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The effect of attentional focus based on learning stages on motor learning in children with intellectual disabilities

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Abstract: The purpose of this study was to investigate the effect of different focus of attention (Internal, External, and Mixed) instructions on the acquisition and learning of a throwing skill in children with intellectual disabilities. Thirty boys with intellectual disabilities (M = 12.1 SD = 1.42 years) with an intelligence quotient ranging between 50 and 69 participated in this study. All participants were randomly assigned to three groups (internal: focusing on the movements of their throwing hand, external: focusing on the movement of the beanbag, and mixed: focusing on the movement of their hand in the first half of training and focusing on the movement of the beanbag in the rest of training). Participants were asked to throw beanbags overhand at a circular target according to their attentional instructions. The results of this study showed that all groups had significant progress during the acquisition phase, although there was no significant interaction effect and all three attention focus strategies are similar. Also, the results of immediate and delayed retention tests showed a significant difference between the mixed and internal focus of attention groups, with better learning outcomes for the mixed group. The findings indicated that if the instructions regarding the focus of attention are provided based on the learning stages, it can be more beneficial for children with ID than presenting a single type of attentional focus throughout the entire learning process.

Keywords: Focus of attention; intellectual disabilities; motor skill; learning

Introduction

Intellectual disability (ID) is considered a cognitive-motor abnormality occurring before adolescence. Traditionally, Intelligence Quotient (IQ) scores less than 70 are classified as ID (American Psychiatric Association, 2013). Studies have shown that children with ID are not only physically but also mentally weaker than Typically Developing (TD) children (Simons et al., 2008). According to Diamond (2000) motor development is frequently compromised when cognitive development is impaired. Some studies have reported a direct link between cognitive functions and motor performance in children with ID. For example, it has been shown that motor performance is influenced by IQ in children who have moderate ID (Wuang et al., 2008). In addition, Hartman and colleagues (2010) reported that the limitation in motor skills was correlated with the limitation in higher-order executive functions. Executive functions involve goal setting, planning, attentional control, and persistence in a specific task. Jurado and Rosselli (2007) contend that executive functions are critical to adaptive behavior and effective performance which are premises for success in performing our daily activities. However, there is a gap in rigorous experimental research

employing cross-sectional designs on the direct link between motor performance or motor development and cognitive functions in children with ID and few researches have used cross-sectional designs (Hartman et al., 2010; Wuang et al., 2008).

Moreover, Mauerberg-deCastro et al., (2009) showed that children with ID were also more vulnerable to distraction than typical children.

Special considerations are required in teaching motor skills to children with ID (Mauerberg-deCastro et al., 2009). Although human development significantly depends on motor skills learning and development, there is a lack of convincing research investigating variables that can improve the learning of motor skills in children with ID.

In learning skills, attentional focus instruction is considered one of the most important factors (Harry et al., 2019). Indeed, during the planning and execution of a motor task, attentional strategies activate different sensory processes (Peh et al., 2011; Piccoli et al., 2018). Attention to the environment and outcome of the movement is considered an external focus; and also attention to the movement and body parts during the action are considered an internal focus as well (Pourazar et al., 2017; Wulf & Su, 2007).

Researches concerning the types of attentional focus have led to conflicting results. Theories and hypothesis such as the "Ideomotor Principle Theory" (James, 1890), the "Constrained Action Hypotheses" (Wulf & Prinz, 2001), and the "Conscious Processing Hypothesis" (Maxwell et al., 2000; Maxwell & Masters, 2002; Poolton et al., 2006) suggest that an external focus leads to better performance and learning by developing automated processes, guiding attention to appropriate information, reducing working memory load, and decreasing effort to represent the movement. On the other hand, the "deautomization of skill hypothesis" shows the superiority of an internal compared to an external focus of attention, especially for beginners or experts who use their non-dominant limbs (Beilock et al., 2002; Ford et al., 2005). Despite the importance of paying attention to the learning stages while teaching motor skills and using teaching instructions, less attention has been paid to the topic.

