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Analysis of motor learning task in children with intellectual disability
Análisis de la tarea de aprendizaje motor en niños con discapacidad intelectual

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Abstract. Children with intellectual disabilities (ID) present cognitive deficits interfering with the motor learning process. Objective: To analyze the motor learning of children with intellectual disability (ID) and compare with typically developing children. Methods: The sample was composed of 20 children of both genders (10 with ID and aged 8.5±1.57 years). The experimental (EG) and control (CG) groups were composed of children with and without ID, respectively. We used a maze task printed on a paper sheet (A4 size). Ten attempts were performed on the first day: five for the acquisition 1 (A1) and five for the acquisition 2 (A2) phase. Five attempts were also performed 48 hours later for the retention phase (RET). *Results*: The results related to the motor learning phases were lower in the EG compared with CG ($p < 0.01$). Within-group comparisons showed no significant differences between the outcomes. Children in the EG maintained the score in the A1 and A2 phases and declined in the RET phase, while the CG maintained the same scores over the three phases. *Conclusion*: Children with ID presented lower performance in the maze task than typically developing children. It seems that motor learning is slower in individuals with ID than controls, and they need more time and repetitions to learn the maze task.
Key words: Child development, Intellectual disability, Motor activity, Learning, Motor task

Resumen. Introducción: Los niños con discapacidad intelectual (DI) presentan déficits cognitivos que interfieren en el proceso de aprendizaje motor. Objetivo: Analizar el aprendizaje motor de niños con discapacidad intelectual (DI) y compararlo con el de niños con desarrollo típico. Métodos: La muestra estuvo compuesta por 20 niños de ambos sexos (10 con DI y edad 8,5±1,57 años). Los grupos experimental (GE) y control (GC) estuvieron compuestos por niños con y sin DI, respectivamente. Utilizamos una tarea de laberinto impresa en una hoja de papel (tamaño A4). Se realizaron diez intentos el primer día: cinco para la fase de adquisición 1(A1) y cinco para la fase de adquisición 2 (A2). También se realizaron 5 intentos 48 horas después para la fase de retención (RET). Resultados: Los resultados relacionados con las fases de aprendizaje motor fueron menores en el GE en comparación con el GC ($p<0,01$). Las comparaciones dentro de los grupos no mostraron diferencias significativas entre los resultados. Los niños del GE mantuvieron la puntuación en las fases A1 y A2 y descendieron en la fase RET, mientras que el GC mantuvo las mismas puntuaciones en las tres fases. Conclusiones: Los niños con DI presentaron menor rendimiento en la tarea del laberinto que los niños con Desarrollo típico. Parece que el aprendizaje motor es más lento en los individuos con DI que en los controles, y necesitan más tiempo y repeticiones para aprender la tarea del laberinto.
Palabras clave: Desarrollo infantil, Discapacidad intelectual, Actividad motriz, Aprendizaje, Tarea motora.

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Introduction

Intellectual disability (ID) is a cognitive dysfunction resulted from incomplete development of the mind that leads to intellectual function consequences (reasoning, learning, perception, memory, and movement sequence) (Robert, Schalock, & Tassé, 2021). Motor delays are commonly present in children with ID, consequently, they might present hypotonia, overweight, and poor body mechanics and balance (Wang et al., 2022). These delays may compromise motor learning in people with ID since this process is responsible for motor skills acquisition and improvements in movement execution(Maxwell, Masters, Kerr, & Weedon, 2001). The learning level is also improved through practice and experience (Spampinato & Celnik, 2021). In this sense, motor impairment in children with ID can be softened when individuals are involved in intervention proposals throughout the motor development process.

