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Modified ride-on cars and mastery motivation in young children with disabilities: Effects of environmental modifications

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ABSTRACT

Background: Independent mobility is important for children's psychological development. Modified ride-on cars are innovative, alternative options to enhance independent mobility, socialization, and motivation in young children with disabilities.

Aim: We compared the effects of combining ride-on car use and a social interaction training program on mastery motivation and home affordances with a home education program in young children with disabilities.

Methods and procedures: Twenty-nine children with disabilities aged 1–3 years were recruited. The treatment group (n = 15) received two 2-h sessions/week for 9 weeks of ride-on car training in a hospital environment in Taiwan. The control group (n = 14) underwent similar home education programs. No treatment except regular therapy was administered during the 9-week follow-up period. Assessments included the Revised Dimensions of Mastery Questionnaire–Chinese version and the Affordance in the Home Environment for Motor Development–Toddler version–Chinese version.

Outcomes and results: The treatment group (compared to controls) had significantly greater improvements in object persistence during the intervention. Both groups showed significant improvements in mastery pleasure and home affordances during the intervention.

Conclusions and implications: This novel study showed the potential use of modified ride-on cars to enhance mastery motivation in a hospital environment.

What this paper adds?

Modified ride-on toy cars as physical environmental modifications have become innovative, alternative options for enhancing independent mobility and socialization in young children with disabilities. Studies further suggested that the combination of physical and social environmental modifications may benefit mastery motivation for children to learn and develop skills. This prospective, pretest–posttest control group study provided evidence for combining ride-on car use with an adult-directed, social training program,

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which act as respective physical and social environmental modifications for improving mastery motivation in young children with disabilities. The combination of ride-on car use and a structured, social training program facilitates the development of object persistence compared to the home education program after the 9-week intervention. Additionally, young children with motor disabilities in both the ride-on car training and home education programs have increased mastery pleasure during the intervention phase. The findings support the positive impacts of environmental modifications by combining social interaction programs with ride-on car use on mastery motivation for young children with disabilities.

1. Introduction

Young childrenare initiators and active participants in their world (Butler, 2009; Gibson, 1988; Perry, 1998). They perceive relevant information on affordances produced by their own movements and can discover how the information can be used to guide their subsequent movements. Affordances refer to the fit between a person's capability and environmental properties (Gibson & Pick, 2000). They are action opportunities that allow the child to perceive, learn, and develop skills. For example, once infants can actively stretch out arms and control their legs to explore a surface, they can discover what things feel like and whether surfaces can support their weight (Adolph, 1997). Independent locomotion allows children to learn the action possibilities that relate to their capabilities and surface layout (e.g., furniture), which enhances development. A positive correlation among home affordances, motor, and cognitive development is evidenced in young children with typical development during their first 18 months (Miquelote, Santos, Cacola, Montebelo, & Gabbard, 2012; Saccani, Valentini, Pereira, Muller, & Gabbard, 2013). The perceived affordances and the intention to master one's environment are highly associated with children's independent mobility and mastery motivation.

1.1. Mastery motivation and young children without disabilities

Mastery motivation is a psychological force that drives a child to initiate and persist in problem-solving or to master a skill or task with moderately challenging levels and pleasure (Morgan, Harmon, & Maslin-Cole, 1990). Object (instrumental) and social (expressive) subtypes of mastery motivation can be measured by the motivated behaviors of persistence and mastery pleasure (Morgan, MacTurk, & Hrncir, 1995). Young children's mastery motivation to move and explore their environments is the foundation of learning during development according to the developmental perspective (Gibson & Pick, 2000; Morgan et al., 1995).

Previous studies showed that toddlers with disabilities, including developmental disabilities, cerebral palsy, and motor delay, may have less mastery motivation and persistence on task performance compared with their typically developing peers (Jennings, Connors, Stegman, Sankaranarayan, & Mendelsohn, 1985; Jennings, Connors, & Stegman, 1988). Diverse experiences associated with physical impairments, social play, maternal didactic interaction, and caregivers' perceptions of children's motivation are possible factors influencing young children's mastery motivation (Hauser-Cram, 1996; Medeiros, Cress, & Lambert, 2016; Wang, Morgan, Hwang, & Liao, 2013; Wang, Morgan, Hwang, Chen, & Liao, 2014). To increase mastery motivation in young children with motor disabilities, physical and social environment modifications by enhancing mobility function and including social play with the caregivers in training programs can be applied (Kenyon, Farris, Aldrich, & Rhodes, 2017; Waldman-Levi & Erez, 2015).

