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ORIGINAL RESEARCH

Effects of positive and negative normative feedback on the learning of throwing task in children with spastic hemiplegic cerebral palsy

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Abstract

Background: Cerebral palsy is a sensory and motor disease that affects control of posture and movement. Children with cerebral palsy show dysfunction in the body such as spasticity, decreased muscle strength, and selective control of movement that may limit functional activity and participation in daily life. **Objective:** The purpose of this study was to investigate the effect of positive normative feedback on the learning of a throwing task in children with spastic hemiplegic cerebral pals. **Methods:** Twenty-four children with cerebral palsy aged 8–10 years participated in an experimental design with acquisition-retention test. The children received positive or negative normative feedback after each practice of learning of throwing task. The positive feedback group received feedback after each block 20% higher than the average score of each block, whereas the negative feedback group received feedback 20% lower than the average score after each block. The control group received normal feedback. A retention test without any feedback was run 48 hours after the practice phase. Statistical tests including one-way analysis of variance and follow-up tests were used to analyze the data. **Results:** The results showed both in the acquisition stage (p = .001) and retention test (p = .001), the positive normative feedback group had better performance compared to the two other groups. **Conclusions:** The results demonstrated that positive normative feedback has a significant motivational effect that enhances the learning of a throwing task in children with cerebral palsy.

Keywords: learning, normative feedback, throwing task, children with cerebral palsy

Introduction

Augmented feedback is arguably a method for achieving or refining specific skills (Adams, 1987; Salmoni et al., 1984). One of the most frequent kinds of augmented feedback is knowledge of results (KR) which gives one insight as to how well a particular task has been carried out. It has become almost commonplace in the literature that KR improves motor learning in different ways (e.g., Guadagnoli & Kohl, 2001; van Vliet & Wulf, 2006). KR is conventionally given by the examiner to the learner based on a predetermined schedule. The impact of KR on motor learning is called the guidance hypothesis (Salmoni et al., 1984). Despite the effectiveness of feedback as a significant variable for learning, feedback with more frequency (providing feedback information after each trial, 100% feedback) may have three major disadvantages including impairment to information processing, reduction of movement stability, and feedback dependency (Salmoni et al., 1984). In particular, some researchers have disputed the guidance hypothesis since they believe young adults' ski simulators must acquire complicated skills that require more control, memory processes, and attention (Wulf et al., 1998). Moreover, some investigators have suggested that the guidance hypothesis is inadequate to explain the interaction between feedback frequency and the sort of attention focus (Wulf et al., 2002). Alternatively, several investigators supported the guidance hypothesis (Butki & Hoffman, 2003; Salmoni et al., 1984). They suggest some techniques such as summary, average, bandwidth, self-feedback, and social-comparative (normative) feedback to compensate for the negative effect of feedback frequency.

Social-comparative (normative) feedback has been one of the experimental methods to deliver feedback. This kind of feedback deals with the data related to others' performance, in other words, a group's performance average score is given rather than a learner's score. In this type of feedback, the KR feedback is presented to the individuals, so that the result of people's performance is presented to them as a percentage of the performance results of others in a positive or negative form (higher or lower than the actual value of individual's performance) and its effects on individual's performance and learning are examined (Wulf et al., 2010). In cases where feedback reveals that a person's performance lies beneath the average, it may lead to a decrease in self-efficacy (situation-specific self-confidence) and task interest as well as negative self-reactions (Kavussanu & Roberts,

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1996). On the other hand, some evidence shows positive feelings for comparing one's performance with a "norm" in question may lead to self-efficacy consolidation (reaching a stable level in this factor for improving the performance), yield positive self-reactions and provide more incentive to practice a motor skill. Normative feedback has the potential to influence performance positively but also seems to leave more stable effects on motor learning. Recently, research results showed that positive feedback improves motor learning compared to negative normative feedback (Wulf et al., 2010). The effect of normative feedback on motor learning/performance has been the subject of numerous research in adult learners (e.g., Drews et al., 2021; Lewis al., 2023; Wulf et al., 2010), however, the effects of this variable on children's performance has not been examined as frequently as that of adults. For the first time, Ávila et al. (2012) examined the effect of normative feedback on the learning of a throwing task in 10-year-old children. They found that on the retention test, a positive feedback group showed a higher accuracy in a throwing task than the control group. In addition, they found that feedback has a significant motivational effect on learning motor skills in children. Gonçalves et al. (2018) examined the enhancing performance expectancies through positive comparative feedback facilitates the learning of basketball free throws in children. The results show that Participants in the positive feedback group demonstrated higher learning of the task, showing greater punctuation scores on the transfer test than participants in the control group. These findings provide evidence that enhancing performance expectancies through positive comparative feedback enhances the learning of sports motor skills in children. Vice versa above research, Drews et al. (2020) show that positive feedback praising good performance does not alter the learning of an intrinsically motivating task in 10-year-old children. Therefore, the results are contradictory in the field of normative feedback.