The learning process occurs when information related to a task is absorbed, and the task is subsequently performed by the individual (A. A. B. de Oliveira, de Mello Gonçales Santana, & de Fatima Matias de Souza, 2021). The motor learning process involves two main phases: acquisition and retention. The former is related to absorption and improvement of new motor actions (D. L. de Oliveira, Corrêa, Gimenez, Basso, & Tani, 2009; Magill, 2011; Schmidt & Lee, 2014; Tani, Freudenheim, Meira Júnior, & Corrêa, 2004) and the latter is characterized by information storage (related to the task) in motor memory (Abe et al., 2011). Thus, evaluating these phases is important to facilitate motor diagnosis and establish intervention proposals to improve motor learning throughout the development (Guillamón, Canto, & García, 2020).

Monteiro et al.(2010) investigated motor learning in children with cerebral palsy using the maze experiment. In this experiment, children were asked to type in a computer to move the “X” letter (displayed on the screen) through the maze and find the exit as fast as possible. These children were compared with typically developing children, and no significant differences were observed in the motor learning process. Possebom et al.(2016) conducted the same maze experiment in people with Down syndrome and typically developing peers. Although participants with Down syndrome improved performance during acquisition and retention phases, no significant differences were observed between groups. Although no significant differences were observed in previous experiments conducted with children with cerebral palsy (Monteiro et al., 2010) and people with Down syndrome(Possebom et al., 2016), both groups improved performance in the maze experiment. Considering that previous maze tests were not printed on a paper sheet, we believe that new and distinct motor and cognitive efforts would be required for completing the test, which is promising for low resources contexts. Adding new challenging skills would also reveal interesting findings in children with intellectual disability, particularly those without history of syndromic disorder, and understand the potential effects of a motor task using the same maze configuration.

Therefore, an interesting and feasible way to observe changes over time and estimate motor learning in this population would be adapting the experiment conducted by Monteiro et al.(2010) for children with ID from scenarios with low resources. Studies investigating the learning processes in these children are necessary, mainly due to delays observed during complex tasks and data scarcity (García, Tejero-González, Esteban-Cornejo, & Veiga, 2019; Luna-Villouta et al., 2022; Schalock, Borthwick-Duffy, Buntinx, Coulter, & Craig, 2010) and because feasible and low-cost assessment tools to evaluate motor learning in children with ID are scarce.

In this sense, we hypothesized that motor learning gains using the maze approach would be lower in children with ID than their peers without ID. This study aimed to analyze the motor learning of children with ID and compare with typically developing children.

Methods

Study characteristics

This is a pre-post experimental study conducted in a public elementary school and the APAE (Association of Parents and Friends of Exceptional children), located in Jacobina (Bahia - Brazil). This study was approved by the local research ethics committee (number 57772616.3.0000.0057) and followed the Declaration of Helsinki and the Resolution 466/12 of the National Health Council. The parents signed the informed consent form after understanding all study procedures.

Participants

Children with ID registered in the APAE were selected to compose the experimental group (EG), while children with typical development matched by age and gender composed the control group (CG) and were recruited from an elementary school. All participants were recruited by convenience. A total of 20 children participated in the study, 10 in the EG and 10 in the CG. First, children with ID were recruited, followed by children with typical development.

The participants of the EG were selected based on the following inclusion criteria: children with a formal diagnosis of ID attested by clinicians; of both gender; aged 6-10 years; capacity to understand the task commands and perform the entire experimental procedure; children whose parents authorized the participation and signed the informed consent form. Disability of all children with ID was congenital.

The children who composed the CG were selected according to the following inclusion criteria: the absence of any disability, disorder, or other clinical implication; registration in the elementary school; of both genders; aged 6-10 years; capacity to understand the task commands and perform the entire experimental procedure; children whose parents authorized the participation and signed the informed consent form.

Children with other associated disabilities were excluded to avoid bias. Finally, none of the children was excluded according to these criteria. Children were asked what hand they use to write. All children performed the task with dominant hand (right hand for all). Characterization of participants is shown in Table 1.

Table 1
Characteristics of the participants.

