

The Effects of Providing a Means of Independent Mobility on Social and Cognitive Development in  
Young Children with Disabilities

by  
Emma Gottfried

A THESIS

submitted to

Oregon State University

Honors College

in partial fulfillment of  
the requirements for the  
degree of

Honors Baccalaureate of Science in Kinesiology  
(Honors Scholar)

Presented June 22, 2020  
Commencement June 2021



## AN ABSTRACT OF THE THESIS OF

Emma Gottfried for the degree of Honors Baccalaureate of Science in Kinesiology presented on June 22, 2020. Title: The Effects of Providing a Means of Independent Mobility on Social and Cognitive Development in Young Children with Disabilities

Abstract approved: \_\_\_\_\_

Samuel Logan

Modified ride-on cars are provided to children as a means of independent mobility. **Purpose:** The purpose of this study was to examine how the provision of modified ROCs to children with disabilities affects the development of problem-solving and personal-social skills. **Methods:** The amount of time children spent driving the modified ride-on cars during a 3-month period was recorded, as well as their pre and post-intervention Ages and Stages Questionnaire (ASQ) scores for the categories of problem-solving and personal-social skills. **Results:** The group was divided in half, with the children who used the car the most being placed in the High Utilization group and the children who used the car the least being placed in the Low Utilization group. The acquisition of skills was slightly higher in the Low Utilization group, but there was not a significant difference between the number of skills gained by either group. **Conclusion:** The lack of impact of the cars may be due to their extremely low levels of use. Specific guidelines for use, regular communication with the researchers, and the usage of a modified ride-on car in a clinical setting may improve the frequency of its use and its impact on the child.

Key Words: *modified ride-on car, independent mobility, driving time, skill acquisition*

Corresponding e-mail address: Gottfrie@oregonstate.edu

©Copyright by Emma Gottfried  
June 22, 2020

The Effects of Providing a Means of Independent Mobility on Social and Cognitive Development in  
Young Children with Disabilities

by  
Emma Gottfried

A THESIS

submitted to

Oregon State University

Honors College

in partial fulfillment of  
the requirements for the  
degree of

Honors Baccalaureate of Science in Kinesiology  
(Honors Scholar)

Presented June 22, 2020  
Commencement June 2021

Honors Baccalaureate of Science in Kinesiology project of Emma Gottfried presented on June 22, 2020.

APPROVED:

---

Samuel Logan, Mentor, representing Kinesiology

---

Jennifer Beamer, Committee Member, representing Kinesiology

---

Michele Catena, Committee Member, representing Kinesiology

---

Toni Doolen, Dean, Oregon State University Honors College

I understand that my project will become part of the permanent collection of Oregon State University, Honors College. My signature below authorizes release of my project to any reader upon request.

---

Emma Gottfried, Author

## **Acknowledgements**

I would like to thank Dr. Logan for his continuous support and encouragement throughout this entire process and for sharing with me with so much knowledge and feedback.

I would also like to thank Dr. Beamer for agreeing to be on my committee and for all of her contributions to my thesis when I was in her class.

Thank you to Dr. Catena for agreeing to be on my committee and also for all she taught me during my Motor Behavior class.

Finally, thank you to my family and friends for their endless encouragement of me during this process.

## **TABLE OF CONTENTS**

Introduction.....	9-15
Methods and Measures.....	15-18
Results.....	18-19
Discussion.....	19-22
Conclusion.....	22-23
References.....	23-27

## **Introduction**

Mobility is defined by the Cambridge English dictionary as the “ability to move freely or be easily moved”, and is critically essential to fulfilling the necessities of everyday life (Cambridge English Dictionary) While it is true that the ability to be solely responsible for one’s own body movements—being self-reliant and autonomous in governing where one goes and when—is a privilege enjoyed by most people, for a less well-known portion of humans, independent mobility is not a guarantee. Disability is prevalent in the United States, with over 61 million people identified as having a disability that impacts their ability to perform everyday tasks (Okoro et al, 2016). Furthermore, there are over 75,000 children documented living in the United States with a disability (Taylor, 2018). Of them, many experience impairment to their motor abilities, which is defined as “the partial or total loss of function of a body part, usually a limb or limbs” (International Neuromodulation Society). For many children who experience a disability that causes an impairment in mobility, powered mobility devices (PMDs), such as wheelchairs, are provided.