1.2. Early power mobility training and mastery motivation

The use of power mobility devices (PMDs) in early power mobility training is an effective method to increase young children's independent mobility and enhance their motor, social, and cognitive development (Livingstone & Field, 2014). Modified ride-on toy cars as a type of PMDs and physical environmental modification are one such option. They are affordable, easily customizable, attractive, and smaller compared to power wheel chairs (Huang & Galloway, 2012; Logan et al., 2017). They could be used in various settings with appropriate space and environment, such as homes, institutions, and hospitals (Huang & Chen, 2017; Huang, Ragonesi, Stoner, Peffley, & Galloway, 2014; Logan, Feldner, Galloway, & Huang, 2016). Other studies found that the fancy appearance of ride-on cars is attractive to children and can cause them to approach, thus having an advantage of being a "social toy" between children with disabilities and their peers, which may enhance their social participation (Huang, Chen, & Huang, 2017; Logan, Huang, Stahlin, & Galloway, 2014). These studies have also indicated that integrating the concept of family-centered service into the ride-on car training program may enhance children's motivation and caregivers' perceptions of their children's capabilities (Huang et al., 2018; Huang, Chen et al., 2017). Furthermore, the increased motivation may be beneficial for children to initiate movements at home and have more action possibilities.

However, no standardized measurements of mastery motivation and home affordances were applied in previous ride-on car studies to examine treatment outcomes. Furthermore, the reported use of ride-on cars lacked the component of "social play" as a social environmental modification, which may be a key element to promote mastery motivation and further influences social function (Huang & Chen, 2017). A previous study found that the combination of ride-on car use and a structured, adult-directed social interaction program in the hospital environment was beneficial for promoting socialization (Huang et al., 2018); however, whether this combination affects mastery motivation and home affordances in young children with disabilities remains unknown. Moreover, the long-term effects of training also remain questionable.

Consequently, we examined the effects of combining physical and social environmental modifications in the hospital environment (i.e., the combination of modified ride-on cars and a family-centered, social interaction program) on improving mastery motivation and home affordances in young children with disabilities. We also investigated the relationship between mastery motivation and home affordances after administering the training program.

2. Materials and methods

2.1. Design

This was a prospective, non-equivalent, pre- and post-test control group study (Portney & Watkins, 2015). This study included a 9-week follow-up phase and a control group that received a home education program with similar treatment dosages and goal settings. Participants' enrollment was from June 2015 until September 2017. Some outcomes of the same project were published in a prior study, including mobility, social function, parenting stress level, and goal achievements (Huang et al., 2018). The study duration for each participant was 18 weeks, including a 9-week intervention and a 9-week follow-up. One licensed occupational therapist (OT) who was blinded to the study hypotheses was responsible for both treatments and did not participate in other project parts. Another licensed OT, who was not involved in the treatment and was blinded to the children's grouping, performed all the assessments. The assessments were performed before and after the 9-week intervention and at the end of the 9-week follow-up phase. At the pretest, the Goal Attainment Scaling (GAS) was used for all participants in an interview between parents and therapists to set functional goals. The GAS results have been previously reported (Huang et al., 2018). Participants were conveniently sampled and recruited from local hospitals and the community (e.g., healthcare practitioners or self-referrals) in Taoyuan and Taipei, Taiwan.

2.2. Participants

Participants were 29 young children with disabilities aged 1–3 years who had not received ride-on car training or socialization training prior. Fifteen received ride-on car training combined with an adult-directed social interaction program, and 14 underwent a home education program. The inclusion criteria were (1) diagnosed as having delayed motor development, resulting in motor impairments that prevented functional independent mobility, such as rolling, crawling, and walking; (2) aged 1–3 years; (3) able to tolerate sitting with support for 30 min; and (4) able to reach objects. The exclusion criteria were described previously (Huang et al., 2018). This study was reviewed and approved by the Chang Gung Medical Foundation Institutional Review Board. Parents provided written informed consent before their children participated.

2.3. Procedure

The combination of ride-on car use with a family-centered, social interaction program was previously described in detail (Huang et al., 2018). Participants were grouped into the treatment group (hospital-based, ride-on car combined with social interaction program) and the control group (home education program without the use of a ride-on car). For the treatment group, the research team modified a toy car based on participants' capabilities a week before the intervention started, including temporary and permanent modifications (Huang & Galloway, 2012). The control system, which was referred to as the switch and joystick activations (Fig. 1), was also previously used (Huang & Chen, 2017; Huang, Chen et al., 2017). The wireless joystick was used as a shared controller for the caregivers to provide assistance when the car needed to turn or for caregivers to interact with the child without stopping the car (Mitchell, Viswanathan, Adhikari, Rothfels, & Mackworth, 2014). Participants in both groups continued their regular therapy, including physical, occupational, and speech therapies, throughout the 18-week study period.