Variables	EG	CG	p-value
Age = Mean (SD)*	8.20 (1.61)	8.80 (1.54)	0.40
Sex = n (%)**			
Girls	2 (20%)	2 (20%)	1.00
Boys	8 (80%)	8 (80%)	

SD: Standard deviation; *Comparison using independent t-test; **Comparison using chi-square test

Experimental Procedures

Motor learning was assessed using the maze task printed on a paper sheet (A4 size) (Figure 1). The maze task had only one right path. The experiment was divided into four moments and performed in two days, with 48 hours in between. Two different maze models were used. The first moment comprised three attempts to familiarize with the first maze model (Figure 1A). The second moment was related to acquisition phase and divided into acquisition 1 (A1) and 2 (A2) (Figure 1B). The last moment was the retention (RET) phase (phase 3), in which children performed the second model (Figure 1B) 48 hours after phase 2 (Souza, França, & Campos, 2006). Our study was based on the study of Monteiro et al.(2010) performed with children with cerebral palsy. Participants were asked to trace the right path using a pencil.

Table 2.
Proposed classification for the children's performance in the maze task.

0 – <u>Bad</u> (unable to complete the task);
1 – <u>Regular</u> (perform the task with considerable difficulty exhibiting motor clumsiness, according to the skills requested in the task);
2 – <u>Good</u> (perform the task with little difficulty exhibiting adequate motor profile, according to the skills requested in the task);
3 – <u>Excellent</u> (perform the task without difficulty exhibiting adequate motor profile, according to the skills requested in the task).

The scores were comprised of mistakes and successes. A mistake was considered when the child could not perform the task (bad), and successes were classified into three categories (regular, good, and excellent) (Table 2). The following classifications were considered: 0 - Bad (failed trial - children did not finish the task), 1 - Regular (children finished the maze but crossed the delimited space twice), 2 - Good (children finished the maze but crossed the delimited space once), and 3 - Excellent (children finished the maze in the first trial without mistakes).

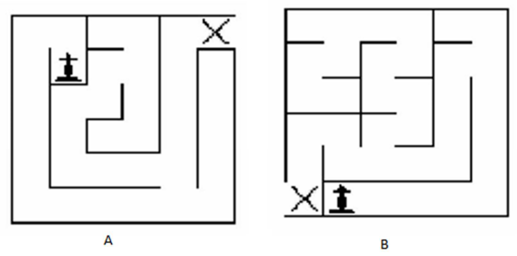

Figure 1. A: Maze design of the familiarization phase; B: Maze design of the acquisition Phase 1 and 2 and retention phase(Souza et al., 2006).

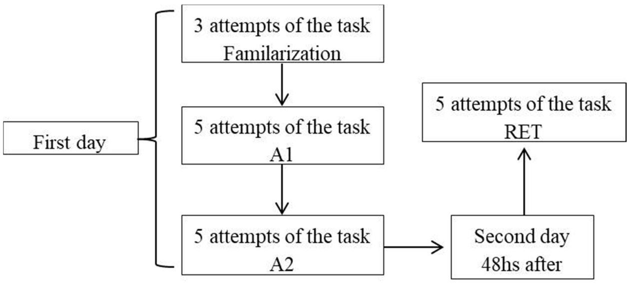

Figure 2. Description of experimental procedures performed in the study.

Outcomes

Motor learning was investigated in the above-mentioned phases: A1, A2, and RET. On the first day, children performed ten attempts to finish the maze task, in which the A1 and A2 phases were obtained from the attempts 1-5 and 6-10, respectively. Lastly, five attempts were performed on the second day (48 hours later) to obtain the RET phase. These outcomes were considered dependent variables, while the group factor (children with and without ID) was considered independent variables.

Statistical analyses

Data are shown as mean and standard deviation otherwise stated. Data normality and homogeneity were verified using the Shapiro-Wilk and Levene tests, respectively. As assumptions of normality were not achieved, within-group differences related to A1 and A2 phases were assessed using the Wilcoxon test, while the Mann Whitney test was used to verify between-group changes related to each phase (A1, A2, and RET). For all analyses, significant differences were considered if $p<0.05$ (two-tailed), and all tests were carried out using the SPSS software (IBM Corp, USA) version 20.0.

