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The degree of stability in motor performance in preschool children and its association with child-related variables

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ABSTRACT

Understanding the stability of individual differences in motor performance during the early years of life, despite normative age-related growth in motor performance, has important implications for identification of motor coordination difficulties and subsequently, early remediation. Therefore, the aims of the present study were to examine the degree of rank-order and individual-level stability in motor performance in young children with different levels of motor skill proficiency. Subsequently, we explored the influence of child variables (i.e., age, gender, and behavioural self-regulation) on different aspects of stability. In this longitudinal study, a community sample of 68 participants (49% girls) with a mean age of 3 years and 11 months (SD = 7 months) were assesses in three six-monthly waves. The total standard score of the Movement Assessment Battery for Children-2 (MABC-2) was used as the measure of motor performance. Rank-order stability was examined with zero-order Pearson correlations. Individual-level stability was examined by means of stability in classifications (at risk for motor coordination difficulties versus typically developing). In addition to examining stability in group classification, the Reliable Change Index (RCI) was calculated to examine if the difference in a child's scores over time exceeded (increased or decreased relative to) the expected change. The results showed moderate to high rank-order stability between time points. No significant differences in degree of rank-order stability were found between boys and girls and between 3-year old and 4-year old children. In terms of stability of classification, it was shown that for ~50% of the children with motor coordination difficulties and ~ 90% of typically developing the classification based on the cut-off score on the MABC-2 was stable. Based on the RCI, over 90% showed individual-level stability. The level of behavioural self-regulation at T1 (as measured with the Head-Toes-Knees-Shoulders task) was not significantly related to individual-level stability in motor performance. In conclusion, our findings highlight the importance of a careful choice of stability measures and a reflection on the implications of their results. More research is needed to understand which child and environmental variables impact on stability.

1. Introduction

The preschool years have been identified as a period of remarkable growth and learning in the motor repertoire of children (Piek,

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Hands, & Licari, 2012). Both individual (e.g., weight status) and environmental factors (e.g., home equipment) play a role in shaping motor development (Barnett et al., 2016; Venetsanou & Kambas, 2010). It is therefore not surprising that children vary considerably in terms of their motor performance already at this young age (Kakebeeke et al., 2018; Michel, Molitor, & Schneider, 2018). While motor skills like throwing a ball, drawing, and getting dressed seem to come naturally to most children, there are some children with significant motor coordination difficulties. These difficulties could be an indication of Developmental Coordination Disorder (DCD; American Psychiatric Association, 2013 [APA]). DCD is a neurodevelopmental disorder characterized by motor coordination difficulties resulting in impairment in activities of daily living, either at home or at school, in the absence of a detectable neurological condition (APA, 2013). The cascading effects of early motor coordination difficulties have been well documented: children with motor coordination difficulties, including DCD, show difficulties in social interaction, lower self-worth and perceived competence, internalizing behavioural problems, executive dysfunction, and reduced educational attainment (Hill et al., 2016; Leonard & Hill, 2014; Piek, Barrett, Smith, Rigoli, & Gasson, 2010; Piek, Dawson, Smith, & Gasson, 2008; Poole et al., 2018). Additionally, the negative effects arising from motor coordination difficulties may extend far beyond childhood; but, important to note, not in all cases (Cantell, Smyth, & Ahonen, 2003; Harrowell, Hollén, Lingam, & Emond, 2018; Kirby, Edwards, & Sugden, 2011; Losse et al., 1991). Thus, it is vital to understand why in some young children motor coordination difficulties persist whereas in a vast majority of young children these problems tend to decrease. Our study aims to add to this, by exploring stability of motor performance on both a group and individual level. Fundamental issues we address regarding the concept of stability are its valid measurement and potential correlates of the level of stability. Such insights are likely to improve our efforts to identify children who are at elevated risk of persistent motor coordination difficulties and subsequent cascading effects. As this has important implications for early diagnosis of DCD risk and subsequently, early remediation these insights are of interest to parents, practitioners, and researchers.

1.1. Stability and change in motor performance

Where individual differences give information about the distribution of motor performance in children, stability provides information about the overall developmental course of the skill (Bornstein, Hahn, & Putnick, 2016). When examining stability, it is important to note that the question of stability is intricately tied to how stability is measured. Two different forms of stability with regard to motor performance are distinguished in the current study: rank-order stability and individual-level stability.

1.1.1. Rank-order stability

Rank-order stability refers to the degree to which the relative differences in motor performance among children remain the same over time. Rank-order stability is high if children in a group maintain their position on a characteristic (i.e., motor performance level) relative to each other over time, even if the group as whole increases or decreases on that characteristic. It is typically indexed by a single correlation coefficient between scores on the same characteristic measured across two time points for a given group (Bornstein, Putnick, & Esposito, 2017).