2.4. Intervention

2.4.1. Treatment group

The caregivers and the OT conducted two 2-h sessions/week for 9 weeks. Three sessions were included: (1) warm-up: natural play

Fig. 1. The Modified Ride-On Toy Car.

activities (15 min); (2) static play: mobility and social training without cars (30–45 min) (e.g., motor skilling training related to mobility and social impairments); and (3) mobility play: mobility and social training with cars (60–75 min) (e.g., the learning of cause-effect concept by pressing the switch to drive the toy car and releasing the switch to stop the car). All the detailed programs were designed according to the expected goals of independent mobility, social function, and motivation discussed by the therapist and caregivers in the GAS. For example, based on the child's current abilities, the caregivers would expect their child to initiate greeting behaviors, explore environments, and to sustain the behaviors for 10 min with positive expressions. The expected goal could be graded as "0" for this child and "+2" referring to changes that exceed expectations, such as sustaining the behaviors for 30 min. During the 30- to 45-min static play, the caregivers also learned how to identify their children's difficulties and apply home techniques. For the 60- to 75-min mobility play, the caregivers and therapist would use verbal encouragement to promote the child's driving and exploration of their surroundings.

During the mobility play session, an adult-directed social training principle (Ragonesi, Chen, Agrawal, & Galloway, 2011) was incorporated. The therapist discussed with the caregivers and graded the social-interactive activities based on participants' social functions. One-on-one instruction was initially conducted to guide the participants in performing the desired social behaviors (e.g., greeting, gestures, or vocalizations). Subsequently, the caregivers and the therapist directed the participant to perform desired social behaviors when he/she met people on the hallway or stores during driving. Explicit and loud encouragement and compliments were provided as positive feedback on the participant's achievements. The last step was to direct the participant towards accomplishing social interaction tasks (e.g., receiving or giving toys to their siblings or other children during driving or collecting stickers from the employees in the stores). Further, several games (e.g., peekaboo, hide and seek) were utilized to provide the participant opportunities for practicing social interactions with family members to enhance the parent–child relationship.

2.4.2. Control group

The parents of children in the control group received a Chinese educational booklet, which contained guidelines to benefit children's mobility, social function, and motivation at home. Activities were graded in each guideline and the similar general principle of social training was applied. The therapist discussed with the research team and caregivers on the initial activity to perform at home after setting up the goals with GAS. The training intensity was suggested as 35-min/day, 7 days/week during the 9-week intervention. The therapist called the caregivers weekly to consult, to answer relevant questions, and to confirm compliance. The therapist also discussed questions with the research team, if necessary. Caregivers were required to use the activity log to record the home training duration and place as well as participants' emotional reactions.

2.4.3. Follow-up

The 9-week follow-up phase followed the intervention; during this time no treatment programs were applied to the participants, except for their regular therapy.

2.5. Measures

The Revised Dimensions of Mastery Questionnaire (DMQ 18) – Chinese version was used to measure both instrumental and expressive aspects of mastery motivation through caregivers' report (MacTurk, Morgan, & Jennings, 1995). The DMQ has 7 scales: cognitive/object persistence, gross motor persistence, social mastery motivation with adults, social mastery motivation with children/peers, mastery pleasure, negative reactions to challenge in mastery situations, and general competence. A Likert-type scale of 1–5 was used to rate similarity, with lower scores indicating lower similarity. The DMQ 18 has four parallel age-related versions for children aged 6 months to 19 years (infant, preschool, school-age rated by adults, and school-age self-report). We utilized the infant version (approximately 6–23 months) and preschool version (approximately 2–6 years) according to the age of the participants. The DMQ 18 shows good validity, internal consistency, and acceptable intra- and inter-rater reliability (Józsa & Morgan, 2015).

The Chinese version of the Affordance in the Home Environment for Motor Development – Toddler version (AHEMD-Toddler-C) was used to measure the motor development opportunities provided by the home environment in children aged 18–42 months. It contains 5 subscales: outside space, inside space, variety of stimulation, fine motor toys, and gross motor toys. The reliability and validity of this version is high (Hsieh et al., 2011).

2.6. Statistical analyses

Data normality was examined using Kolmogorov–Smirnov and Shapiro–Wilk tests (Rosenthal, 1968). Due to the normal distribution of the data, independent t-tests and chi-square tests were used to compare the demographic data between the groups. The effects of the two programs (T1, T2, and T3) were evaluated using repeated measures analysis of variance (group [2] × time [3]) with the outcome measures as the dependent variable. The overall interaction (group × test session) allowed testing of whether the time course differed between groups. In the case of a significant interaction, time and treatment effects were further analyzed using the pairwise post-hoc Bonferroni test at each time point separately. An α level of 0.05 denoted statistical significance during hypothesis testing. All analyses were performed using SPSS 22.0 software (SPSS Inc, Chicago, Illinois).