Unfortunately for children who experience a disability, PMDs are very expensive and require a variety of other assistive devices in order to actually use them: ramps in the house, a car with a wheelchair lift or the ability to store one, etc. PMDs are bulky and can weigh up to 40 pounds (Karman Healthcare). For many children who experience delayed walking but are ultimately expected to walk, there are even fewer options available. Recently, researchers have investigated an alternative method of independent mobility: the Ride-on Car (ROC) (Logan et al, 2014). ROCs are modified toy cars that can be purchased at many superstores. ROC’s are cheaper, lighter, and more easily transported compared to PMDs. The ROC itself often costs around one hundred dollars, and the modifications bring the cost up to about two hundred

dollars—significantly cheaper than PMDs (Cerebral Palsy Foundation). Modifications can include the use of velcro, PVC pipe, pool noodles and a kickboard to create a comfortable and secure roll cage that supports the child’s postural control, as well as inserting a large push-button steering wheel that may help a child with fine motor control impairments accelerate and steer the car more easily (Huang and Galloway, 2012). The ROC’s lightweight frame makes it easy to move from place to place, and the bright colors and toy-like appearance make it less intimidating and frightening to children, as well as their peers. This broader variety of options has sparked parental interest in studies pertaining to the importance of mobility in young children with disabilities.

While the ability to independently explore one’s environment is a privilege many take for granted, for many children with severe mobility impairments it is not guaranteed. When disability inhibits their ability to perform an unassisted movement, many children are left unable to explore and entirely dependent on those around them for transportation. Although research indicates that PMDs can help provide autonomy and independence to these children (Feldner, et al 2016, Anderson et al 2013, Gustafson, E., 2016), wheelchairs are often expensive, bulky, and largely unavailable to children under the age of three. This is concerning as most typically developing children begin walking around twelve months of age, creating a two-year gap in which some children are able to explore their environments without assistance while children with mobility impairments are not (Gustafson, 1984). This discrepancy is problematic as it significantly decreases the number of opportunities these children have to learn about and interact with the world around them. Locomotion is especially important because it allows children to interact with their environment and to begin to understand the relationships between objects, other people, and themselves, as well as how they affect and influence one another.

Typically developing children spend these early years running around, falling over, putting things in their mouths, and using their senses to explore the world. The capacity to explore provides the chance to interact with the environment around them and in doing so, it is easier to understand cause-and-effect relationships (Lobo et al, 2013, Nilsson and Nyberg, 2003). This critical time of development sets the stage for achieving future milestones throughout the later years of childhood.

In addition to a greater desire to learn about the world, independent mobility also allows children to develop their sense of personal motivation by setting intrinsic goals, which is a skill they will use throughout the rest of their lives. When a child is able to move without being carried or pushed in a stroller, they then have a reason to try new things. They also are able to experience successes and failures, as well as the important emotional and mental growth that comes with them. Furthermore, independent mobility increases the number of interactions that occur between the child and those around them, especially with their caregiver. This is because when the child is attempting to explore their environment, the parent often responds with either words of encouragement or caution (Campos et al, 2000). The development of motivation and initiation are essential skills that would assist in meeting future developmental milestones, as well as providing the tools to be successful in a variety of other areas throughout the child's life.

Additionally, there is evidence to suggest that when children have a method of independent mobility, their curiosity and desire to explore their environment is intensified (Feldner et al 2016). When a child has everything done for them, including moving them from one place to another, they have no reason to explore a world that has already been explored for them. This was made clear in a study that found that once independent mobility was provided, the number of self-initiated movements made by the children significantly increased compared to

before they had the powered mobility devices (Dietz, Swinth, and White, 2002). Beyond that, when young children are given the opportunity to be independently mobile, the onset of a variety of developmental milestones begin to occur. This includes the expansion of emotional and social skills as well as a more advanced understanding of spatial awareness (Campos et al, 2000). The provision of independent mobility has been shown additionally to increase general mobility and vocalization (Huang et al, 2014). For children who are unable to independently locomote, the development of these critical skills can be inhibited, causing them to fall behind not only in physical domains, but also when it comes to interacting with their peers. The delay or even absence of these skills can lead to feelings of isolation and segregation amongst the child and their peers.

While it may appear that a child with a motor disability would only be inhibited in the physical domain, researchers have found that social and emotional development may also be impacted by mobility impairments (Kennedy-Behr, Rodger, and Micken, 2011, Macdonald et al, 2017). Young children, particularly those with conditions that cause spinal muscular atrophy, may have an increased chance of developmental delay in realms outside of their physical impairment (Jones, McEwen, and Hansen, 2003). Furthermore, children with disabilities that impact their locomotion have been found to be more isolated and more prone to solitary play (Hestenes and Carroll, 2000). Although there is not yet a substantial body of research documenting socialization and independent mobility, it can be observed when watching children at play that a large amount of their socialization is impacted by their ability to move around freely (Logan et al 2015, Logan et al 2016). Thus, when independent mobility is provided during playtime and bonding activities, children with disabilities may experience greater levels of socialization with their peers. The provision of independent mobility allows the child to cover a

significantly greater amount of distance, therefore it increases the potential for interactions to occur, especially in a classroom or playground setting; that is, increased mobility results in increased opportunities.