In typically developing preschool children, strong correlation coefficients (.53–.67) have been found with regard to motor performance from three to five years of age (Wang, Lekhal, Aaro, Holte, & Schjolberg, 2014). Comparable correlation coefficients were reported in 3- to 6-year old typically developing children (.50–.54; Zysset, 2018) and in 5- to 6-year old typically developing children (.58; Roebers et al., 2014) over a period of one year. Ahnert and Schneider (2007) examined rank-order stability separately for 4- to 6-year old boys and girls over periods of one year and two years and found that rank-order stabilities in boys were higher than for girls in this age period (.58–.69 versus .31–.47). Another study in 4- to 6-year old children compared one-year rank-order stability for typically developing children and children with motor coordination difficulties (<10th percentile on the Movement Assessment Battery for Children −2 [MABC-2]; Henderson, Sugden, & Barnett, 2007) (Michel et al., 2018). This study suggested that rank-order stability is approximately the same in children with motor coordination difficulties and typically developing children (.46 versus .48).

In sum, only a handful of studies have examined rank-order stability of motor performance in preschool children. Overall, the results suggest moderate to high rank-order stability meaning that individual differences with regard to motor performance are fairly stable in young children. A potential limitation of these studies concerns their focus on one- and two-year intervals, which prevents a more fine-grained analysis of rank-order changes across shorter time spans. This may be a particular limitation during early childhood, when changes are expected to be relatively pronounced and rapid (Piek et al., 2012).

1.1.2. Individual-level stability

Although association studies are informative on our understanding of the rank-order stability of motor performance at the population level, they provide limited information at the level of the individual child. In contrast, *individual-level stability* refers to the extent to which an individual displays similar levels of behaviour over time (Verhoeven, Junger, Van Aken, Dekovic, & Van Aken, 2007). Thus, individual-level stability indicates for each individual child whether he or she changed in his or her level of motor performance in comparison to a same aged reference group. To be more specific, in this study we define changes in level of motor performance as the degree to which individual children change position along the normative distribution. Identification of preschool children who are most likely to have persisting problems would be most useful for prevention and intervention. Therefore, stability has also been studied categorically using symptom cut-points or diagnostic classifications. For example, Michel et al. (2018) found that 100% of the 4- to 6-year old children who scored above the 10th percentile on the MABC-2 at baseline also scored above the 10th percentile one-year later, while 48% of the children who scored below the 10th percentile on the MABC-2 at baseline also scored below the 10th percentile one-year later. Similarly, in a clinically referred sample of 4- to 6-year old children with, or at risk of, Autism Spectrum Disorders (ASD), Attention-Deficit–Hyperactivity disorder (ADHD), and/or DCD it was found that 55% of the children still scored at or below the 15th percentile on the Movement Assessment Battery for Children (MABC; Henderson & Sugden, 1992) two to three years later (Van Waelvelde, Oostra, DeWitte, Van Den Broeck, & Jongmans, 2010). Interestingly, individual-level stability of the motor coordination difficulties seemed to vary with the type of developmental problems (87% for children with or at risk of ASD, 50% for children with or at risk for ADHD, and 33% for children with no ASD or ADHD diagnosis). Moreover, in a group of 5- to 6-year old children with borderline or definite motor coordination difficulties based on their score on the MABC, it was found that 79% of children with definite motor coordination difficulties remained in the same category at 2-year follow-up, whereas for children with borderline motor coordination difficulties this percentage was much lower, i.e., 39% (Pless, Carlsson, Sundelin, & Persson, 2002).

Overall, these findings show that individual-level stability of motor performance varies from weak to strong, depending on characteristics of the study sample. Interestingly, all these studies but one (Michel et al., 2018) did only include children with motor coordination difficulties. It is possible that the stability of motor performance in children with motor coordination difficulties is different from that in typically developing children because factors that affect motor performance also may impact on its stability. Therefore, it would be relevant to examine individual-level stability in children on a continuum of motor skill proficiency and examine the role of potential factors related to stability.

An additional approach to individual-level stability would be to identify whether a given child shows a level of change above chance fluctuations. The reliable change index (RCI) is a sophisticated method for characterizing the type and magnitude of change for each individual (Jacobson & Truax, 1991). It provides information regarding the likelihood that a change in test scores "results from 'true' or reliable change or results from chance" based on the measurement's test-retest reliability. Additionally, the RCI enables detection of change or stability anywhere on the scoring distribution. As such, on the one hand the use of the RCI might prevent overestimation of instability, which might occur within a categorial approach when labelling small, unreliable changes as significant. On the other hand, by also accounting for change on the high end of the motor performance continuum, the RCI method may detect a higher degree of change as compared to using a diagnostic cut-point. To our knowledge, this statistic has not previously been used in the literature regarding individual-level stability of motor performance.