Table 1
Demographic Data.

	Treatment Group (n = 15)	Control Group (n = 14)	P Value
Mean age-month (SD)	18.53 (7.69)	18.14 (7.33)	.89
Diagnosis, n (%)			
Developmental Delay	11 (74%)	9 (65%)	
Cerebral Palsy	2 (13%)	2 (14%)	
Others	2 (13%)	3 (21%)	
Gender, n (%)			.56
Male	7 (47%)	5 (36%)	
Female	8 (53%)	9 (64%)	
Regular treatment time in minutes per week (SD)	104 (66.95)	121.25 (78.32)	.53
ROC or home training time in minutes per week (SD)	240 (0)	200.33 (123.73)	.07

3. Results

3.1. Participants

Participants' demographic data is shown in Table 1. None of the participants could crawl or walk independently and could only sit with minimal, moderate, or full support. No significant difference was found between the treatment and control groups regarding sex, age, frequency of regular therapy, and additional therapy received weekly (Table 1).

3.2. Ride-on car training, mastery motivation, and home affordances

During the pretest, no significant differences were found between the treatment and control groups regarding the subscales of cognitive/object persistence (P = .14), gross motor persistence (P = .52), social persistence with adults (P = .53), social persistence with children (P = .31), mastery pleasure (P = .86), negative reactions to challenge-frustration/anger (P = .27), and general competence (P = .65). No significant differences were also found on the total and subscale scores of AHEMD-Toddler-C between the two groups at pretest (total: P = .07; subscale: outside space: P = .36, inside space: P = .83, variety of stimulation: P = .42, fine motor toys: P = .06, gross motor toys: P = .06).

Tables 2 and 3 show the means for the treatment and control groups at each time point for the measures of mastery motivation and home affordances. Only the measures of cognitive/object persistence and negative reactions to challenge-frustration/anger showed a significant time by group interaction, whereas the other measures of mastery motivation showed no significant interaction effect for the mastery motivation measured using the DMQ 18.

The post-hoc tests indicated that the participants had significantly more object persistence at posttest than at pretest in the treatment group. No significant difference was observed during the three testing sessions in the control group. In addition, pairwise comparisons indicated that the ride-on car training produced better effects on object persistence than the home education program (P = .02). The negative reactions to challenge-frustration scores improved significantly in the treatment group (Table 2). The pairwise post-hoc test showed significantly more treatment effects on negative reactions to challenge-frustration/anger for the ride-on car training program, compared with the home education program (P = .03).

The main effect of the testing session was observed for both treatments on gross motor persistence and mastery pleasure. A further post-hoc test showed a significant difference on gross motor persistence for the changes between pretest and follow-up test (P = .05) and mastery pleasure for pretest and posttest scores (P = .05). No main effect on testing session or group was found on social persistence with adults, social persistence with children, and general competence.

For home affordances measured using the AHEMD-Toddler-C, a significant time by group interaction was found for the subscale of gross motor toys. The post-hoc tests indicated that the participants had significantly more gross motor toys at the posttest than at the pretest in the treatment group. In the control group, no significant difference was observed among the three testing sessions. In addition, pairwise comparisons indicated that the ride-on car training group had more gross motor toys at home than the home education group (P = .05). A main effect of testing session was observed for both treatments on total scores, outside space, and fine motor toys. A further post-hoc test showed a significant difference on total scores (P < .01) and fine motor toys for the changes between pretest and posttest scores (P < .01), and outside space for the changes between posttest and follow-up test (P = .02). In addition, a main group effect on total scores and outside space was observed, whereas the control group had more home affordances and outside space than the treatment group (P = .03). No main effect of testing session or group was found on inside space and variety of stimulation.

3.3. Correlation between mastery motivation and home affordances

To understand the relationship between mastery motivation and home affordances during intervention, the correlation coefficient was calculated using the 7 scales of DMQ 18 and the total scores of AHEMD-Toddler-C (Table 4). No significant correlation was found between mastery motivation and home affordances in the treatment group. Only negative reactions to challenge-frustration/anger of

Table 2
Comparisons on mastery motivation measured by Revised Dimensions of Mastery Questionnaire.