Review of previous studies shows that in all the training sessions, only one type of attentional focus instruction has been provided by the majority of researchers regardless of the learning stages. However, the theoretical principles for learning motor skills refer to the importance of matching instructions with the learning stage (Newell, 1985; Peh et al., 2011; Schmidt & Lee, 2011).

Previous research findings showed that an internal focus was better for beginners and an external focus for more skilled individuals (Porter et al., 2013; Tahan et al., 2021; Castaneda & Gray, 2007; Perkins-Ceccato et al., 2003; Newell, 1985). The interpretation of the above findings based on Newell's model (1985) means that with more practice and increasing the proficiency level of the learner during the acquisition phase, the characteristics of the performance and learner change, and the learner progresses from the coordination stage to the control stage. (Magill & Anderson, 2007; Newell, 1985). Thus, changes in the training programs and particularly in the instructions presenting attentional focus seem necessary (Magill & Anderson, 2007). Numerous studies have reported that certain interventions can improve the motor behavior of persons with ID (Lotan et al., 2004; Shih et al., 2010; Shin et al., 2009). In an important study, Westendorp and colleagues (2011) reported that in children with ID there is a connection between gross motor skills development and organized sport participation and found a positive correlation between object control skills and the participation of children with ID (Westendorp et al., 2011). This finding lends support to the idea that children's future sport participation can be boosted by the development of object control tasks (e.g., throwing). Hence, given the fact that children with ID have many problems in throwing tasks (Chiviacowsky et al., 2013), we investigate

the effectiveness of internal, external, and mixed (based on learning stage) attentional focus on the learning of a throwing task in children with ID. In other words, the present study intends to compare traditional methods of presenting attentional focus (internal and external) with a combined method of presenting attentional focus based on learning stages.

Materials and Methods

Participants

According to the effect size reported in Chiviacowsky et al., a, (2013) (ηp2 =0.39) and considering an α level of 0.05 and actual statistical power of 0.90, using G * Power 3.1 (Faul et al., 2007), we estimated that 10 participants were needed in each of our three research groups. Thirty boys aged between 10 to 14 years (mean age: 12.1 ±1.42 years) were recruited from special schools in Sabzevar city, Iran. They were unaware of the purpose of the experiment, and the task was novel to all of them. Participants were selected using the following inclusion criteria: IQ ranging from 50 to 69 based on medical records, having the ability to stand and walk, having normal vision and hearing with or without auxiliary equipment (necessary to hear and perform the task), and lack of neurological disorders. These inclusion criteria were established based on participants' medical records. Oral assent was obtained from the participants, and written consent from their parents/guardians and the schools. There was no difference in ethnicity between the groups. They were also informed that the data gathered in this study would be kept completely confidential. The study was approved by the Hakim Sabzevari University's ethics committee (Approval ID: IR.HSU.REC.1398.006).

Apparatus and Task

The task used in this study was similar to the study by Chiviacowsky et al., (2008) and (2013). Participants stood behind a line drawn on the floor and tossed the beanbags (100 g) with their dominant arm at a circular target with a 10cm radius placed 3m from the participants. Subjects were asked to aim at the center of the target (Chiviacowsky et al., 2008). One hundred points were given if the bean bag hit the center of the target, 0 point outside of the target, and 90, 80, 70, etc., respectively in areas around the target. The higher score was recorded if the bean bag hit the line (Figure 1).