Regarding the difference between adults and children, some feedback manipulations have resulted in similar effects in children and adults, while other feedback-related variables had different effects in different age groups. For example, self-controlled relative to yoked feedback schedules are effective in both adults (Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010) and children (Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Chiviacowsky, Wulf, Medeiros, Kaefer, & Wally, 2008). Similarly, feedback after "good" as opposed to "poor" trials has been shown to have learning benefits in adults (Chiviacowsky & Wulf, 2007) as well as children (Saemi et al., 2011). However, learning in adults but not in children, appears to benefit from more precise feedback (Newell & Kennedy, 1978). Also, Sullivan et al. (2008) demonstrated that while a reduced frequency of feedback improved the learning of a discrete arm movement in adults when compared with a KR frequency of 100%, the opposite pattern of results was found in children. Finally, in self-controlled feedback paradigms, adults who selected a relatively low versus high feedback frequency did not show different degrees of learning (Chiviacowsky et al., 2005); yet, children who chose a low frequency demonstrated impaired learning relative to those who chose a high feedback frequency (Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Chiviacowsky, Wulf, Medeiros, Kaefer, & Wally, 2008). Thus, children can differ from adults in terms of how they respond to different types of feedback. However, according to the aforementioned normative feedback research, the effects of this feedback are similar in children and adults.

While several studies have focused on the impact of normative feedback on motor learning, they have primarily dealt with typical adults and children and a few studies have examined the function of feedback in individuals with physical difficulties such as cerebral palsy (CP).

Therefore, the effects of feedback may depend on any motor or cognitive impairment a person may have. This begs the question of whether the "feedback rules" from the able-bodied population are generalizable to children with CP. Motor planning deficits (Mutsaarts et al., 2006) might make it difficult for them to make optimal use of some forms, but augmented feedback could also enhance their learning, providing compensation for sensory impairments. Therapy programs in children with CP ultimately aim to elicit relatively permanent improvements in motor skill capability that can be transferred and generalized to new learning situations. For this, knowledge is needed about which augmented feedback forms can be utilized to improve motor skills. Robert et al. (2017) conducted a review, where feedback effects in upper extremity tasks were examined in children with CP and typically developing children. They concluded that there was a lack of consistency in modalities and frequencies of feedback studies and stressed the need for a better and more comprehensive understanding of the influence of feedback on motor learning in children with CP. In the most recent review, Schoenmaker et al. (2023) examined the effectiveness of different extrinsic feedback forms on motor learning in children with cerebral palsy. The evidence of this research is that children with CP generally benefit from feedback provided during or after performing a movement task. However, Due to the heterogeneity of existing studies, it is difficult to draw firm conclusions regarding the relative effectiveness of feedback forms. This review showed that more high-quality research is warranted on the effectiveness of specific feedback forms on motor learning in children with CP.

Therefore, although much research has been done in the field of different forms of feedback in CP children; until now, no research has considered the motivational aspect of feedback (normative feedback) in this population. The present study is the first research that examines the effect of normative feedback on motor skill learning in children with CP. Finally, our general assumption is that normative feedback, like other forms of feedback, is beneficial for CP children's motor learning.

Methods

Participants

Twenty-four male children diagnosed with a disability attending special schools in Jahrom city (Iran) participated in this study. The inclusion criteria were: diagnosed with spastic hemiparesis, absence of any intellectual disability, and age 8–10 years. Descriptive statistics related to the experimental groups are presented in Table 1. To determine hand dominance, the participants were asked to perform a writing test. In addition, they were asked to make use of their non-dominant hand for throwing a tennis ball toward a target.

The exclusion criteria included having neurodegenerative diseases, psychiatric illness, traumatic head injury, epilepsy, hearing and visual impairment, and moderate to profound mental retardation to the extent it would interfere with their ability to do the task. Furthermore, the topography and severity of motor disability were recorded by the related therapists in rehabilitation centers using the Gross Motor Function Classification System (Palisano et al., 2000). The participants who were at the first to third levels managed to attain self-mobility without employing a powered wheelchair (Palisano et al., 1997) they were qualified to participate in this research. In contrast, those in the fourth and fifth levels who faced moderate to severe restrictions in motor controls and failed to carry out the required movements were excluded from the study.

None of the participants had any previous experience with the task nor were aware of the aim of the research. The parents or the guardians of the child signed the informed consent. All the collected data were confidentially protected. The study was approved by the institutional review board and was performed according to the ethical principles described in the 1964 Declaration of Helsinki and its later amendments.