Results

The children's mean age was 8.5±1.57 years, and no significant differences were found between the CG (8.20±1.61 years) and EG (8.80±1.54 years) ($p = 0.40$). Sixteen children were male (eight in each group) and four were female (two in each group), allowing the adequate matching by age and gender.

Children with ID scored the same classification in the A1 and A2 phases, but scores were lower in the RET phase. In contrast, children with typical development maintained maximum scores during the three phases of the maze task.

Table 3.
Median distribution in each phase of the maze task (A1, A2, and RET).

Phase	EG	CG
A1	3.50	15.00
A2	3.50	15.00
RET	0.00	15.00

EG: Experimental group; CG: Control group; A1: Acquisition 1; A2: Acquisition 2; RET: Retention.

Table 4 shows the within-group analyses related to A1 and A2 phases. No significant differences were observed.

Table 4
Within-group analyses related to A1 and A2 phases.

Group	p-value	Z
EG	1.00	0.00
CG	0.31	-1.00

As shown in Table 5, significant between-group differences were observed in all phases (A1, A2, and RET). Although the CG presented higher scores than the EG, similar values were obtained in each phase, indicating the maintenance of the learned skill.

Table 5
Between-group analyses in each learning phase (A1, A2, and RET).

Phase	p-value*	Z - value
A1	<0.001	-3.924
A2	<0.001	-3.922
RET	<0.001	-3.963

*Level of significance $p<0.05$ using the Mann-Whitney test

Discussion

The main objective of this study was to investigate the acquisition and retention phases of motor learning using the maze task in children with ID and compare with typically developing children. As expected, lower scores were found in the EG compared with the CG.

These results confirm our initial hypothesis and indicate maintenance of learning rate inferred based on motor performance throughout acquisition phases and decrease in RET phase, which may be justified by the lack of interest of participants with ID or poor object control and visuomotor coordination. Children with ID have poor object control due to the degree of intellectual disability (B. J. Jeoung, 2013). As all children with ID of this study received specialized attendance and understood commands, we can suppose they received personalized treatment to improve writing and drawing abilities. However, the maze task is probably an extra demand for them; therefore, they need more personalized treatment to improve motor skills (Martins, Honório, & Martins, 2022). A possible lack of interest of participants with ID was not assessed in our study, and we could only estimate it using qualitative observations during experiments. Further studies should investigate this variable using formal instruments to attest to the influence of children's interest on task performance.

Three possible explanations might be considered: (i) number of attempts was not sufficient, assuming that children with ID present substantial concentration and attention difficulties (Djuric-Zdravkovic, Japundza-Milisavljevic, & Macesic-Petrovic, 2010), (ii) acquisition and retention processes of the maze task were challenging for EG, and (iii) task was not suitable for EG since CG achieved maximum scores and maintained over the phases.

Attention and task repetition are critical for automating skills and retaining information to interpret and use long-term memory(Carratú, Mazzitelli, Xavier, & de Sá, 2012; Ladewig, 2017; Sá, 2007). Long-term memory is crucial for learning process and people with ID may dissociate between explicit and implicit memory (Norris, 2017). However, it can vary according to etiology of ID because children with Down syndrome presented lower performance in explicit memory tasks, whereas children with Williams' syndrome performed similar to typically developed controls. Furthermore, those with Williams' syndrome had impaired implicit memory task, whereas peers with Down syndrome did not (Vicari, 2004). Therefore, long-term memory deficit may not be attributed to global cognitive deficit observed in children with ID, but due to peculiarity of each ID etiological profile. Detailed information regarding etiology was not collected in our study; thus, it is unclear whether ID was syndromic or not.