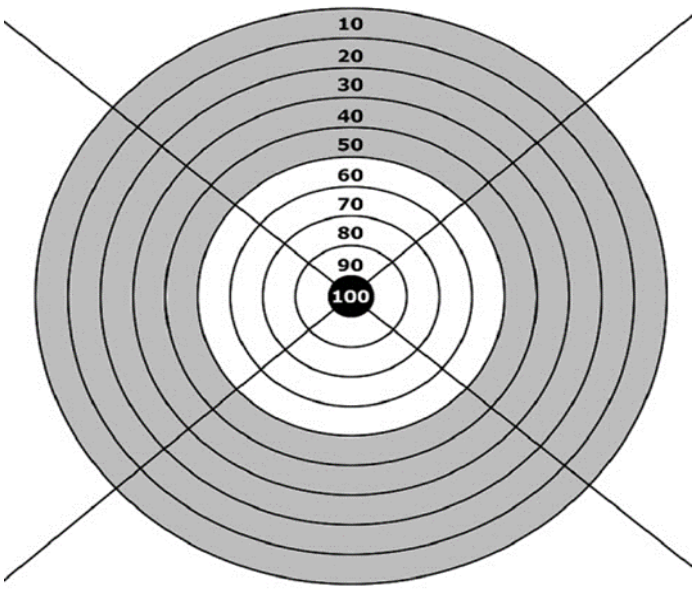

Figure 1. Schematic of the target area.

Procedure

Basic instructions were given to all participants about how to perform an overarm throw. The technique of throwing beanbags was explained and demonstrated by the experimenter prior to practice. The experiment was performed individually in a quiet room. Participants stood behind a line 3 m away from the target while throwing beanbags (Chiviacowsky et al., 2008). They were randomly divided into three groups (internal, external, and mixed). Both participants and team members were blinded to group assignment at the time of subject enrollment. After enrollment, participants and research team members learned group assignment by opening a sealed, opaque envelope. In the internal focus group, participants were asked to focus on the movements of their throwing hand, while in the external focus group, participants were asked to focus on the movement of the beanbag. Finally, participants in the mixed group (internal and external focus) were asked to direct their attention to the movement of their hand (internal attention) as beginners during the first half of the acquisition phase, which is called the coordination stage based on Newell's model, and to the movement of the beanbag (external attention) as more expert during the second half of the acquisition phase, which is called the control stage based on Newell's model.

It should be noted that there is no specific procedure to determine when the participants enter the control stage from the coordination stage. Therefore, the acquisition phase was divided into two parts based on similar articles (Lawrence et al., 2014). In the first half of the acquisition phase, individuals are beginner and in the process of acquiring coordination patterns; in the second half of the acquisition phase, individuals become more skilled and enter the parameterization step of the acquired pattern. In the acquisition phase, attentional focus reminders were given after every third trial instructing them to keep focusing on the arm movement (internal focus group) or on the movement of the beanbag (external focus group) during the trials. The experimenter made sure that all participants understood the instructions. Specifically, participants were asked to verbally explain what they wanted to do to ensure their understanding of the instructions. The practice phase included six 10-trial blocks (60 trials in total), with 2-minute rest periods between blocks (Chiviacowsky et al., 2008). Immediate retention test (one day after the acquisition phase) and a delayed retention test (one week later) were performed, both consisting of 10 trials, without instructions or reminders.

Data Analysis

Descriptive and inferential statistics were used to analyze the data. The Shapiro-Wilk test was used to understand the normality of data distribution. Averages across 6 blocks of 10 trials were calculated for the practice phase and were analyzed in a 3 (groups: external focus, internal focus, mixed) x 6 (blocks) analysis of variance (ANOVA) with repeated measures on the last factor. For the immediate and delayed retention test, scores were averaged across all 10 trials and analyzed with a one-way ANOVA. Tukey's post-hoc test was used for follow-up analyses. The level of significance was set at 0.05. Statistical analysis was conducted using SPSS 23.0 software (IBM Corp., 2015).

Results

Descriptive information about the participants (Table 1) and the mean and standard deviation of the experimental groups in the practice phase, immediate, and delayed retention tests are presented in Table 2. There were no significant differences in age, height, and body weight between the groups of children with ID.

Table 1. Participant demographics**.**

Groups	N	Age (year)		Weight (kg)		Height (cm)	
		M*	SD	M	SD	M	SD
Internal focus	10	12.0	1.63	33.4	4.16	133.4	3.06
External focus	10	12.2	1.47	35	3.19	132.7	4.39
Mixed	10	12.1	1.28	33.4	4.16	133.4	3.06

***Mean and standard deviation**

Table 2. Mean and standard deviation of throwing accuracy scores for the internal, external, and mixed focus groups in practice (6 blocks), immediate, and delayed retention.