Simply providing independent mobility to children with disabilities is not enough. The age at which children are provided PMDs appears to be crucial, as an association between immobility and lack of social interactions can be created early on. Delaying this can make it difficult for the child to learn that independent mobility can lead to increased opportunities to interact with those around them (Ragonesi et al, 2010). In a study that provided wheelchairs to young children with disabilities, researchers found that their participants experienced a significant increase in their social skills after the six-month intervention. Once the children were given the wheelchairs, they were able to participate more actively in the playground activities. Their level of play increased rapidly as well as their interactions with their peers (Guerette, Furumasu, and Tefft, 2013). The increased peer-to-peer interactions can not only assist in the development of social skills but can also enhance feelings of belonging.

While it is true that there are many reasons that PMDs are typically not available to very young children, one of the main reasons is due to a belief that some children with such severe disabilities would not be able to learn to use the device, or would be physically incapable of doing so (Feldner et al, 2016). However, multiple case studies of children with extreme functional limitations (such as spastic quadriplegic cerebral palsy) found that with time and instruction, the children were able to master the powered mobility devices (Huang et al 2014, Jones et al 2012, Logan et al 2016). Beyond that, in doing so the participant experienced an increase in social interactions with his family, as well as more frequent vocalizations and facial expressions showing positive emotions (Logan et al, 2014).

In addition to the belief that a child is too severely disabled to use a PMD, these devices are often seen as a long-term treatment and not an option for children who simply have delayed mobility, such as children with Down Syndrome (DS). Children with DS are typically mobile eventually and start walking a year later than their peers, at age two but in this delay they will still lose a year of mobility-related development and exploration (University of Nevada School of Medicine). There is a misconception in the medical field that the provision of a PMD will inhibit mobility by eradicating any motivation a child has to learn how to walk, but research has shown that this is untrue (Hospodar et al). In a study conducted with a 13-month old girl, Natalie, with DS, she was provided with an ROC for several months. Not only was she able to grasp the skills required to drive the ROC, but she and her family experienced more mobility and social interactions as a result, and she ultimately walked as expected. Moreover, her Pediatric Evaluation of Disability Inventory (PEDI) scores (an assessment performed on children that analyzes a variety of functional skills) improved from before the intervention to after (Logan et al, 2014). This child's use of the ROC was different from the typical approach to PMDs because she was only using it as a temporary form of assistive technology. In spite of the fact that the ROC was not meant to provide independent mobility for the rest of her life, it did allow her to become independent in exploring her surroundings, interact more with her peers, and provided an opportunity for her to participate in physical activity with her family in ways she had never been able to before, such as helping choose the direction her family traveled during walks and beginning to play with her sister as well. Her family reported that when the ROC was removed during the retention period, Natalie became unhappy and frustrated by her loss of autonomy and inability to explore on her own. However, the ROC was returned to Natalie once the study was complete.

Although it is not always thought of this way, access to independent mobility is a human right. Providing independent mobility to young children with disabilities is essential because it encourages positive social development and promotes independent exploration. ROCs offer a more affordable, more child-friendly, and feasible alternative when compared to other mobility devices. While it has been previously believed that children under the age of three, as well as children with severe disabilities, would not be ideal candidates for PMDs, various studies have indicated that with proper instruction, the children are in fact capable of learning to master the device and benefit from its use (Hospodar et al, Logan et al 2016, Logan et al 2018). It is clear that while many people view PMDs as a last resort option, they should be considered as an early intervention treatment due to their positive impact on cognitive and social development in young children with disabilities. Research on this topic should continue to occur in order to build the baseline evidence needed to advocate for policy change, so young children with severe disabilities are able to have the most opportunities possible to enhance their development. The purpose of this study is to examine how the provision of modified ROCs to children with disabilities affects the development of problem-solving and personal-social skills.

## **Methods**

### Study Design

Per the 2019 study conducted by Logan et al, a prospective, descriptive observational design was used (Logan et al, 2019). This study was a component of a larger study that investigated the effectiveness of using modified ROCs as a means of providing independent mobility to children with disabilities, measured the changes in each child's development before

and after the intervention, and examined caregivers' attitudes towards independent mobility, models of disability, and people with disabilities.

### Participants

This study was conducted from August 2017 to June 2018, in three-month time periods for each participant. At the beginning of the study, there were 18 children enrolled, however only 13 completed the intervention and the follow-up session. The inclusion criteria consisted of the following: participants must be between 10 months and 3 years of age at the beginning of the study, they must be able to sit with support, and be either diagnosed with a motor disability or a motor delay, or considered at risk for delayed independent mobility. The 13 participants who completed this study filled out the initial forms, engaged in modified ROC use for 3 months.