1.2. Child variables related to degree of stability in motor performance

To better understand the degree of stability of motor performance in young children, it is necessary to examine variables that impact on it. Knowledge regarding the variables that predict not only the presence but also the stability of motor coordination difficulties is of utmost importance for clinical practice. Several variables are known to impact motor performance (Barnett et al., 2016; Venetsanou & Kambas, 2010) and it is possible that the mechanisms that produce mean-level differences in motor performance also influence stability (Bornstein, Hahn, Putnick, & Pearson, 2019). In the present study, we focus on personal variables for the following reasons. First, demographic variables such as age and gender may provide a first indication of those groups in the general population that have different dispositions of relatively more or less stable children. Relating age to stability of motor performance provides crucial information for early screening purposes, i.e., to know at what age motor coordination difficulties can reliably be detected. The literature thus far has not provided a precise picture of how motor performance varies with preschool age because studies either did not collect data on the youngest age groups within the preschool period or combined age groups together, and the inconsistent results make it difficult to draw any definite conclusions. In addition, motor development is acknowledged to differ in typically developing boys and girls (Kokštejn, Musálek, & Tufano, 2017; Matarma, Lagström, Eliisa Löyttyniemi, & Koski, 2020). Compared to boys of the same age, 3- and 4-year-old girls have shown better total motor, fine motor, and balance scores (Kokštejn et al., 2017). However, it has also been noted that differences are of small magnitude and with great heterogeneity in young children (Peyre et al. 2019). Although mean-differences between boys and girls do not necessarily imply gender differences in stability, evidence from previous studies points towards a somewhat different ontogenetic and phylogenetic course of motor development between boys and girls (Hands, Parker, Larkin, Cantell, & Rose, 2016). One overview study dating back to 1984 (Branta, Haubenstricker, & Seefeldt, 1984) suggested lower rank-order stabilities in girls than in boys from 5 to 6 years of age. Similarly, Ahnert and Schneider (2007) reported lower rank-order stabilities of motor performance in girls than in boys from 4 to 5 years of age and from 5 to 6 years of age. To date, we can only speculate about the mechanisms driving a moderating role of gender on motor stability. One tentative line of thought pertains to the enculturated nature of motor development (Adolph & Hoch, 2019), stressing the interrelatedness of a child's motor development and the environment or context where this occurs. Research on sex differences in DCD has suggested both lower prevalence and better developed coping mechanisms and resilience in girls which may disguise some of the difficulties that might be more obvious in boys (Blank et al., 2019; McCarthy, 2015). Also, stereotypical expectations of motor performance have been suggested to influence parent ratings of their child's motor skills (e.g., Cantell, Houwen, & Schoemaker, 2019). This might result in boys eliciting a more consistent response by the environment in terms of remediation and treatment efforts. If caregivers or childcare professionals respond divergently to motor coordination difficulties based on gender, this is likely reflected in a varied level of stability of motor performance.

In addition to demographic variables, cognitive variables are potential predictors of motor performance (Jokić & Whitebread, 2011; McClelland, Geldhof, Cameron, & Wanless, 2015). One specifically relevant cognitive variable in this regard is behavioural self-regulation.[1] While growing evidence links motor skills to self-regulation (Aadland et al., 2017; Becker, McLelland, Loprinzi, & Trost, 2014; Carson et al., 2016), self-regulation is also considered necessary for successful motor performance. When a task requires a child to concentrate on a specific movement, or a movement feature, the child needs to engage cognitive control processes to perform the

[1] Behavioural self-regulation is defined as "deliberately applying multiple component processes of attentional or cognitive flexibility, working memory, and inhibitory control to overt, socially contextualized behaviours" (McClelland et al., 2014).

task successfully (Stuhr, Hughes, & Stöckel, 2018). More specifically, self-regulation processes facilitate the flexible allocation of cognitive resources, such as the use of goal-directed self-talk during motor performance, and allows a child to stay focused and complete tasks (Brick, Campbell, & Moran, 2020).

Empirical research examining the role of self-regulation in the motor coordination difficulties of children with DCD also points to a link between both domains. For example, it has been indicated that children with DCD possess less detailed and interconnected knowledge about motor tasks than their age peers. They tend to focus on irrelevant information when identifying and addressing performance problems, select inappropriate performance strategies, and are less likely to spontaneously plan, monitor and evaluate their performance compared to children without DCD (Jokić & Whitebread, 2016; Martini & Shore, 2008). In addition, Martini, Wall, and Shore (2004) found that children with and without DCD showed similar amounts of metacognitive verbalizations during practice of a novel motor task, but that children with DCD showed significantly more frequent verbalizations of inappropriate, inaccurate or irrelevant statements related to planning and evaluation of motor activities.

With regard to behavioural self-regulation being a predictor of the stability of motor performance, it is also interesting to note that initial level of executive function at age 4 has been associated to the rate of growth over a 2-year interval (Hughes, Ensor, Wilson, & Graham, 2009). More specifically, the better children performed on executive function at age 4, the less they gained in EF skills over the transition to school. Speculatively, it could be that these differences in relative growth also involve diverging amounts of stability in behavioural self-regulation. As behavioural self-regulation and motor performance are related, it might then be expected that differences in stability of motor performance reflect related variations in the level of stability in behavioural self-regulation, as indexed by its initial level (Bornstein, Hahn, & Haynes, 2004).

1.3. Current study

Against this background, the aim of the present study was to examine the degree of rank-order and individual-level stability in motor performance in young children with different levels of motor skill proficiency, including typically developing children and children at risk for motor coordination difficulties.[2] Subsequently, we explored the influence of child variables (i.e., age, gender, and behavioural self-regulation) on different aspects of stability. Based on the small literature regarding the stability of motor performance in preschool children, we expected moderate-to-strong rank-order stability. Given the limited and mixed research literature with regard to individual-level stability and the influence of child variables, no specific hypotheses were formed and the focus of the present study is mainly exploratory.

