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The Early Motor Questionnaire (EMQ): A parental report measure of early motor development

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ABSTRACT

Children's early motor skills are critical for development across language, social, and cognitive domains, and warrant close examination. However, examiner-administered motor assessments are time consuming and expensive. Parent-report questionnaires offer an efficient alternative, but validity of parent report is unclear and only few motor questionnaires exist. In this report, we use cross-sectional and longitudinal data to investigate the validity of parent report in comparison to two examiner-administered measures (Mullen Scales of Early Learning, MSEL; Peabody Developmental Motor Scales, PDMS-2), and introduce a new parent-report measure called the Early Motor Questionnaire (EMQ). Results indicate strong correlations between parent report on the EMQ and a child's age, robust concurrent and predictive validity of parent report with both the MSEL and PDMS-2, and good test–retest reliability of parent report on the EMQ. Together, our findings support the conclusion that parents provide dependable accounts of early motor and cognitive development.

1. Introduction

The motor system provides infants with a means of exploring and engaging with the world and is critical for several aspects of development (e.g., language, social interactions, and learning). Unfortunately, assessing motor skills via examiner-administered assessments is time consuming, expensive, and prone to underestimating a child's true ability due to a lack of performance at test. In contrast, parent-report measures are cost effective and draw on the extensive knowledge of a child's primary caregiver. However, the validity or parent report remains unclear as only few questionnaires on early motor development (during the first two years of life) exists and only a small number of studies have investigated the validity of parent report measures in the motor domain (e.g., Bodnarchuk & Eaton, 2004; Goldstein, 1985; Knobloch, Stevens, Malone, Ellison, & Risemberg, 1979). The present study introduces a new parent-questionnaire focusing on early motor development – the Early Motor Questionnaire (EMQ) – and investigates the concurrent and predictive validity of parent report in comparison to two examiner-administered assessments of early motor and cognitive development.

1.1. The role of early motor skills in development

Motor skills and abilities play a critical role for overall development during the first years and are predictive of later developmental outcomes. In particular, attainment of new motor skills open up opportunities for learning about the physical

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and social world (Bushnell & Boudreau, 1993; Gibson, 1988) and therefore have cascading effects on cognitive, social, and language development (Campos et al., 2000; Iverson, 2010; Libertus & Needham, 2011). Embodied theories of development acknowledge the pivotal role of motor skills and motor experiences, especially early in life when children's bodies change rapidly and shape the dynamic interactions between child and environment (Needham & Libertus, 2011; Smith, 2005). Empirical support for embodied notions of development comes from studies showing that motor enrichment (i.e., 'sticky mittens') at age 3 months may facilitate concurrent motor and social development (Libertus & Needham, 2011). At the same time, motor deficits early in development have been associated with developmental delays or disorders. For example, children with motor delays have been reported to show increased rates of behavioral, affective, attentional, or social problems in later childhood (Gillberg & Kadesjo, 2003). Similarly, the presence of motor delays during the first four years of life has been found to predict later cognitive performance (in particular working memory and processing speed, Piek, Dawson, Smith, & Gasson, 2008). More recently, motor delays at age 6 months (i.e., head lag) have been associated with autism spectrum disorders (ASD) at age 36 months (Flanagan, Landa, Bhat, & Bauman, 2012).

Other prominent developmental theories also highlight the importance of early motor experiences. For example, Piaget's theory of development emphasizes the role of self-produced sensorimotor experiences for learning (Piaget, 1953). Similarly, Gibson's ecological theory of development suggests that the acquisition of new motor skills changes the perceived opportunities for actions on objects (Gibson, 1988; Gibson & Pick, 2000). Thus, motor experiences seem critical for learning, overall developmental trajectories across domains, and may even predict future learning delays or developmental disabilities. These findings highlight the potential value of an objective and reliable measure of early motor skills and emphasize the need for the development of such a measurement tool.

1.2. Motor-skill assessments

Motor skills can be assessed either via examiner-administered assessments or via parent-report measures. Both methods will be discussed in the following and each has its own benefits and limitations. For the current report, we use the term "standardized" to denote that a particular test has been standardized in the way its items are administered and has been normed to provide a standardized test score (in comparison to the normative-sample). Norm-referenced standard scores provide information about a child's performance relative to other children of the same age. While raw scores indicate how many items have been passed on a test, standardized scores compare performance to expected values at this age. Thus while raw scores increase with age, standardized scores are expected to remain relatively stable over time. However, if a child showed identical performance on a test at age 6 and at age 14 months, raw scores would not change but standard score would be lower for the second assessment since expectations at this age are that the child would pass more items.