### Modified ROC

The ROC was modified to become safer and easier to use for the participants. This involved the insertion of a large button that could be easily pressed to activate the car. For safety, structural support was added to the car in the form of PVC pipes with pool noodles around them for softness. It was required for the parents to demonstrate the ability to safely place their child into the car and secure them in it, to turn the car both on and off, and to charge the battery. They were also required to be an arms length away from the child at all times while supervising. An engineer checked all of the modifications to ensure the cars were safe before they were given to the children to use. Three different ROC options were available to best meet each child's seating needs and were designed specifically for children up to 36 months of age. Each operated with a 6V battery, could reach a maximum speed of 2 miles per hour, and was able to move in the forward direction only.

## Measures

The amount of time the children used the car was measured in two ways: a parent reported activity log, and the Feather Interface Tracking System. The activity logs asked the parents to record the date, location, and start and end time of their child's car use over the three month period. The Feather Interface Tracking System was a device that recorded the date, timestamp, and number of milliseconds the switch was pushed each time it was activated. This data was stored on a micro SD card and downloaded at the follow-up visit. A driving session was defined as at least five minutes of elapsed time between the first and last switch activation, and if there was a ten minute (or longer) period in between switch activations, this was considered a separate driving session.

## Procedure

This study consisted of three components: the initial home visit, three months of using the modified ROC, and a final home visit at the end. At the initial visit, the families of participants filled out the Ages and Stages Questionnaire (ASQ) and participated in a 1.5 hour long training on modified ROC safety. The researchers ensured that the ROC was modified to correctly fit the child and the child was allowed to explore their surroundings in the presence of the researcher. Researchers directed the family members to try to fit the car into their daily lives over the three month period. During this time, the researchers did not maintain consistent contact with the families and asked them to independently log their usage hours on a form given to them during the initial visit. At the final home visit at the end of the three month period, the researchers collected the data from the logs and administered the questionnaires a second time.

### Dependent Measures

Ages and Stages Questionnaire (ASQ). In the pre and post ASQ, the parents and guardians of the children answered six questions regarding problem-solving and personal social skills. For each question, there were three possible responses: Yes (recorded as the number ten during data collection), Sometimes (recorded as the number five), and Not Yet (recorded as the number zero). The numerical results from the pre and post-intervention ASQ were then compared to determine the number of questions each participant increased their response value. An increase in numerical value was decided to be associated with an improvement in skill, and these increases were recorded as a skill acquisition in Table 2.

### Data Analysis

Visual analysis was the primary means of data analysis in this study. The thirteen participants were split into groups of six and seven, with their overall driving time determining whether they were placed into the High Utilization group or Low Utilization group. The six participants with the highest usage were placed in the High Utilization group and the seven participants with the lowest usage were placed in the Low Utilization group.

## **Results**

The high utilization group gained an average of 2 skills (range = 0-6), while the low utilization group gained an average of 2.43 skills (range = 0-6). The skills gained by each child, as well as the number of skills they had before and after the intervention, are shown in Table 2. In the high-utilization group, the children had variety skill levels prior to the intervention. The parents of one child (ID #012) answered all 12 questions asked with either a “Yes” or “Sometimes” in regards to their whether or not their child performed th skill, while the parents of

two other children (ID #s 013 and 009) answered “Not Yet” to all of the questions asked. The rest of the children in the group fell somewhere in between. In the low-utilization group, the parents of one child (ID #019) reported “Sometimes” or “Yes” to 8 of the questions asked. Only the parents of one child (ID #027) in the low-utilization group reported 0 skills at the beginning of the study, and the rest of the children fell somewhere in between. The mean number of skills prior to the test for the high-utilization group was 4, and the mean number of skills following the intervention was 3.6. For the low-utilization group, the mean number of skills prior to the intervention was 5.6 and the mean number of skills following the intervention was 4.

## **Discussion**

The ROC has been associated with the development of motor, cognitive, and social skills in children with disabilities in both single subject and larger sample studies (Logan et al, 2014, Logan et al 2018, Huang et al 2017). The purpose of this study was to examine how the provision of modified ROCs to children with disabilities affects the development of problem-solving and personal-social skills.

The children in this study overall demonstrated an acquisition of skills ( $\bar{x}_{\text{avg}}=2.22$ ) in their pre- and post-intervention questionnaires. However, due to the absence of a control group, it is difficult to determine if the acquisition of skills was due to the intervention or if they were developmental milestones that would have occurred regardless of the intervention. The lack of a control group is not uncommon for studies examining the effects of assistive devices on development in children with disabilities, due to ethical concerns regarding withholding an intervention from a child who may benefit from it (Henderson et al, 2008). Additionally, studies with children can be challenging to conduct due to the fluctuating nature of both childhood development and disability (Butler, 1991).