2. Method

2.1. Participants

Our study was part of a longitudinal research project with an accelerated design where we followed a community sample of Dutch-speaking children with regard to their motor skills, executive functions, and language abilities, spanning from three-year-olds to entry into first grade; at enrolment, participants were between the ages of 36 and 71 months (see also Houwen, Kamphorst, van der Veer, & Cantell, 2019). Assessments were spaced at 6-months intervals until the child completed three waves of assessment or until the child's sixth birthday. Children who were recruited between 36 and 59 months of age were invited back at two subsequent time points, children who were recruited between 60 and 65 months of age were invited back at one subsequent time point, while children who were recruited between 66 and 71 months of age were not invited back for subsequent testing. A parent-reported socio-demographic questionnaire was used to ascertain the absence of physical disabilities, neurological disorders (e.g., intellectual disability or autism spectrum disorder), and sensory impairments. Participants were recruited from day care centres, playgroups, preschools, and primary schools as well as via social media, public advertisements and snowball sampling.

The sample of the present study consisted of 68 children (49% girls) who took part in all three waves of data collection, with a mean age of 3 years and 11 months (SD = 7 months; range: 36–59 months) at the first wave. There were no children with a formal diagnosis of DCD, but 14% scored at or below the 16th percentile and 4% at or below the 5th percentile on the Dutch version of the MABC-2 (Henderson, Sugden, Barnett, & Smits-Engelsman, 2010) at the first wave, putting them at risk for motor coordination difficulties. There were no children with a parent-reported formal diagnosis of ADHD, but 9% scored in the clinical range on the Attention Problems syndrome scale of the Child Behaviour Checklist /1.5–5 (Achenbach & Rescorla, 2000).

2.2. Instruments

2.2.1. Motor performance

Motor performance was assessed with age band 1 from the MABC-2 (Henderson et al., 2010). This test consists of three sections: Manual Dexterity (three items), Aiming and Catching (two items), and Balance (three items). Raw item scores can be converted into age-corrected item standard scores and summed into a total test score. The total test score can then be converted to a standard score

[2] Since a diagnosis of DCD is not recommended before the age of 5 (Blank et al., 2019), we identified children who were at risk for motor coordination difficulties. A moderately less stringent criterion of impaired performance at or below the 16th percentile for impairment was used rather than the 5th percentile.

equivalent (range 1–19, mean score = 10, SD = 3) and percentile equivalent. In accordance with the MABC-2 guidelines, children falling at or below the 16th percentile were classified as being at risk for motor coordination difficulties; children above the 16th percentile were considered typically developing. The psychometric properties of the MABC-2 suggest that it is a valid and reliable measure to be used in young children (Ellinoudis, Kourtessis, Kiparissis, Kampas, & Mavromatis, 2011; Smits-Engelsman, Niemeijer, & Van Waelvelde, 2011).

2.2.2. Behavioural self-regulation

The Head-Toes-Knees-Shoulders (HTKS; Ponitz, McClelland, Matthews, & Morrison, 2009) was used to assess children's behavioural self-regulation and requires inhibitory control, working memory, and cognitive flexibility. First, the child was asked to do the opposite of what the tester was doing (e.g., touch head when experimenter touches the toes). There were four practice trials and 10 test trials. Second, children were asked to touch their shoulders when the tester touched his/her knees, and vice versa. After four practice trials, the tester gave 10 trials of head, toes, knees, and shoulders commands. Children received 2 points for a correct response, 1 point for a self-corrected response, and 0 points for an incorrect response. A self-corrected response was defined as any motion to the incorrect response, but self-correcting and ending with the correct action (McClelland et al., 2014). The two sets of test trials were summed to give a total score (0–40) where higher scores indicate higher levels of behavioural self-regulation. The construct validity of the HTKS task has been supported by moderate-to-strong correlations with other EF tasks (McClelland et al., 2014) and moderate correlations with ratings of EF (Ponitz et al., 2009). Internal consistency is high with an alpha coefficient of 0.93 (Lonigan, Allan, Goodrich, Farrington, & Phillips, 2017). McClelland et al. (2014) showed high inter-rater reliability (92.3%) and acceptable test-retest reliability over a period of 3–7 months ($r = 0.60$ in pre-kindergartners and $r = 0.74$ in kindergartners).

2.3. Procedure

The study was approved by the Ethics Committee of the Department of Pedagogical and Educational Sciences, Faculty of Behavioural and Social Sciences, University of Groningen, The Netherlands. Parents/caregivers gave written informed consent.

Children were tested three times (T1, T2, and T3) with approximately six months between measurement occasions. This time span was expected to be long enough to exclude the measurement of training effects and short enough to measure the same constructs over time using the same tasks. The children were assessed in two home sessions as part of a larger study, each lasting up to 90–120 min. While the parents filled out questionnaires, children completed a battery of tasks measuring motor skills, EF, language, and general cognitive ability. Children were allowed rest breaks and received stickers for completing each task. After the home visits were completed, children were given a small gift and a diploma, and parents received a short report of the results by mail. The assessments were videotaped to allow later review of the data, fidelity in following testing procedures, and coding of participant behaviours during the sessions. To ensure confidentiality, data were entered and stored using a personalized study identifier.