Apparatus and task

The task was similar to the one employed by Chiviacowsky, Wulf, Medeiros, Kaefer, and Tani (2008). The participants were instructed to throw a tennis ball from a 3-m distance to a target consisting of a series of concentric circles on the floor. The target was similar to the one used in previous studies (Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Porter et al., 2007; Porter & Magill, 2010). The central circle had a radius of 10 cm and concentric circles with radii of 20, 30, 40, 50, 60, 70, 80, 90, and 100 cm surrounded the center circle. These marks were used as a scoring base. The tennis ball landing in the center circle received 100 points. The ball landing in the second circle next to the center was scored 90 and for respective circles, scores of 80, 70, 60, 50, 40, 30, 20, 10, or 0 points were respectively recorded. In case the ball fell on a line separating the two rings, the participant was awarded the higher score.

Table 1 Descriptive statistics ($M \pm SD$) for the weight, height, and age in the three groups of children with spastic hemiplegic cerebral palsy

Variable	Group		
	Negative feedback (n = 8)	Positive feedback (n = 8)	Control (n = 8)
Weight (kg)	34.20 ± 1.30	32.65 ± 1.32	33.20 ± 1.33
Height (cm)	130.21 ± 1.54	132.45 ± 1.63	129.88 ± 1.62
Age (years)	9.25 ± 0.34	9.20 ± 0.45	9.50 ± 0.39

Procedure

The research sessions were conducted in the specialized growth and learning center (this center belongs to the first author of the article). The training was organized in 11 consecutive sessions. The first session was related to familiarizing the participant with training conditions, research tools, and how to perform skills. Familiarization instructions were provided by the study authors. Following the completion of the pre-test, the subjects were randomly assigned into three groups: positive, negative normative feedback and control group. The level of disability of children in the three groups was similar. The second session was the pre-test stage. In this session, the participants performed 2 blocks of 5 attempts as a pre-test stage. The third to tenth sessions were related to the research intervention. The research intervention consisted of 8 consecutive sessions with 30 throwing trials (6 blocks of 5 trials). The eleventh session was related to the retention test. This test was conducted 48 hours after the last training sessions.

The positive feedback group received a 20% higher than the true score they performed on the task at the end of each block whereas the negative normative feedback group received feedback 20% lower than the true score on the task at the end of each block. The participants in the control group did not receive any feedback at the end of every block. Also, before and after each throwing session, the subjects performed warm-up and cool-down trials for 5 minutes respectively.

Data analysis

Univariate analysis of variance (ANOVA) was used for the pretest and retention test, and a 3 (groups) × 8 (session, 6 blocks of 5 trials) ANOVA with repeated measures on the last factor to analyze the practice data. All assumptions of ANOVA with repeated measures were checked including normality, homogeneity, homogeneity of regression slopes, and linearity, and met before analyzing the data. IBM SPSS Statistics (Version 23; IBM, New York, NY, USA) was used for all statistical analyses. The level of significance was set at $p < .05$.

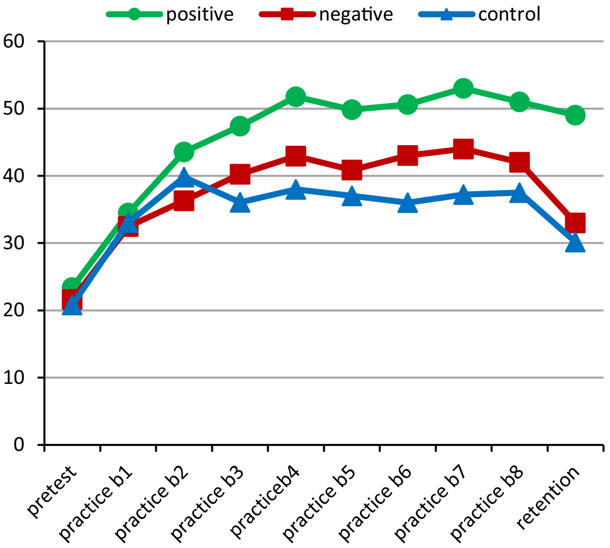
Results

The result of the analysis showed that there were no significant differences in age, height, and body weight in the groups of children with spastic hemiplegic cerebral palsy (SHCP).

The result of the one-way ANOVA indicated that there were no significant differences in these variables in the pretest scores ($F(2, 21) = 0.20$, $p = .81$; Figure 1).