The participants were divided into low-usage and high-usage groups, with high-usage consisting of a range of 110.5 to 791 minutes, and the low-usage consisting of a range of 0 to 94.9 minutes of ROC use in the three-month period. Overall utilization was low, so the group was divided by individual usage to determine if there were any benefits experienced by the high utilization group that would otherwise be imperceptible when combined with the data from the low utilization group. However, when the data were analyzed following this study, they demonstrated that the children in the low-usage group actually obtained a slightly higher number of skills on average ( $\bar{x}_{low}=2.43$ ,  $\bar{x}_{high}=2$ ), as well as a slightly higher number of skills overall following the study ( $\bar{x}_{low}=4$ ,  $\bar{x}_{high}=3.6$ ). This makes it difficult to determine if there is an association between ROC usage and skill acquisition, since there was not a drastic difference between the high and low-usage groups. In fact, one child (ID #019) did not use the ROC at all and still showed an acquisition of five skills, which was the largest number of skills gained for both of the groups. On average, the low-usage group actually had a greater number of skills prior to the study ( $\bar{x}_{low}=5.6$ ) compared to the high-usage group ( $\bar{x}_{high}=4$ ). One possible explanation for these data could be that the parents of children who started out with a greater number of skills were less motivated to encourage them to use the intervention.

Another aspect that needs to be considered is the abilities and skills of the participants prior to the study. Other research has found that children who have a certain level of cognitive and problem-solving skills have a higher likelihood of being able to master the ROC (Furumasu et al, 2004). It could be argued that these children beginning this study with differing levels of cognitive and problem-solving skills may have impacted the maximum benefit they were able to achieve from the ROC. Additionally, the children who participated in this study had a variety of disabilities and disability-specific anticipated timelines for achieving various cognitive and social

milestones. Finally, some children began the study already receiving the maximum possible score on questions on the pre-test, which resulted in the analysis showing zero improvement and skill development between their pre- and post-test scores.

The usage of the modified ROC reported was less than in preceding studies (Logan et al, 2020). A previous study analyzed a multitude of perceived barriers that have been reported by family members and caregivers as reasons for low ROC usage, with 25% of the reasons comprising of barriers relating to the device, 19% relating to barriers within the environment, and 12% relating to barriers due to the child's health. Other perceived barriers included caregiver time, motivation, and physical requirements, as well as the child's abilities and tolerance (Logan et al, 2019). It is possible that these perceived barriers contributed to the low use of the modified ROCs reported in this study, which may have limited their impact. There is great discrepancy between the studies evaluating the time necessary to simply master the ROC, with some children mastering the ROC in under 3 weeks, while others required over a year to achieve the same level of mastery (Butler, 2008, Jones et al, 2012). As stated above, the time needed to master the ROC may be dependent on the child's ability level prior to being introduced to the ROC. At the initial home visit in this study, the researchers conducted a 1.5 hour long ROC safety training and then left the ROCs with the families for a 3 month period. The children were not evaluated to see if they had properly mastered the ROC. This may have skewed the results as it is unclear if a child using the ROC without fully mastering it would experience the same benefits as a peer who had mastered the device.

### Strengths, Limitations and Future Research

A strength of this study is that it examined a comparatively large sample size (n=13) when compared to many other studies on ROCs conducted with a single-subject design.<sup>21,22,23</sup>

The larger sample size also allowed researchers to study a broader range of disabilities compared to the single-subject case study. A limitation of this study is that skills reported in the pre- and post-intervention questionnaires were reported by the parents and caregivers and therefore are not an objective measurement of the child's capabilities. The ASQ only asks six questions per category, so it is possible that other relevant skills were left out. The children may have improved in those areas during the intervention, but it would not have been recorded due to the limited nature of the ASQ. Some of the participants had already received the maximum score (10) on various questions prior to the intervention, which made it impossible to show any change in skill level. As discussed above, there was no control group, which makes it difficult to determine if the changes in skill level can truly be attributed to the use of the ROC. Finally, while this study's sample size was larger than many of the single-subject case studies, conducting a study with a larger sample size may reveal other trends in skill acquisition. Further research utilizing a larger sample size, objective skill measurements, and specific ROC usage guidelines would be beneficial.

## **Conclusion**

As discussed above, in the present study, there is no substantial difference in skills acquired by the high and low-usage group. This may be attributed to overall low ROC usage. The current study is an important step in understanding the necessity of specific guidelines for families who have been given an ROC. This may contribute to future research by highlighting the potential benefit of regulated ROC use. The low usage by families who were given the ROC with no support or contact from researchers during the three-month period may indicate to

pediatric physical therapists the need for regular communication with the families regarding the ROC or even the usage of the ROC in a clinical setting at predetermined frequencies.