1.2.1. Examiner-administered assessments of motor development

Standardized examiner-administered tests of motor development are widely used to identify developmental delays, to measure performance of particular skills, and to monitor progress of interventions. Administration is performed by a trained examiner using specific probes to create opportunities for objective, replicable observations presumed to be reflective of a child's abilities. A recent review of standardized developmental assessments identified the Bayley Scales of Infant Development (BSID-III, Bayley, 2006) and the Mullen Scales of Early Learning (MSEL, Mullen, 1995) as two of the most commonly used standardized developmental tests (Johnson & Marlow, 2006). The BSID-III assesses 3 sub-domains (cognitive, fine- and gross-motor, receptive and expressive language), is normed for ages 1–42 months, takes between 30 and 90 min to administer, and is one of the most widely used standardized developmental assessments (Bayley, 2006; Johnson & Marlow, 2006). However, due to its lengthy administration, the BSID-III is not commonly used in clinical populations such as in children with ASD – in this area the MSEL is the preferred assessment (e.g., Burns, King, & Spencer, 2013; Landa & Garrett-Mayer, 2006). The MSEL assesses 5 domains (Gross Motor, Fine Motor, Visual Reception, Receptive Language, Expressive Language), is normed for ages 0–68 months, and takes between 15 and 60 min to administer (Mullen, 1995). Another commonly used standardized assessment of early motor development is the Peabody Developmental Motor Scales (PDMS-2). The PDMS-2 assesses gross and fine motor development, is normed for ages 0–60 months, and takes 45–60 min to complete (Folio & Fewell, 2000). In contrast to the MSEL or BSID-III, the PDMS-2 focuses exclusively on motor development and offers a more in-depth assessment of this domain.

Examiner-administered assessments offer several benefits. First, the examiner is highly familiar with the assessment protocol and child development in general. Second, the probes and test stimuli are standardized and consistent across different examiners and sites, resulting in comparability of standard scores across age groups and settings. At the same time, examiner-administered assessments also have limitations. First, administration by a trained examiner is expensive and time consuming. Second, long assessments may fatigue the child and negatively impact test scores. Third, test scores depend heavily on the level of comfort and rapport between the child and examiner. And finally, examiner-administered assessments are not feasible for studies collecting data remotely (e.g., web surveys).

1.2.2. Parent-report measures of early motor development

Parent-completed developmental questionnaires (PCDQs) are structured tools providing access to parent's knowledge about their children (Easley et al., 1996). PCDQs require minimal time for scoring and studies have estimated their costs to be only about $0.32–$2.50 (Bricker & Squires, 1989; Bricker, Squires, Kaminski, & Mounts, 1988; Dobrez et al., 2001). In contrast, examiner-administered assessments cost hundreds of dollars (Bricker & Squires, 1989; Bricker et al., 1988; Dobrez et al., 2001). PCDQs are utilized in all developmental domains including cognitive and language development (e.g., Fenson et al., 2007; Rescorla & Alley, 2001; Sparrow, Balla, & Cicchetti, 1984), but relatively few PCDQs focus on early motor development (for a list of commonly used PCDQs see Duby et al., 2006).

Some PCDQs that include measures of early motor development are the Minnesota Infant Development Inventory (MIDI, Creighton & Sauve, 1988; Ireton & Thwing, 1980), the Child Development Review – Parent Questionnaire (CDP-PQ, Ireton, 1996), the Child Development Inventory (CDI, Ireton & Glascoe, 1995), and the Ages & Stages Questionnaire (ASQ, Squires, Bricker, & Potter, 1997). Among these PCDQs, only the MIDI and the ASQ cover early motor development during the first two years of life. The MIDI is designed for ages 0–18 months, includes 15 pass/fail items for gross motor and 15 pass/fail items for fine motor development, takes about 10 min to complete, and is arranged in a developmental sequence. The ASQ is a widely used developmental screening tool consisting of 11 questionnaires designed for different ages (total range of ASQ 4–48 months), it includes 6 items for gross motor and 6 items for fine motor development on each questionnaire, is scored on a 3-point scale, and takes about 15 min to complete. Thus, while there are some parent-report tools to measure early motor development, these PCDQs assess only a limited number of items (i.e., 30 items total on MIDI) or are non-continuous across development and therefore not as useful for research settings and longitudinal studies (i.e., ASQ uses different questionnaires for different ages).