	Pretest Mean (SD) (95%CI)	Posttest Mean (SD) (95%CI)	Follow-up Mean (SD) (95%CI)	Change Score Pretest to Posttest Mean (SD) (95%CI)	Change Score Posttest to Follow-up Mean (SD) (95%CI)	Group Effect *P* Value (Partial η^2)	Testing Session Effect *P* Value (Partial η^2)	Interaction Effect *P* Value (Partial η^2)
Cognitive/Object Persistence						*P* = .93 (0.00)	*P* < .01 (0.18)	*P* < .01* (0.17)
Treatment (n = 15)	1.67(0.50) (1.39, 1.94)	2.29(0.63) (1.94, 2.64)	2.48(0.59) (2.15, 2.80)	0.62(0.72) (0.22, 1.02)	0.19(0.58) (−0.13, 0.51)			
Control (n = 14)	2.12(1.01) (1.54, 2.70)	2.07(0.96) (1.52, 2.63)	2.17(1.08) (1.55, 2.79)	−0.49(0.67) (−0.44, 0.34)	0.09(0.50) (−0.19, 0.38)			
Gross Motor Persistence						*P* = .97 (0.00)	*P* = .02* (0.14)	*P* = .34 (0.04)
Treatment (n = 15)	2.48(0.59) (1.62, 2.19)	1.91(0.52) (2.02, 2.70)	1.36(0.62) (2.02, 2.60)	0.45(0.71) (0.60, 0.85)	−0.05(0.57) (−0.37, 0.26)			
Control (n = 14)	2.09(0.88) (1.58, 2.60)	2.19(1.07) (1.60, 2.80)	2.33(1.07) (1.72, 2.94)	0.10 (0.64) (−0.27, 0.47)	0.14(0.47) (−0.13, 0.41)			
Social Persistence with Adults						*P* = .88 (0.001)	*P* = .08 (0.09)	*P* = .13 (0.07)
Treatment (n = 15)	2.7(0.91) (1.56, 2.57)	2.42(0.72) (2.02, 2.82)	2.52(0.83) (2.06, 2.98)	−0.28(0.82) (−0.10, 0.81)	0.10(0.68) (−0.28, 0.47)			
Control (n = 14)	2.30(1.05) (1.69, 2.90)	2.18(1.08) (1.55, 2.81)	2.40(0.95) (1.85, 2.94)	−0.12(0.47) (−0.39, 0.15)	0.10(0.63) (−0.27, 0.46)			
Social Persistence with Children						*P* = .86 (0.001)	*P* = .33 (0.04)	*P* = .13 (0.07)
Treatment (n = 15)	1.56(0.75) (1.14, 1.98)	1.90(0.80) (1.46, 2.34)	1.92(0.68) (1.54, 2.30)	0.34(0.80) (−0.10, 0.79)	0.02(0.61) (−1.29, 7.25)			
Control (n = 14)	1.89(0.98) (1.33, 2.50)	1.75(1.04) (1.15, 2.35)	1.90(0.99) (1.33, 2.46)	−0.14(0.73) (−0.57, 0.28)	0.15(0.34) (−1.06, 9.20)			
Mastery Pleasure						*P* = .53 (0.02)	*P* < .01* (0.19)	*P* = .24 (0.05)
Treatment (n = 15)	2..84(0.96) (2.31, 3.37)	3.44(0.75) (3.03, 3.86)	3.41(0.99) (2.87, 3.96)	0.60(0.73) (0.19, 1.01)	−0.02(0.70) (−0.42, 0.36)			
Control (n = 14)	2.76(1.43) (1.93, 3.59)	2.87(1.29) (2.13, 3.62)	3.34(1.36) (2.56, 4.13)	0.11(0.76) (−0.32, 0.55)	0.47(1.00) (−0.11, 1.05)			
Negative Reactions to Challenge-Frustration/Anger						*P* = .84 (0.001)	*P* = .01* (0.16)	*P* = .05* (0.11)
Treatment (n = 15)	2.07(0.89) (1.57, 2.56)	2.65(0.73) (2.25, 3.06)	2.89(0.73) (2.49, 3.30)	0.59(0.96) (0.05, 1.12)	0.24(0.68) (−0.14, 0.62)			
Control (n = 14)	2.49(1.09) (1.86, 3.11)	2.80(1.33) (2.03, 3.57)	2.51(1.02) (1.93, 3.10)	0.31(0.73) (−0.11, 0.74)	−0.29(0.94) (−0.83, 0.26)			
General Competence						*P* = .62 (0.01)	*P* = 16 (0.07)	*P* = .95 (0.002)
Treatment (n = 15)	1.28(0.52) (0.99, 1.57)	1.41(0.57) (1.10, 1.73)	1.43(0.61) (1.09, 1.77)	0.13(0.34) (−0.06, 0.32)	0.01(0.26) (−0.13, 0.16)			
Control (n = 14)	1.39(0.71) (0.98, 1.80)	1.50(0.78) (1.05, 1.95)	1.57(0.79) (1.11, 2.03)	0.11(0.70) (−0.12, 0.27)	0.19(0.70) (−0.22, 0.59)			

* Difference is significant (P < .05).

the control group showed significant negative correlation with home affordances (P = .01). Other scales of mastery motivation also did not show significant correlations with home affordances in the control group.