2.4. Data analysis

The analyses were conducted using IBM SPSS Statistics 24, unless stated otherwise. First, preliminary analyses were conducted to evaluate the distribution of variables.

On a group-level, rank-order stability was examined with zero-order Pearson correlations. We used the total standard scores of the MABC-2 as the measure of motor performance. Standardized scores were used for examining stability, as these explicitly describe a child's performance on a particular skill relative to peers of the same age. Stability in motor performance, in this sense, would mean that standard scores change little over the years, such that children with low motor scores continue to score at the bottom end of the distribution of motor scores. If the rate of improvement is the same at the higher and lower ends of the distribution, standard scores will remain unchanged and motor performance is considered 'stable', even if there has been progress in real terms. In describing the degree of stability, we used Cohen's (1988) established criteria for weak ($r = .10$). moderate ($r = .30$), and strong ($r = .50$) effect sizes. Using Fisher's r-to-z tests (http://vassarstats.net/rdiff.html), it was investigated whether the group-level stability coefficients differed significantly for boys versus girls and for 3-year old children versus 4-year old children.

Subsequently, individual-level stability of a child's relative normative standing, based on categorical measures was examined. First, we classified each child at each time point according to the cut-off score of the MABC-2, into 'at risk for motor coordination difficulties' ($\leq$ 16th percentile) or 'typically developing' (>16th percentile). To investigate the stability of this classification, we made cross-tables of the presence or absence of motor coordination difficulties between all combinations of two time points, i.e., between T1 and T2, T2 and T3, and T1 and T3 (i.e., proportions of children in the following groups: "persistent presence of motor coordination difficulties:", "from presence of motor coordination difficulties to absence", "from absence of motor coordination difficulties to presence", and "persistent absence of motor coordination difficulties"). Chi-square analyses for independence were then used to examine stability in classifications between all combinations of two time points. Because the data showed sparseness of information (i.e., more than 20% of expected cell counts ≤ 5) on all time point combinations we used Fisher's exact test. Effect sizes were calculated in terms of Cramer's V, and considered weak (0.10), moderate (0.30) and strong (0.50).

Table 1
Means, SDs, and range of scores for the study variables for the total sample and separately for 3- and 4-year old children and boys and girls.

	Total (n = 68)			3-year olds (*n* = 37)			4-year olds (*n* = 31)			Boys (*n* = 35)			Girls (*n* = 33)		
MABC-2	M	SD	Range	M	SD	Range	M	SD	Range	M	SD	Range	M	SD	Range
Total Score (T1)[a]	10.1	3.0	5–19	10.9	3.3	5–19	9.1	2.4	5–14	9.5	2.7	5–18	10.7	3.3	5–19
Total Score (T2)[a]	10.1	2.8	3–17	10.7	3.0	5–17	9.3	2.6	3–13	9.3	2.5	3–15	10.9	2.8	5–17
Total Score (T3)[a]	9.6	2.9	3–17	9.8	2.7	5–17	9.4	3.2	3–16	9.1	3.2	3–16	10.1	2.4	5–17
	Total (*n* = 51)			3-year olds (*n* = 24)			4-year olds (*n* = 27)			Boys (n = 24)			Girls (n = 27)		
HTKS	M	SD	Range	M	SD	Range	M	SD	Range	M	SD	Range	M	SD	Range
Total Score (T1)[b]	27.3	8.3	7-39	23.0	9.8	7–39	31.0	4.2	23–29	26.9	8.1	7–38	27.6	8.7	9–39

Note. MABC-2 = Movement Assessment Battery for Children −2; HTKS = Head Toes Knees Shoulders.
[a] age-standardized scores.
[b] raw scores.

In addition to examining stability in classifications, the RCI was calculated using the approach by Chelune, Naugle, Luders, Sedlak, and Awad (1993) to examine if the difference in a child's scores over time exceeded (increased or decreased relative to) the expected change. This approach takes the impact of practice effects and measurement error into consideration. The alternative standard error of the differences proposed by Iverson (2001) was used. Scores that exceeded a 95% confidence interval were assumed to represent true change on the MABC-2 and, based on these scores, all children were divided into two groups ('reliable change' and 'no reliable change/ stable'). Using this metric, we compared the degree and nature of reliable change between boys and girls and 3- and 4-year olds with a Monte Carlo permutation chi-square test of independence, using an Excel-Add-in specifically developed for resampling and Monte Carlo analysis techniques (Steinkrauss, 2016). The number of iterations per test was set to 1000. We used Monte Carlo techniques, because of their capacity for dealing with small and unbalanced datasets in a flexible manner. A power analysis (G*Power Version 3.1.9.2) revealed a projected sample size of 108, with an alpha = 0.05, medium effect size, and power = 0.80. Thus, our study would be underpowered given the achieved sample of 68 children, possibly resulting in biased parameter estimates. In these cases, non-parametric techniques are advised, which include Monte Carlo permutations (Kunnen, 2012). These techniques assess the probability that the empirical findings are a result of chance. In our case, this meant simulating 1000 chi-square tests based on resampled data, and counting how often the simulated test statistic exceeded our observed one. If this was very unlikely (probability $< .05$), we could conclude that our findings are not random, but reflect actual differences between boys and girls (or 3- and 4-year olds).