## References

- Anderson, D. I., Campos, J. J., Witherington, D. C., Dahl, A., Rivera, M., He, M., . . . Barbu-Roth, M. (2013). The role of locomotion in psychological development. *Frontiers in Psychology*, 4. doi:10.3389/fpsyg.2013.00440
- Butler, Charlene. “Effects Of Powered Mobility On Self-Initiated Behaviors Of Very Young Children With Locomotor Disability.” *Developmental Medicine & Child Neurology*, vol. 28, no. 3, 2008, pp. 325–332., doi:10.1111/j.1469-8749.1986.tb03881.x.
- Butler, Charlene. “Augmentative Mobility.” *Physical Medicine and Rehabilitation Clinics of North America*, vol. 2, no. 4, 1991, pp. 801–815., doi:10.1016/s1047-9651(18)30683-1.
- Campos, J., Barbu-Roth, M. A., Hubbard, E. M., Witherington, D., & Anderson, D. (2000). Travel broadens the mind. *Infancy*, 1(2), 149–219.
- Deitz, J., Swinth, Y., & White, O. (2002). Powered mobility and preschoolers with complex developmental delays. *American Journal of Occupational Therapy*, 56, 86-96.
- Feldner, H., Logan, S., & Galloway, J. (2016). Why the time is right for a radical paradigm shift in ... Retrieved May 23, 2020, from <http://europepmc.org/abstract/MED/26340446>
- Furumasu, Jan, et al. “Relevance of the Pediatric Powered Wheelchair Screening Test for Children with Cerebral Palsy.” *Developmental Medicine & Child Neurology*, vol. 46, no. 07, 2004, doi:10.1017/s0012162204000775.
- Guerette, P., Furumasu, J., & Tefft, D. (2013). The Positive Effects of Early Powered Mobility on Children’s Psychosocial and Play Skills. *Assistive Technology*, 25(1), 39–48, doi: 1080/10400435.2012.685824
- Gustafson, E. E. (1984). Effects of the ability to locomote on infants’ social and exploratory behaviors: An experimental study. *Developmental Psychology*, 20, 397–405.
- Henderson, Stacey, et al. “Assistive Devices for Children with Functional Impairments: Impact on Child and Caregiver Function.” *Developmental Medicine & Child Neurology*, vol. 50, no. 2, 2008, pp. 89–98., doi:10.1111/j.1469-8749.2007.02021.x.
- Hestenes, L. H., & Carroll, D. E. (2000). The play interactions of young children with and without disabilities: Individual and environmental influences. *Early Childhood Research Quarterly*, 15, 229–246.

Hospodar, C., Sabet, A., Logan, S., Catena, M., & Galloway, J. (2019). Exploratory analysis of a developmentally progressive ... Retrieved May 23, 2020, from <https://www.ncbi.nlm.nih.gov/pubmed/31939311>

Huang H-H., Ragonesi C.B., Stoner, T., Peffley, T., & Galloway, J.C. (2014). Modified ride-on cars for mobility and socialization: case report of a child with cerebral palsy.

Huang, Hsiang-Han, et al. "Ride-On Car Training for Behavioral Changes in Mobility and Socialization Among Young Children With Disabilities." *Pediatric Physical Therapy*, vol. 29, no. 3, 2017, pp. 207–213., doi:10.1097/pep.0000000000000426.

Huang, H. H., & Galloway, J. C. (2012). Modified ride-on toy cars for early power mobility: a technical report. *Pediatric Physical Therapy*, 24(2), 149–154. <https://doi.org/10.1097/PEP.0b013e31824d73f9>

International Neuromodulation Society. Motor impairment. Retrieved from: <https://www.neuromodulation.com/motor-impairment>.

Jones, Maria A., et al. "Effects of Power Wheelchairs on the Development and Function of Young Children With Severe Motor Impairments." *Pediatric Physical Therapy*, vol. 24, no. 2, 2012, pp. 131–140., doi:10.1097/pep.0b013e31824c5fdc.

Jones, M.A., McEwen, I.R., & Hansen, L. (2003). Use of powered mobility for a young child with spinal muscular atrophy. *Journal of the American Physical Therapy Association*, 83, 253-262.