4. Discussion

To the best of our knowledge, this is the first two-group study to investigate the effectiveness of environmental modifications by using modified ride-on cars and a structured, social interaction program on mastery motivation and home affordances in young children with motor disabilities. Although normal development may play a key role for the participants, the outcomes of motivation indicate that the treatment group generally had more positive changes during intervention than at the follow-up phase. Specifically, the results demonstrate that the use of this combined approach is beneficial for increasing object persistence and producing better outcomes than the home education program. The results of mastery pleasure also show significant improvements in young children with motor disabilities during the 9-week intervention, but not during the follow-up phase, which may support the treatment effects of both programs. However, no effects on social persistence with adults or children and general competence were observed for both treatments. The findings are consistent with the behavioral observations of previous ride-on car studies, indicating that ride-on cars may improve children's motivation to reach and interact with the objects and experience pleasure during play (Huang et al., 2014; Huang, Chen et al., 2017; Logan et al., 2014).

Table 3
Comparisons on home affordances measured by the Chinese version of the Affordance in the Home Environment for Motor Development – Toddler version.

	Pretest Mean (SD) (95%CI)	Posttest Mean (SD) (95%CI)	Follow-up Mean (SD) (95%CI)	Change Score Pretest to Posttest Mean (SD) (95%CI)	Change Score Posttest to Follow-up Mean (SD) (95%CI)	Group Effect *P* Value (Partial η^2)	Testing Session Effect *P* Value (Partial η^2)	Interaction Effect *P* Value (Partial η^2)
Total AHEMD						$P = .02^*$ (0.18)	$P < .01^*$ (0.21)	$P = .58$ (0.02)
Treatment (n = 15)	9.40(2.59) (8.52, 10.28)	9.93(1.34) (9.19, 10.67)	10.87(2.33) (9.58, 12.15)	0.53(1.58) (−0.27, 1.34)	0.93(1.58) (0.06, 1.81)			
Control (n = 14)	11.00(2.66) (9.46, 12.54)	12.14(2.45) (10.73, 13.55)	12.36(3.00) (10.62, 14.09)	1.14(1.23) (0.43, 1.85)	4.07(8.89) (−1.06, 9.20)			
Outside Space						$P = .05^*$ (0.14)	$P < .01^*$ (0.20)	$P = .19$ (0.06)
Treatment (n = 15)	0.80(1.70) (−0.14, 1.74)	0.67(1.40) (−0.11, 1.44)	1.43(2.03) (0.41, 2.66)	−0.13(1.30) (−0.85, 0.59)	0.76(6.72) (−3.11, 4.33)			
Control (n = 14)	1.50(2.31) (0.16, 2.84)	2.50(2.57) (1.02, 3.98)	3.29(2.67) (1.74, 4.83)	1.00 (2.11) (−0.22, 2.22)	0.79(1.25) (0.06, 1.51)			
Inside Space						$P = .81$ (0.002)	$P = .16$ (0.07)	$P = .77$ (0.009)
Treatment (n = 15)	12.50(2.45) (11.14, 13.86)	12.57(2.54) (11.17, 13.98)	13.15(2.29) (11.88, 14.41)	0.07(1.71) (−0.87, 1.02)	0.65(1.71) (−0.30, 1.59)			
Control (n = 14)	12.68(1.86) (11.61, 13.75)	12.96(2.08) (11.76, 14.17)	13.13(1.87) (12.05, 14.21)	0.29(1.03) (−0.31, 0.88)	0.45(1.60) (−0.47, 1.37)			
Variety of Stimulation						$P = .44$ (0.02)	$P = .25$ (0.05)	$P = .37$ (0.04)
Treatment (n = 15)	11.95(1.37) (11.19, 12.71)	12.12(1.26) (11.42, 12.81)	12.77(1.70) (11.83, 13.71)	0.17(1.51) (−0.67, 1.01)	0.65(1.67) (−0.28, 1.58)			
Control (n = 14)	15.40(10.48) (9.35, 21.45)	19.85(12.08) (12.87, 26.83)	23.92(14.22) (15.71, 32.13)	4.45(7.52) (0.10, 8.80)	4.07(8.89) (−1.06, 9.20)			
Fine Motor Toys						$P = .02^*$ (0.18)	$P < .01^*$ (0.27)	$P = .42$ (0.03)
Treatment (n = 15)	19.8(11.50) (13.43, 26.17)	26.27(9.21) (21.17, 31.37)	28.87(11.01) (22.77, 34.96)	6.47(7.61) (2.26, 10.68)	9.07(12.55) (2.12, 16.02)			
Control (n = 14)	31.79(14.74) (23.28, 40.30)	37.00(12.73) (29.65, 44.35)	36.57(15.27) (27.76, 45.39)	5.21(8.32) (0.41, 10.02)	−0.43(7.01) (−4.48, 3.62)			
Gross Motor Toys						$P = .11$ (0.09)	$P < .05^*$ (0.11)	$P = .05^*$ (0.10)
Treatment (n = 15)	11.00(4.28) (8.63, 13.37)	14.27(5.91) (10.99, 17.54)	14.33(6.37) (10.81, 17.86)	3.27(4.18) (0.95, 5.58)	0.07(3.65) (−1.96, 2.09)			
Control (n = 14)	16.07(5.33) (13.00, 19.15)	16.50(4.80) (13.73, 19.27)	15.71(4.45) (13.15, 18.28)	0.43(3.76) (0.31, 3.48)	−0.79(4.19) (−3.21, 1.63)			