Group	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6		Immediate retention		Delayed retention	
	M*	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Internal focus	32.70	11.95	38.40	6.58	43.80	7.81	49.80	11.66	59.60	6.48	70.30	8.09	51.80	5.13	44.00	8.85
External focus	33.90	10.13	44.60	16.07	52.90	11.45	45.40	15.32	59.30	10.23	68.10	11.82	60.50	9.40	49.50	9.61
Mixed	32.10	10.23	41.30	11.71	49.70	7.61	47.90	15.94	50.30	10.30	61.70	8.76	61.20	6.94	58.20	8.65

***Mean and standard deviation**

Shapiro-Wilk test and Leven test showed the normality of data distribution and the homogeneity of variances in all phases, respectively. Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated $X^2(14) = 18.15$, $p = .20$.

Based on the ANOVA with repeated measure during the acquisition phase, significant main effect was found for practice blocks F (5,135) = 73.80, p = 0.001, η2 = 0.73 showing a meaningful progress in three groups. However, main effects of group F (2, 27) = 0.85, p = 0.43, η2 = 0.05 and interaction of practice blocks with groups F (10,135) = 1.87, p = 0.055, η2 = 0.12 were not significant.

Results of One-way ANOVA showed significant difference between groups in the immediate retention test F (2, 27) = 5.04, p = 0.01, η2 = 0.27 (medium effect size). As well as significant difference between experimental groups in the delayed retention test F (2, 27) = 6.25, p = 0.006, η2 = 0.31, medium to large effect size (Cohen, 1988).

The Tukey post hoc test for the immediate retention test revealed significant performance differences between the mixed and internal groups (mixed: M= 61.2±6.94; internal: M= 51.8±5.13, p= 0.02), external and internal group (external: M= 60.5±9.4; internal: M= 51.8±5.13, p= 0.03), and there was no significant performance differences between the mixed and external groups (mixed: M= 61.2±6.94; external: M= 60.5±9.4, p> 0.05). Tukey post hoc test for the delayed retention test indicated significant performance difference between the mixed and internal groups (mixed: M= 58.2±8.65; internal: M= 44±8.85, p= 0.004) so that the mixed group performed more accurately than the internal group. However, despite of better scores in the mixed group than the external group, this difference was not significant (mixed: M= 58.2±8.65; external: M= 49.5±9.61, p = 0.09). Also, there was no significant difference between the internal and external focus groups (internal: M= 44±8.85; external: M= 49.5±9.61, p = 0.37).

Discussion

The purpose of this study was to investigate the benefits of implementing focus of attention instruction, based on a learning stage model, in improving motor learning of children with intellectual disabilities. The research aimed to explore the potential benefits of this approach in enhancing the learning outcomes and motor skill development in these

children. Perceptual and cognitive delays in children with ID might affect fundamental motor learning patterns and motor skills development (Mauerberg-deCastro et al., 2009; Vuijk et al., 2010; Westendorp et al., 2011). Studies showed that children with ID had more difficulties in controlling attention than typically developing children (Mauerberg-deCastro et al., 2009). Design of training sessions and provision of teaching instructions require more consideration based on the learning stages, especially for these children. Thus, we examined the effectiveness of internal, external, and mixed attentional focus instructions (based on learning stages) in children with intellectual disabilities.

Results of the acquisition phase showed that despite significant progress during the training sessions, there was no significant difference between the experimental groups, and the interaction effect was not significant either. Thus, no method was significantly better than other methods. This indicates the same performance of children during the acquisition phase. These findings were in line with previous studies (Emanuel et al., 2008; Harry et al., 2019; Uehara et al., 2008). The lack of a significant difference between groups during the acquisition phase was probably due to the fact that the temporary effects of training instructions might be so high that the different ways of presenting them did not show superiority to each other, leading to the same progression between groups (Pourazar et al., 2017; Schmidt & Lee, 2011).