ANOVA with repeated measures 3 (group) × 8 (practice blocks) was employed to analyze the throwing scores in acquisition. The result showed that there is a significant effect of group ($F(2, 21) = 31.57$, $p = .001$, $\eta_p^2 = .75$) and Tukey-Kramer post hoc test result showed that there is a significant difference between the positive and negative normative feedback group ($p = .001$) as well as between the positive feedback and control group ($p = .001$) in acquisition test. Post-hoc analysis also indicated that there was no

Figure 1 Performance scores across the pre-test, acquisition, retention phases in the three groups of children with spastic hemiplegic cerebral palsy



significant difference between the negative normative feedback and the control groups (p = .64). In addition, there is a significant effect of practice block (F(7, 147) = 177.87, p = .001, η_p^2 = .89). The groups by session interaction were also significant (F(14, 147) = 9.87, p = .001, η_p^2 = .48; Figure 1).

The results of one-way ANOVA for throwing scores in the retention test indicated that there were significant differences among the normative positive, negative feedback, and the control group (F(2, 21) = 86.38, p = .001, η_p^2 = .84). Tukey-Kramer post hoc analysis indicated that the positive normative feedback group (M = 49.94, SD = 3.57) scored significantly higher than both the negative normative feedback (t = 4.23, p = .001, d = 5.25; M = 33.88, SD = 2.43), and control group (t = 3.89, p = .001, d = 7.29; M = 30.24, SD = 1.36). The post-hoc analysis also indicated that there is no statistical difference between the negative normative feedback and the control group (p = .12; Figure 1).

Discussion

The fact that KR plays a crucial role in motor learning is well established (Young & Schmidt, 1992). Nonetheless, most of the studies on feedback have focused on normal participants (Lewthwaite & Wulf, 2012), and a limited number of researches have focused on other populations (Hemayattalab et al., 2013). This study was specifically designed to address the effectiveness of normative feedback on motor skill learning of children suffering from SHCP. The result of several researches has shown that positive feedback improves motor learning in young adults (Wulf et al., 2010) and older adults (Wulf et al., 2012). The findings of the present study showed that normative positive feedback significantly improved the performance and learning of CP children on ball-throwing tasks. This result is in agreement with the findings of other studies regarding learning of motor skills in other populations (Cairney et al., 2008; Wulf et al., 2010, 2012). Based on the findings of the present research, the superior performance of the positive feedback group may be attributed to a higher score of the group that in turn increases the motivation that contributes to the improvement of learning of children with SHCP. Even though the motivational effects of positive normative feedback were not evident during the practice stage, its effectiveness was demonstrated during the learning stage; that is, the positive normative feedback group showed a successful performance in the delayed retention test. The result of the present research was in agreement with the findings of Ávila et al. (2012). These authors demonstrated that presenting positive feedback resulted in higher scores in the retention test of a throwing task compared to no feedback groups. However, it needs to be noted that the participants of these two researchers were different; while Ávila et al. studied adult participants, the present research examined children with CP. Nevertheless, there are research reports that have examined the effect of feedback on children with CP for different variables such as the frequency and self-control types of feedback.

Based on the findings of the present research, it seems like normative positive feedback results in the improvement of motor skill learning in children with CP. These findings may be useful to professionals such as physiotherapists in offering greater motor learning services to children with CP. This finding of the present research may add additional intervention means to the available ways of helping individuals with CP or other disabilities in CNS to acquire motor skills. There are many experimental techniques employed to rehabilitate these patients (Garvey et al., 2007). Research results have shown that there is more vulnerability in the non-dominant part of the body in the case of children suffering from SHCP since they often make use of the less damaged part of their body (Dunn, 2000). Research on spasticity has suggested that range-of-motion limitation and muscle weakness are more prevalent in the non-dominant part of the body of people with SHCP. As the dominant side of the body possesses less spasticity due to its overuse, doing activities with the opposite side naturally augments the coordination and fluency of the affected limbs of these people. the present research was one of the first attempts to include the use of positive normative feedback in motor skill learning in CP children, however, the research acknowledges the limitation of this study for the sample size and age group in addition to the participants with SHCP. Further research with a larger sample and age group is needed to examine the role of normative feedback in these groups of children.

Conclusions

Current findings showed positive feedback compared to negative feedback resulted in improvement of motor learning in SHCP children. This finding is confirmation of the convergent evidence that believes that motivational consequences feedback directly affects the learning of motor skills. Practitioners must be aware of the fact that feedback rarely provides neutral information and almost always has motivational consequences. The present findings are necessary for educational and practical environments where teachers tend to give feedback to prevent mistakes and guide SHCP children to the correct movement pattern. Therefore, it is suggested that sports coaches and teachers plan their programs for SHCP children according to current findings and use positive feedback more than negative feedback to improve their motor performance and learning.

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Conflict of interest

The authors report no conflict of interest.

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