2.33
Dribble	8.16	3.72

Table 5 provides the fit statistics for the four prediction models, revealing that all models demonstrated a good fit to the data.

The standardized regression weights indicated that self-reinforcement and self-management had significant effects on basketball performance, with values of $r = 0.25$ ($t = 3.05$, $p = 0.001$) and $r = 0.39$ ($t = 4.05$, $p = 0.000$). Again, self-criticism ($r = 0.09$, $t = 0.72$, $p = 0.218$) and social-assessment ($r = 0.07$, $t = 0.39$, $p = 0.594$) did not show significant effects. Figures 2 depicts the prediction models linking self-

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reinforcement and self-management inner speech to basketball performance. These findings underscore the predictive validity of the MLISS, demonstrating that two of its subscales effectively forecast basketball performance in a theoretically relevant manner.

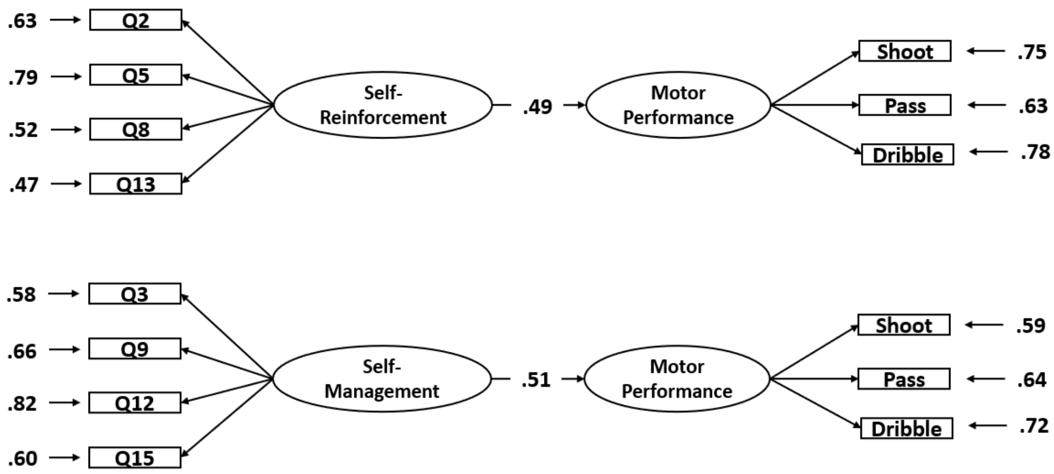
Table 5

Fit results of the predictive models illustrating the relationship between dimensions of the MLISS and motor performance

	X^2	df	RMSEA	CFI	IFI	NNFI	SRMR
Model 1 (self-criticism)	14.13	13	0.072	1.00	1.00	1.00	0.028
Model 2 (self-reinforcement)	12.02	13	0.068	0.99	1.02	1.06	0.064
Model 3 (self-management)	10.09	13	0.028	0.95	1.00	1.05	0.093
Model 4 (social assessment)	8.82	13	0.010	0.96	1.00	1.03	0.055

Figure 2

The prediction model



3.5. Discussion

In Study 2, we investigated the predictive capacity of the MLISS regarding learners' motor performance. The findings indicated that the MLISS demonstrated strong predictive validity for basketball skills, with self-reinforcing and self-managing inner speech emerging as the most significant functions of inner speech associated with motor learning.

The phenomenon of self-reinforcement is not unexpected, as individuals often engage in inner dialogue to boost their motivation (15, 30). This form of self-talk may also enhance a person's self-efficacy, a concept articulated by Bandura (1977), which posits that successful experiences contribute to increased confidence. Bandura emphasizes that verbal encouragement plays a crucial role in fostering self-efficacy, closely linking it to self-talk (31). Self-efficacy is a vital factor influencing motor learning, as highlighted in the review by Wulf and Lewthwaite (2016) (32). Empirical studies have demonstrated that motivational self-talk can elevate both self-efficacy and motor learning outcomes (11, 33). The self-reinforcement aspect of inner speech parallels motivational self-talk, where individuals use affirmations to enhance their motivation for executing motor skills (15, 28, 30, 34). Therefore, the self-reinforcement dimension of inner speech is likely to bolster motivation and self-efficacy, ultimately leading to improved motor performance and learning. Future research should investigate the impact of self-reinforcing inner speech on motivation and self-efficacy within the context of motor performance and learning.

Self-management plays a crucial role in the cognitive regulatory function of inner speech, as highlighted by Brinthaupt et al. (2009), and is significantly linked to cognitive performance, according to Ren et al. (2016) (21, 35). These insights affirm the effectiveness of our inner speech scale in forecasting students' motor learning

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outcomes. The self-management aspect of inner speech bears resemblance to instructional self-talk, which has been shown to enhance cognitive-behavioral regulation during motor skill execution. For instance, athletes often engage in self-talk to focus their attention, manage anxiety, and evaluate their performance, thereby creating a space for emotional expression and cognitive adjustment that can enhance motor skills (12, 28, 34, 36). Consequently, the self-management dimension of inner speech is likely to bolster cognitive and behavioral regulation, leading to improved motor performance and learning. Future research should investigate the impact of self-managing inner speech on motivation and self-efficacy in the context of motor performance and learning.

4. Conclusion

In summary, the findings from the initial study indicate that the Motor Learning Inner Speech Scale (MLISS) is both a reliable and valid tool for evaluating motor learning-specific inner speech among young adults. The results demonstrate that the MLISS, along with its four components—self-criticism, self-reinforcement, self-management, and social assessment—exhibits satisfactory psychometric properties, including internal consistency and construct validity. This scale represents a novel extension of existing measures of inner speech into the realm of motor learning, thereby enhancing our understanding of how inner experiences influence young adults. From a practical standpoint, the MLISS can serve as a valuable resource for instructors aiming to design targeted interventions that promote motor learning in beginners. Furthermore, the second study revealed significant correlations between the self-reinforcement and self-management dimensions of the MLISS and basketball performance, highlighting the importance of these factors. Future research should investigate the underlying mechanisms that connect these dimensions to motor performance and learning, considering variables such as motivation, self-efficacy, and cognitive-behavioral regulation that may play a crucial role in the motor learning process.

Authors' Contributions

All authors equally contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study placed a high emphasis on ethical considerations. Informed consent obtained from all participants, ensuring they are fully aware of the nature of the study and their role in it. Confidentiality strictly maintained, with data anonymized to protect individual privacy. The study adhered to the ethical guidelines for research with human subjects as outlined in the Declaration of Helsinki.

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