On the other hand, the results of the present study showed a difference between both the external and mixed groups with internal focus groups in the immediate retention test. However, in the delayed retention test, there was a significant difference between the mixed and internal focus groups, with better performance of the mixed group in both tests. The superiority of the mixed group in the immediate and delayed retention tests revealed an internal focus of attention instruction in the first half of the acquisition phase where participants were beginners and an external focus of attention instruction in the second half of the acquisition phase when participants became more skilled, which would result in more lasting retention scores than the other groups.

Findings of the present study explain the need to provide focus of attention instructions for children with ID in accordance with the stage of learning. A framework that might provide insight into the relative efficacy of presenting attentional focus with considering the stages of learning motor skills was Newell's learning model (1985). According to this model, adopting an internal and external focus of attention was more useful in the coordination and control stages, respectively. In other words, in designing successful learning experiences, the specific role of internal focus of attention instructions, when referenced to Newell's model of learning, may still have a role to play very early in the acquisition of movement coordination or under specific task constraints. Nevertheless, in a later stage, self-organizing processes should be exploited, and the use of an external focus of attention on movement effects seems to encourage such processes (Peh et al., 2011; Tahan et al., 2021). These findings were consistent with the results of Castaneda and Gray (2007) and Perkins-Ceccato et al., (2003) suggesting that adopting an internal focus of attention is more beneficial for beginners, whereas an external focus is more effective for skilled individuals.

The results of the immediate retention test showed that the external focus group performed better than the internal focus group. The current finding is in line with previous research conducted by Chiviacowsky et al. (2013) on 12-year-old children with ID, Pourazer et al. (2017) on 10-year-old children with cerebral palsy, Saemi et al. (2013) on 10-year-old children with ADHD, and Emanuel et al. (2008) on 9-year-old children with Typically Developing (TD). These studies collectively demonstrate that individuals, across various age groups and with different conditions, exhibit improved performance when provided with external focus instructions.

Also, based on the "constrained action hypothesis," internal focus may interfere with automatic motor control processes; but in contrast, external focus may increase the effectiveness and efficiency of movement by allowing automatic control (Marchant et al., 2007; Niźnikowski et al., 2022; Thomas et al., 2022; Piccoli et al., 2018; Wulf & Su, 2007). But the challenge arising here was the usefulness of the external focus of attention for beginners which seemed to be inconsistent with the theoretical foundations based on Newell's model (Newell, 1985). According to this model, adopting an internal focus was more beneficial for beginners who had not yet achieved the proper pattern of skill (coordinated structure). Abdolmaleki & Ghafari (2016) justified this finding by referring to the issue of simple skill or the participant's familiarity with the throwing skill. As a result, participants quickly passed from the coordination stage to the control stage. Therefore, such participants could not be considered as beginners, so it seemed logical that the external focus of attention was beneficial for them.

Based on the better results of mixed focus instructions, physical education teachers, sports coaches, physiotherapists, and occupational therapists are suggested to facilitate the learning of children with ID by emphasizing mixed attention focus in the curriculum. The capacity to successfully participate in such activities can provide important opportunities for children with ID, allowing them to further improve their motor competencies. Success in sports skills for children with ID is an important opportunity to increase their competency, self-esteem, and social interactions (Yang et al., 2022). The main limitations of the present study were different motivational conditions due to age, motor limitations, and difficulty in performing the task in children with ID. Another limitation was that selecting individuals with the same IQ was not feasible. Finally, the small sample size is another limitation that needs to be more explained in future studies. If results from this study are corroborated, the therapists would be prepared to create settings in which children with intellectual disabilities could improve their motor skills and independence as quickly and effectively as possible through interventions in attentional focus instructions.

Perspectives

In this study, we examined the benefits of providing focus of attention instruction based on the learning stages model (the Newell model) in children with ID. A review of previous studies shows that only one type of attentional focus instruction is provided by the majority of researchers from the beginning to the end of training sessions, regardless of the learning stage of the learner. However, the theoretical principles for learning motor skills refer to the importance of matching instructions with the learning stage. The results of this study show better results for mixed (internal-external) focus instructions. In fact, the findings of the present study explain the need to provide focus of attention instructions in accordance with the stage of learning.

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