* Difference is significant (P < .05).

Table 4
Pearson correlation coefficient between home affordances and mastery motivation regarding the change of pretest to posttest.

Total score of AHEMD- Toddler-C	Subscales of DMQ 18						
	Cognitive/Object Persistence	Gross Motor Persistence	Social Persistence with Adults	Social Persistence with Children	Mastery Pleasure	Negative Reactions to Challenge-Frustration/Anger	General Competence
Treatment (n = 15)	0.44	0.11	−0.04	0.31	0.05	0.06	0.19
Control (n = 14)	0.04	−0.21	−0.04	0.08	−0.09	−0.67*	0.02

* Difference is significant (P < .05).

Intervention strategies focusing on children's capabilities and psychological function and caregivers' perceptions and involvement are suggested to enhance children's motivation in mastering suitable tasks of moderate difficulty (Huang, Sun, Lin, & Chen, 2017; Majnemer, Shevell, Law, Poulin, & Rosenbaum, 2010). Using PMDs may provide efficient independent mobility and physical environmental modifications, which benefits exploration and increase motivation (Huang, 2018). One study investigated the effects of using an alternative power wheelchair trainer on mastery motivation in 3 young children with multiple, severe physical impairments (Kenyon, Farris, Gallagher et al., 2017). They found that the use of early PMD may improve the DMQ scores for both instrumental and expressive aspects of mastery motivation. Appropriate physical modifications may afford the child moderate task difficulty and allow

them to achieve the goal with higher motivation (i.e., persistence and pleasure) (Majnemer et al., 2010). Huang, Chen et al. (2017) proposed that a customizable toy car, which is modified to fit a child's current sitting and reaching capability, may be helpful to promote his/her attempts to reach the toys or interact with the adults. Therefore, compared to the control group, which lacked physical environmental modifications, the treatment group may have higher persistence and pleasure to interact with the toys.

Waldman-Levi and Erez (2015) also emphasized the role of social environmental modification on mastery motivation resulting in positive effects (e.g., an encouraging and supportive environment). The treatment principles of combining suitable physical and social environmental modifications proposed by the previous study (Huang, 2018), may provide possible explanations for the improvements on object persistence and mastery pleasure in children with disabilities. Our strategy of using attractive toy cars with an adult-directed, social training program may provide an encouraging, supportive environment during intervention and facilitate parent-child relationships, which are the two main factors relating to mastery motivation in young children with disabilities (Hauser-Cram, 1996; Waldman-Levi & Erez, 2015). Of note is that the similar general principle of social interaction was applied on the control group, which also shows positive effects on mastery pleasure and supports the benefits of social environmental modifications. Moreover, the control group had more positive changes on mastery pleasure during follow-up phase than did the intervention group. A probable reason may be the learned strategies in the home environments from educational booklets. The control group may continue the practice as social environmental modification while the treatment group did not have both environmental modifications during the follow-up phase. Future studies should include a control group in the same context with no additional therapy provided during follow-up phase.