One research conducted with 121 individuals with Down syndrome(Palisano et al., 2001) observed that more time or repetition is needed to learn and retain certain tasks (e.g., running, climbing, or jumping). Typically developing children performed better in the acquisition phases (A1 and A2) than children with ID, probably because children without ID adapted faster to the motor task during familiarization. Adaptation requires implicit information about the movement, without awareness of what is to be learned(Kitago & Krakauer, 2013). Therefore, the attempts may have been insufficient for motor task adaptation in children with ID, possibly due to the interference of cognitive impairment on motor action processes, which depends on cortical association areas (Garcia-Marin & Fernández-López, 2020). As these children present a delayed central nervous system maturation, relatively simple tasks can be real challenges for children with ID (Fernández-blanco & Dierssen, 2020)

Another aspect to be considered is that children with disability present a considerable motor delay compared with children without disability, which makes the task perform exhausting(Gallahue, Ozmun, & Goodway, 2012) and may explain the low scores observed. Similar results were found by Possebom et al.(2016), who performed the maze test using a computer and observed that Down syndrome individuals aged 10 to 36 years presented a lower performance than their peers.

The maze task using a computer was also performed with children with cerebral palsy and typically developing controls aged 7 to 12 years(Monteiro et al., 2010). Differently from our results and previous studies(Possebom et al., 2016), children with cerebral palsy performed better the acquisition phase than their typically developing controls, probably indicating that children with typical development considered the task easy and demotivating. Nevertheless, cognitive impairments are not common in children with cerebral palsy(Patel, Neelakantan, Pandher, & Merrick, 2020), which may have interfered with task comprehension and processing. Despite the high fine motor skill demand to control an object while tracing the path using a pencil and considering possible extra demands to think about the right path and attention needed to complete the path, the maze task might be a cognitive-based task rather than motor-based task for children with ID. Impaired perceptual-motor skills present in people with ID (B. Jeoung, 2018; Memisevic & Djordjevic, 2018) could explain the increased time to practice complex tasks, such as the maze task in a paper sheet, which may provide low visual feedback and self-control compared with maze task performed in a computer. This allowed us to infer that maze task may not be the most suitable test for children with ID. The lack of previous motor experiences capable of enabling transfers to the maze task may have also interfered with the results.

Sá (2007) analyzed the retention process among groups of children aged 7 to 12 years old and without neurological impairments using a throwing task (sandbag throwing). After one week without training, the 7-year-old group presented a reduced retention due to performance instability. This finding is explained by the fact that the higher the amount of previous experiences, the greater the performance, regardless of the time interval without performing the task. An investigation conducted with cerebral palsy children aged 5 to 12 years (Carratú et al., 2012) did not find significant results in the retention phase after 20s and 60s without training. According to the authors, the lack of motor experience, the group heterogeneity, and the low amount of task repetition may have interfered with the results.

Some limitations should be considered. Although the same experiment was performed in other studies (Monteiro et al., 2010; Possebom et al., 2016), this is the first time that the maze test was performed using a paper sheet. This may have generated an extra demand for the children since motor control using pencil and paper is different from controlling a computer mouse while watching the representation of the maze on the screen. We did not record the time needed to complete the test, which would be an important outcome. The relatively small sample size and the extrapolation of the results to other conditions must also be performed cautiously. Last, the only information received by researchers was that ID of all children was congenital; origin of disease (whether syndromic or not) and IQ levels were not informed.

Main reason was that children were from a countryside area with low resources, where many children with disabilities are still at home without any chance of schooling. Despite improvements observed over the last years, some have difficulties accessing clinician's appointments because most specialists attend in large cities, far from countryside. Despite this, we selected children with ID and similar characteristics, and their typically developing peers were closely matched by age and gender.

Conclusion

In conclusion, motor learning (acquisition and retention phases) inferred based on motor performance of children with ID was lower than typically developing children. The EG presented greater difficulties than the CG, maintaining the same scores during the A1 and A2 phases and declining in the RET phase. CG maintained maximum scores during the three phases, confirming greater performance. However, this study does not allow us to state about motor learning in general, but only motor learning based on motor performance of a maze task printed on a paper sheet.

Based on results of this study, specific psychomotor interventions are required for EG, particularly considering perceptual-motor profiles. We suggest interventions using different tasks for improving fine motor skills focused on object control and visual-motor coordination. Thus, physical education teachers and clinicians are encouraged to propose interventions to stimulate motor learning development from childhood.

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