To examine the relationship of behavioural self-regulation with the degree of stability in motor performance, a simple linear regression analysis was conducted. The assumptions of the regression model were examined and met. Level of significance was set at $p < .05$.

3. Results

3.1. Descriptives

Table 1 shows the means, standard deviations, and ranges of the MABC-2 scores for the total sample, for 3- and 4-year olds, and for boys and girls.

3.2. Stability

3.2.1. Rank-order stability

Table 2 shows the Pearson correlations between the MABC-2 scores at different time points for the total sample and separately for 3-year and 4-year olds and for boys and girls. The correlations showed moderate to high rank-order stability between time points for the total sample. The magnitudes of stability coefficients were moderate to high in 4-year olds and boys and were low to moderate in 3-year olds and girls. Although the correlations for 4-year old children were higher than those for 3-years old children (except for T1-T2), Fisher r-to-z transformation showed that these differences were not significant (T1-T2: $z = 0.55, p = .582$; T2-T3: $z = -1.34, p = .180$; T1-T3: $z = -1.20, p = .230$). Correlations between time points were higher for boys than for girls. However, Fisher r-to-z transformation showed that the correlation coefficients did not differ significantly between boys and girls (T1-T2: $z = 1.01, p = .313$; T2-T3:

Table 2
Pearson correlations between MABC-2 scores at different time points for the total sample and separately for 3- and 4-year olds and boys and girls.

	T1-T2		T2-T3		T1-T3	
	r	*p*	*r*	*p*	*r*	*p*
Total	0.52	<0.001	0.41	<0.001	0.30	0.014
3-year olds	0.52	0.001	0.31	0.065	0.19	0.258
4-year olds	0.41	0.024	0.58	0.001	0.46	0.010
Boys	0.60	<0.001	0.54	0.001	0.46	0.006
Girls	0.41	0.018	0.21	0.249	0.08	0.662

Table 3
Degree of individual-level stability as indexed by the RCI.

	RCI T1-T2					RCI T2-T3					RCI T1-T3				
				≠	=				≠	=				≠	=
	M	SD	Range	n (%)	n (%)	M	SD	Range	n (%)	n (%)	M	SD	Range	n (%)	n (%)
Total sample	−0.07	0.99	−2.1–3.1	3 (4)	65 (96)	0.05	1.02	−2.8–2.5	3 (4)	65 (96)	−0.01	1.02	−3.4–3.0	5 (7)	63 (93)
3-year olds	−0.13	1.09	−2.1–3.1	3 (8)	34 (92)	−0.10	1.12	−2.8–1.5	2 (5)	35 (95)	−0.20	1.11	−3.4–2.2	4 (11)	33 (89)
4-year olds	0.00	0.87	−1.8–1.7	0 (0)	31 (100)	0.24	0.88	−1.1–2.5	1 (3)	30 (97)	0.21	0.86	−1.6–3.0	1 (3)	30 (97)
Boys	−0.16	0.80	−2.1–1.7	1 (3)	34 (97)	0.17	0.94	−1.8–2.5	1 (3)	34 (97)	0.01	0.90	−1.6–3.0	1 (3)	34 (97)
Girls	0.03	1.16	−1.5–3.1	2 (6)	31 (94)	−0.07	1.11	−2.8–1.5	2 (6)	31 (94)	−0.04	1.14	−3.4–2.2	4 (12)	29 (88)

Note. RCI = reliable change index; ≠ reliable change; = no reliable change. If the absolute value of the reliable change index (RCI) is greater than 1.96, the difference in scores between the two intervals is statistically significant at a 95% confidence interval.

Table 4
Simple linear regression with the RCIs as criterion variables and the HTKS as predictor variable (n = 46).

	RCI T1-T2			RCI T2-T3			RCI T1-T3		
	B	SE	CI (95%)	B	SE	CI (95%)	B	SE	CI (95%)
HTKS	−0.02	0.02	−0.06–0.02	0.00	0.02	−0.04–0.04	−0.01	0.02	−0.06–0.03

Note. RCI = Reliable Change Index, CI = confidence intervals, HTKS = Head Toes Knees Shoulders.

z = 1.54, *p* = .124; T1-T3: z = 1.64, *p* = .101). This indicates that boys and girls do not differ in degree of group-level rank-order stability.

3.2.2. Individual-level stability

In terms of stability of classification, that is, whether children stay in their original group (using the 16th percentile point as the cut-off), it was shown that for 79% of the total sample the classification based on the cut-off score on the MABC-2 between T1-T2 was stable. Looking into more detail into the two groups, it was shown that 42% of the children in the at risk for motor coordination difficulties group ($n = 12$) showed no change in classification at T2 (i.e., they still scored at or below the 16th percentile), whereas 88% of the typically developing group ($n = 56$) showed no change in classification at T2 (i.e., they still scored above the 16th percentile). Fisher Exact test showed a significant moderate association between classification at T1 and T2 ($p = .030$, Cramer's V = 0.29).