Kennedy-Behr, A., Rodger, S., & Mickan, S. (2011). Physical and Social Play of Preschool Children with and without Coordination Difficulties: Preliminary Findings - Ann Kennedy-Behr, Sylvia Rodger, Sharon Mickan, 2011. Retrieved May 23, 2020, from <https://journals.sagepub.com/doi/abs/10.4276/030802211X13099513661199>

Lobo, M., Harbourne, R., Dusing, S., & Westcott Mccoy, S. (2013). Grounding early intervention: Physical Therapy cannot just be about motor skills anymore. *Physical Therapy*, 93, 94–103, doi: 10.2522/ptj.20120158

Logan, S. W., Hospodar, C. M., Bogart, K. R., Catena, M. A., Feldner, H. A., Fitzgerald, J., ... Smart, W. D. (2019). Real World Tracking of Modified Ride-On Car Usage in Young Children With Disabilities. *Journal of Motor Learning and Development*, 7(3), 336–353. doi: 10.1123/jmld.2019-0015

Logan, S.W., Huang, H-H., Stahlin, K., & Galloway, J. C. (2014). Modified ride-on car for mobility and socialization: Single-case study of an infant with Down Syndrome. *Pediatric Physical Therapy*, 26, 418-426, doi: 10.1097/PEP.0000000000000070.

Cerebral Palsy Foundation. Go Baby Go. Retrieved from:

<https://www.yourcpf.org/cpproduct/go-baby-go-the-ultimate-toy-hack/>.

Logan, Samuel W., et al. "Modified Ride-on Car Use by Children With Complex Medical Needs." *Pediatric Physical Therapy*, vol. 28, no. 1, 2016, pp. 100–107., doi:10.1097/pep.0000000000000210.

Logan, Samuel W., et al. "Modified Ride-on Car for Mobility and Socialization." *Pediatric Physical Therapy*, vol. 26, no. 4, Jan. 2014, pp. 418–426., doi:10.1097/pep.0000000000000070.

Logan, S.W., Feldner, H.A., Bogart, K.R., Catena, M.A., Hospodar, C.M., Raja, J.S., Smart, W.D., & Massey, W. (in press). Perceived barriers of modified ride-on car use of young children with disabilities before and after a three-month period. *Pediatric Physical Therapy*.

Logan, S.W., Feldner, H.A., Bogart, K.R., Catena, M.A., Hospodar, C.M., Raja, J.S., Smart, W.D., & Massey, W. (in press). Perceived barriers of modified ride-on car use of young children with disabilities: A content analysis. *Pediatric Physical Therapy*.

Logan, Sam W, et al. *Modified Ride-On Car Use by Young Children With Disabilities : Pediatric Physical Therapy*. Wolters Kluwer, 2018, doi:10.1097/PEP.0000000000000468

Logan, S. W., Schreiber, M., Lobo, M., Pritchard, B., George, L., & Galloway, J. C. (2015). Real-World Performance. *Pediatric Physical Therapy*, 27(4), 433-441. doi:10.1097/pep.0000000000000181

Logan, S. W., Ross, S. M., Schreiber, M. A., Feldner, H. A., Lobo, M. A., Catena, M. A.,...Galloway, J. C. (2016). Why We Move: Social Mobility Behaviors of Non-Disabled and Disabled Children across Childcare Contexts. *Frontiers in Public Health*, 4. doi:10.3389/fpubh.2016.00204

Logan, S. W., Hospodar, C. M., Feldner, H. A., Huang, H., & Galloway, J. C. (2018). Modified Ride-On Car Use by Young Children With Disabilities. *Pediatric Physical Therapy*, 30(1), 50-56. doi:10.1097/pep.0000000000000468

Macdonald, M., Ross, S., McIntyre, L. L., & Tepfer, A. (2017). Relations of Early Motor Skills on Age and Socialization, Communication, and Daily Living in Young Children With Developmental Disabilities. *Adapted Physical Activity Quarterly*, 34(2), 179-194. doi:10.1123/apaq.2015-0091

"Mobility." *Cambridge English Dictionary*, Cambridge University Press, 1995

Nilsson, L.M., & Nyberg, P.J. (2003). Case report--Driving to learn: A new concept for training children with profound cognitive disabilities in a powered wheelchair. *American Journal of Occupational Therapy*, 57, 229-233. *Pediatric Physical Therapy*, 26, 76-84, doi: 10.1097/PEP.0000000000000001

Okoro CA, Hollis ND, Cyrus AC, Griffin-Blake S. Prevalence of Disabilities and Health Care Access by Disability Status and Type Among Adults — United States, 2016. *MMWR Morb Mortal Wkly Rep* 2018;67:882–887. DOI: <http://dx.doi.org/10.15585/mmwr.mm6732a3>

Ragonesi, C. B., Chen, X., Agrawal, S., & Galloway, J. C. (2010). Powered mobility and socialization in preschool: A case study of a child with cerebral palsy. *Pediatric Physical Therapy*, 22, 322–329

Ross, S. M., Catena, M., Twardzik, E., Hospodar, C., Cook, E., Ayyagari, A., . . . Logan, S. W. (2017). Feasibility of a Modified Ride-on Car Intervention on Play Behaviors during an Inclusive Playgroup. *Physical & Occupational Therapy In Pediatrics*, 38(5), 493-509.  
doi:10.1080/01942638.2017.1400491

Taylor, D. (2018). Americans With Disabilities: 2014. *U.S. Census*, 32.