Notably, the results did not show decreased negative reactions to failures during the intervention, which differs from the findings of a single subject study using a power wheelchair trainer (Kenyon, Farris, Aldrich et al., 2017). Our ride-on car training group had significantly more negative reactions from pretest to follow-up phase than the home education group. The trend of more increased pleasures and negative reactions to failures observed during the intervention phase as compared with in the follow-up phase partially explains the effects of combining physical and social environmental modifications on the expressive aspects of mastery motivation. Independent mobility plays a key role in psychological development (Anderson et al., 2013). With increased independent mobility, young children with disabilities can move freely and show more facial expressions when interacting with people (Huang, 2018; Huang, Chen et al., 2017; Livingstone & Field, 2014). In the previous study, this ride-on car training with structured social training program was shown to increase the attainment of children's social experience, enrich their emotional life, and allow them to learn reactions to events or other people, including both negative and positive ones (Huang et al., 2018).

In addition, decreased social persistence with adults for motivation was observed in both treatment groups during the intervention phase, but it was not significant. Considering the goal settings of motivation and social function and the implementation of adult-directed, social training program, this finding was unexpected even though significant goal achievements were observed after the intervention in a past study (Huang et al., 2018). Wang et al. (2013) showed that young children with motor delay were rated lower by their mothers on all the persistence scales of the DMQ than the typical development group, but had similar levels of persistence measured using observational tasks. Perceptions are influenced by mothers' interpretation of motivation and the implied task difficulty of testing items in the DMQ. Mother's perception of motivation in toddlers with motor delay is based on the toddlers' competence levels (Wang et al., 2013, 2014). Hence, although the caregiver's involvement in the treatment program helps to achieve desired goals and decrease the parenting stress level (Huang et al., 2018), the perceived motivation measured using the DMQ may still reflect the Taiwanese caregiver's perception of having a child with a disability as having less persistence of mastery motivation, particularly socially (Wang et al., 2014).

Both ride-on car training and home education programs have increased home affordances and fine motor toys during the intervention phase. The home education program had more home affordances than did the treatment group, and they had significantly more negative reactions to failures with less home affordances provided during the intervention. Two factors related to the characteristics of the AHEMD-Toddler-C may have an influence on the current findings, including the timing of providing the assessment and the interpretation of affordances. First, Miquelote et al. (2012) suggested that six months may be the appropriate duration for administering AHEMD to detect changes since families will not intensely alter their living environment in a few months. The result that the control group had more home affordances than the treatment group in the beginning of the study and tended to maintain the similar pattern throughout the study partially supports this explanation. Second, Cacola, Gabbard, Santos, and Batistela, (2011) found that the questionnaire could not measure the affordances that young children actually perceived. For example, we could only acquire the information from the AHEMD regarding the number of toys placed at home instead of obtaining the information on the number of toys children truly play with at home.

This study had several limitations. First, the sample size limited the generalizability of the results to all young children with motor disabilities. There is no prior power calculation supporting the number of recruited participants; therefore, type II errors are likely to occur due to the small sample size. Second, we used a non-randomized recruitment method and did not consider the influence of diverse severity levels of motor and cognitive impairments, which may have affected mastery motivation (Hauser-Cram, 1996; Majnemer et al., 2010). Mastery motivation can be influenced by many factors, e.g., severity level of impairments, maternal interactive behavior, or socioeconomic status, which we had no information on and was not fully controlled in this study (Carlton & Winsler, 1998; Wang et al., 2014). These factors may account for the improvements of outcome observed after the ride-on car training. In addition, we failed to control the follow-up phase for the control group. A larger sample with diverse developmental, environmental, and socioeconomic levels using a randomized recruitment method without additional therapy provided in the follow-up phase should be conducted. Based on the current results of object persistence, social persistence, and mastery pleasure with a power of 0.8 and effect size ranging from 0.63 to 1.59, the estimated sample size for a matched group design would be 16 to 46 young children with disabilities, meaning at least 8 to 23 children in each group for detecting differences with sufficient statistical power.

Detailed information regarding participants' motor abilities or postural control can assist clinicians in determining candidates for the program in the future. Finally, a longer intervention and follow-up duration is also required to track mastery motivation changes.

5. Conclusions

This study provides evidence of using ride-on cars with an adult-directed, social training program for improving object persistence and mastery pleasure in young children with motor disabilities. The ride-on car training and home education programs may both be beneficial for increasing home affordances during the intervention. Clinicians may consider environmental modifications by using the combined program as an approach to increase mastery motivation. They can also educate parents about the importance of early power mobility training, how to observe and support children's performances during the intervention, and to provide moderately challenging environmental modifications. The novel use of modified ride-on toy cars with structured, social training program seems to be an effective and feasible treatment approach for clinical therapists and families to improve mastery motivation.

Conflict of interest

The authors declare no conflict of interest.

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