For both T2-T3 and T1-T3, it was shown that for 81% of the total sample the classification based on the cut-off score on the MABC-2 was stable. Of the at risk for motor coordination difficulties group ($n = 12$), 50% of the children showed no change in classification at T3 (i.e., they still scored at or below the 16th percentile), whereas 88% of the typically developing group ($n = 56$) showed no change in classification at T3 (i.e., they still scored above 16th percentile). Fisher Exact test showed a significant moderate association between classification at T2 and T3 ($p = .008$, Cramer's V = 0.36) and between classification at T1 and T3 ($p = .008$, Cramer's V = 0.36).

Table 3 shows the percentage for the total group and of each group (3-year old children versus 4-year old children, boys versus girls) that changed reliably or remained stable (no reliable change) in terms of RCI. Of the 68 children, 65 (96%) children showed no reliable change for T1-T2, indicating individual-level stability. There was no significant difference in proportions of children with reliable change and children without reliable change between the 3-year olds and 4-year olds, $\chi2(1, N = 68) = 2.63$, $p = .114$. With regard to gender, there was no significant difference in the proportions of children with reliable change and children without reliable change between boys and girls, $\chi2(1, N = 68) = 0.41$, $p = .567$. The same pattern of results was found for T2-T3 (3-year old children versus 4-year old children: $\chi2(1, N = 68) = 0.19$, $p = .742$; boys versus girls: $\chi2(1, N = 68) = 0.41$, $p = .578$) and T1-T3 (3-year old children versus 4-year old children: $\chi2(1, N = 68) = 1.42$, $p = .309$; boys versus girls: $\chi2(1, N = 68) = 2.14$, $p = .139$).

The level of behavioural self-regulation at T1 was not significantly related to individual-level stability index in motor performance as indicated by the RCI for T1-T2, T2-T3, and T1-T3 (see Table 4).

4. Discussion

4.1. Main findings

The aim of the present study was to examine the degree of rank-order and individual-level stability in young children with different levels of motor skill proficiency, including typically developing children and children at risk for motor coordination difficulties. Subsequently, we explored the influence of child variables (i.e., age, gender, and behavioural self-regulation) on different aspects of stability. The results showed moderate to high rank-order stability in the whole sample of 3- to 4-year old children, with a somewhat lower stability estimate for the longer (i.e., one year) interval than for the shorter (i.e., six months) intervals. Rank-order stability coefficients did not differ significantly between 3- and 4-year old children and between girls and boys. With regard to individual-level stability, the results showed that for ~50% of the children at risk for motor coordination difficulties and ~ 90% of typically developing the classification based on the cut-off score on the MABC-2 was stable. Based on the RCI, over 90% of the whole sample showed individual-level stability. The level of behavioural self-regulation was not significantly related to individual-level stability in motor performance.

The results with regard to rank-order stability converge with earlier studies examining larger time intervals (i.e., one to two years) in preschool children (Ahnert & Schneider, 2007; Roebers et al., 2014; Wang et al., 2014; Zysset, 2018). Thus, motor performance appears to be relatively stable during the preschool years. However, it is also important to note that even strong correlations (e.g., $r = 0.50$), leave 75% of the shared developmental variance in a motor performance measure unaccounted (Bornstein et al., 2019).

Although previous studies have indicated that rank-order stability of individual differences increases with age (Fraley & Roberts, 2005; Roberts & DelVechhio, 2000), in the current study, no evidence of increasing stability in early childhood was found. This could be due to the narrow age, i.e., only 3- and 4-year old children were assessed, and the relatively low sample size per age group. A broader age range and larger samples are probably necessary to detect changes in rank-order stability coefficients over time. With regard to gender, we also did not find any significant differences in rank-order stability. At the same time, however, it also should be noted that the differences between these correlations – with lower stability coefficients in girls than in boys -tend to be quite substantial in magnitude for T2-T3 and T1-T3. Also, Ahnert and Schneider (2007) reported lower rank-order stabilities of motor performance in girls than in boys. The reasons for these lower stability coefficients in girls are not clear, but it might be based on somewhat different developmental timetables of girls and due to biological and environmental differences during the early years (Hands et al., 2016; McCarthy, 2015). This area warrants further investigation with more highly-powered samples.

The percentages in this study with regard to individual-level stability in terms of group classification correspond to the percentages reported in earlier studies in children with motor coordination difficulties (Michel et al., 2018; Pless et al., 2002; Van Waelvelde et al., 2010). It shows that children who scored below a cut-off point at one particular measurement point did not necessarily do so at the next assessment. Accordingly, there seems to be considerable variation in the “at risk zone” of motor coordination difficulties in early development. These results underscore the recommendation of the European Academy of Childhood Disability (EACD) not to make a formal diagnosis of DCD under the age of five years, unless in case of severe problems (Blank et al., 2019). As the use of the 16th percentile of the MABC-2 as an appropriate cut-off point with regard to at risk status has been questioned with regard to preschool children, it would be important to examine different levels of severity of motor coordination difficulties with regard to stability of motor performance. Individual difference characteristics important for motor performance could potentially operate differentially with regard to stability in children with more versus less severe difficulties (Bornstein et al., 2019). Few studies have addressed this issue, but the results of the study by Pless et al. (2002) indeed suggest that, among young children with motor coordination difficulties, those whose problems persist have more severe motor coordination difficulties (performing at or below the 5th percentile). Unfortunately, the present study did not allow such a comparison because of the relatively small sample size of children at risk for motor coordination difficulties.