University of Nevada School of Medicine, Family Medicine. When will my child with Down Syndrome learn to walk? Retrieved from <https://www.sharecare.com/health/down-syndrome/when-child-down-syndrome-walk/>.

**Table 1.** Demographics information for the participants as reported by the parents. The questions about motor abilities were open ended.

Participant ID	Age in Months	Gender	Disability	Motor Abilities at Entry
003	27.5	Female	Down Syndrome	Able to walk
004	28.6	Male	Wolf-Hirschhorn syndrome	<ul style="list-style-type: none"> <li>● Unable to walk</li> <li>● Able to army crawl</li> <li>● Able to stand in walker</li> </ul>
007	12.2	Female	Spina bifida, hydrocephalus, Chiarri II	<ul style="list-style-type: none"> <li>● Uses mobile stander with parent assistance</li> <li>● Learning to use Bumbo wheelchair</li> </ul>
008	16.0	Male	Global developmental delay, hypotonia, epilepsy	<ul style="list-style-type: none"> <li>● Unable to crawl or walk</li> <li>● Able to roll</li> </ul>
009	12.1	Male	Global developmental delay	Unable to roll, crawl, sit, stand or walk
011	12.3	Male	Global developmental delay with mild hearing loss	Unable to crawl or walk
012	17.0	Male	Spina bifida	<ul style="list-style-type: none"> <li>● Unable to stand or walk</li> <li>● Able to army crawl</li> <li>● Uses zipzac wheelchair and mobile stander</li> </ul>
013	23.4	Female	Cerebral palsy, microcephaly	<ul style="list-style-type: none"> <li>● Unable to sit</li> <li>● Able to scoot and roll</li> </ul>
014	32.5	Male	Sjogren-Larsson syndrome	<ul style="list-style-type: none"> <li>● Unable to walk</li> <li>● Able to crawl</li> </ul>

				<ul style="list-style-type: none"> <li>• Able to pull to stand</li> </ul>
019	12.8	Male	Spina bifida, hydrocephalus	Limited use of legs
020	20.7	Female	Microcephaly	Able to walk
023	27.8	Male	Down Syndrome (trisomy 21)	<ul style="list-style-type: none"> <li>• Able to crawl</li> <li>• Able to walk with walker</li> </ul>
026	17.9	Female	Cerebral palsy	<ul style="list-style-type: none"> <li>• Able to sit with support</li> <li>• Able to roll with support</li> </ul>
027	18.3	Male	Cerebral palsy (spastic quadriplegia), cortical vision impairment	<ul style="list-style-type: none"> <li>• Able to walk with gait trainer</li> <li>• Able to scoot, occasionally scoots</li> </ul>

Table 2. Skills Gained from Pre- to Post-Intervention in High vs Low Utilization Groups

	Child ID	PR (Pre) <sup>1</sup> n <sub>total</sub> =6	PS (Pre) <sup>2</sup> n <sub>total</sub> =6	TS (Pre) <sup>3</sup> n <sub>total</sub> =12	PR (Gained) n <sub>total</sub> =6	PS (Gained) n <sub>total</sub> =6	TS Gained:Lost n <sub>total</sub> =12	PR (Post) n <sub>total</sub> =6	PS (Post) n <sub>total</sub> =6	TS (Post) n <sub>total</sub> =12
High Utilization	004	0	1	1	0	1	1:1	0	1	1
	013	0	0	0	0	0	0	0	0	0
	011	4	5	9	1	2	3	2	4	6
	008	0	2	2	2	3	5:2	2	3	5
	012	6	6	12	2	1	3:5	5	5	10
	009	0	0	0	0	0	0	0	0	0
Low Utilization	019	4	4	8	3	2	5:6	3	4	7
	007	3	4	7	4	1	5:6	4	2	6
	020	3	4	7	1	1	2:5	1	3	4
	014	3	1	4	0	0	0:2	1	1	2
	026	5	2	7	1	1	2:6	2	1	3
	027	0	0	0	0	0	0	0	0	0
	023	3	3	6	2	1	3:3	3	3	6

1: Number of problem-solving skills prior to the intervention. 2: Number of personal-social skills prior to the intervention. 3: Number of total skills prior to the intervention.