Crossing a cut-off point can make a distinction between scores reflecting a clinical versus a typically developing population, which arguably reflects change with clinical relevance. However, it does not make a distinction between smaller and larger changes. Random fluctuations in scores closely clustered around the cut-off point will be reported as ‘significant’, while large changes (positive and negative) which fail to cross the cut-off point will not. Therefore, information about individual-level stability in terms of group classification should be used in combination with RCI (Wolpert et al., 2015). Unlike group classification based on a cut-off point, RCI takes account of change anywhere in the scoring range. Moreover, it provides a measure of whether the change in an individual’s score over time is within or beyond what might be accounted for by measurement variability and is not tied to a particular measure, control group or previously established norms (Jacobson & Truax, 1991; Wolpert et al., 2015). In our study, individual-level stability based on RCI values pointed to a higher degree of stability of motor performance as compared to individual-level stability based on a cut-off point. However, it is important to note that the used correlations coefficients in the RCI formulas were rather low. Thus, the measurement error surrounding differences was large, requiring large changes in performance in order to interpret a change score as reliable.

It has been suggested that stability in one domain (e.g., motor performance) might actually be attributable to stability or change in another developmental domain (Bornstein & Putnick, 2012). The fact that we did not find an association between behavioural self-regulation and motor performance might thus indicate that the former is prone to change and variability rather than stability. Studies have indeed shown that that behavioural self-regulation (and the executive function skills that support behavioural self-regulation) develop(s) in a nonlinear fashion with early, rapid gains during the preschool (e.g., Cameron et al., 2008; Montroy, Bowles, Skibbe, McClelland, & Morrison, 2016). An alternative explanation is that motor performance and behavioural self-regulation each follow their own unique developmental trajectories with both periods of continuity (i.e., smooth pattern) and discontinuity (i.e., jumps and spurts), which attenuates possible covariation between the two domains (Ben-Sasson & Gill, 2014).

4.2. Strengths and limitations

The primary strength of this study was the comparison of results across different indicators of stability, which expands the traditional focus on group stability correlations with individual-level stability characteristics. Another strength was the exploration of the influence of several child-related variables on different aspects of stability.

Limitations to the study results include, among others, the use of a single motor measure; more varied motor measures would strengthen the study. While the examination of child-related variables was an important strength, other child and environmental variables, such as child temperament, motivation, parent-child interaction, and home environment, as well as their interactions, also need to be considered in future studies in order to more deeply understand child and environmental effects on stability.

Another limitation was the relatively small sample size, specifically with regard to the number of children at risk for motor coordination difficulties, which implies the need to replicate the results in larger samples. The sample size was further influenced by the young age of the participants, which reduced the number of individuals able to complete the HTKS.

4.3. Implications for future research and practice

Research into the degree of stability in motor performance enhances our understanding of individual differences in (early) childhood and has implications for other developmental domains because motor performance can be seen as an important contributor to children's overall functioning and well-being (McClelland & Cameron, 2019). We have focussed on stability *in individual differences* of motor performance, which is vital from the perspective of early screening/assessment and remediation. While we have considered this issue from both the population and the individual level, a true idiographic approach would require an even more detailed study of individual developmental trajectories (Keijsers & Van Roekel, 2018). That is, variability and change might be masked, by using age-standardized scores and employing time intervals at the developmental time scale of months and years. As posited by the dynamic systems approach to development, variability at a micro timescale of weeks or even days is prerequisite for an individual to self-organise into a new developmental phase/stage (Thelen & Smith, 2006). Thus, future studies should zoom in to this small-scale developmental level, by using a more narrow/dense/intensive time sampling and consider raw scores.

Our findings highlight the importance of a careful choice of stability measures and a reflection on the implications of their results. In our study, individual-level stability based on a cut-off pointed to a lower degree - albeit still moderate- of stability as compared to individual-level stability based on RCI values. As pointed out before, when using a cut-off point with regard to individual-level stability the amount of change might be inflated due to some children that are near the cut-off point at one time-point that subsequently could change to another category with only minor changes in actual motor performance. In this case, it is unknown whether this change is a result of true development or random fluctuations. This also holds implications for the broadly implemented use of the traffic-light system in categorising children based on their motor performance. We realize that diagnostic cut-off points are pragmatically necessary in clinical practice and cannot be ignored. However, instead of focusing on point-estimates for motor performance classification which might be too strict, consideration of a range or confidence interval might be more adequate. This might especially hold for follow-up evaluations into the persistence of motor coordination difficulties, that is to prevent children from being incorrectly classified as 'persistently at risk of motor coordination difficulties'.

5. Conclusion

Our aim was to examine the rank-order and individual-level stability of motor performance in preschool children. Our findings indicated moderate-to-high rank-order stabilities of motor performance during the preschool years. Degree of individual-level stability varied depending on the indices used. On the one hand, only low- to-moderate stability over time was found when a classification approach was used for indicating children at risk of motor coordination difficulties. On the other hand, the RCI showed that over 90% of all children showed no reliable change in their motor performance score. No association was found between child variables (age, gender, and behavioural self-regulation) and the stability indices.

Declarations of Competing Interest

None.

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