Due to the retrospective nature of PCDQs, concerns regarding their validity remain (Long, 1992; Seifer, 2008) and parents may over- or underestimate their child's true abilities (especially in the motor domain; Bartlett & Piper, 1994). Nevertheless, several studies suggest that well designed and structured PCDQs may provide accurate information about a child's current developmental status (e.g., Bricker et al., 1988; Faraone, Biederman, & Milberger, 1995; Glascoe & Dworkin, 1995; Knobloch et al., 1979).

The validity of parent report on motor development has been investigated mostly in older children (Kennedy, Brown, & Chien, 2012; Kennedy, Brown, & Stagnitti, 2012; Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000). In younger children, studies using daily diaries suggest that parents provide accurate accounts of their child's early motor skills (Bodnarchuk & Eaton, 2004; Ellis-Davies, Sakkalou, Fowler, Hilbrink, & Gattis, 2012). The validity of one-time motor-domain PCDQs remains largely unknown (c.f., Goldstein, 1985; Knobloch et al., 1979).

1.3. The current study

In this report we examine concurrent and predictive validity of parent report on early motor development in 3- to 24-month-old children by comparing questionnaire to examiner-administered measures, and introduce a novel parent-report measure of early motor development called the Early Motor Questionnaire (EMQ). The EMQ is designed as a fast and easy to complete motor questionnaire, and is organized into 3 sections: Gross motor skills, fine motor skills, and perception-action integration skills. The EMQ is not a standardized assessment, but can be used in research settings, serve as a motor screener, or as complement to standardized measures of early motor development. In addition to assessing the validity of parent report, we examine the concurrent and predictive validity of the EMQ in comparison to the standardized MSEL and the PDMS-2.

2. Methods

2.1. Participants

Participants were 94 parent-child dyads with children aged between 3 and 24 months ($M = 11.57$ months, $SD = 6.75$ months, range 2.39–24.95 months) who enrolled in a longitudinal study on the early detection of ASD. Age was adjusted in 9 children who were born slightly prematurely ($M = 35.22$ weeks gestation, $SD = 1.06$). Children were recruited from 6 discrete age groups: 3, 6, 10, 14, 18, and 24 months. Detailed participant demographics for the entire sample, split by recruitment age group are shown in Table 1. About 59% of the children are younger siblings of a child with a confirmed diagnosis of ASD diagnosis ('sib-As') and are at heightened risk for developing ASD (Landa & Garrett-Mayer, 2006). EMQ and MSEL scores were available for all children. Additionally, 73 children completed the PDMS-2 (not completed at age 3 months, and missing for one 24-month-old). Children scored within the average range on the Gross and Fine Motor and Visual Reception scales of the MSEL and PDMS-2 (see standard scores in Table 2). Prior to participation, all parents provided oral and written informed consent. The Johns Hopkins Medical Institutions IRB approved all materials and procedures.

2.2. Measures

A trained Master's or Ph.D. level professional administered all standardized developmental assessments and a primary caregiver completed the EMQ. The examiner was blind to EMQ scores at the time of assessment. The MSEL was generally performed before the PDMS-2, and consequently the examiner was not blind to the child's performance on the MSEL while administering the PDMS-2.

Table 1
Sample characteristics.

	N (% total)	Age (SD)	SES[a] (SD)	Males (% group)	Caucasian (% group)	Sib-A (% group)
All ages	94 (100%)	11.57 (6.75)	54.39 (10.64)	60 (64%)	75 (80%)	55 (59%)
3-Month-olds	20 (21%)	3.08 (0.39)	53.14 (12.21)	12 (60%)	13 (65%)	16 (80%)
6-Month-olds	16 (17%)	6.43 (0.52)	50.72 (11.63)	10 (63%)	12 (75%)	4 (25%)
10-Month-olds	17 (18%)	10.43 (0.85)	52.79 (11.80)	9 (53%)	16 (94%)	7 (41%)
14-Month-olds	16 (17%)	14.72 (0.72)	57.17 (7.64)	11 (69%)	14 (88%)	10 (63%)
18-Month-olds	16 (17%)	18.30 (1.18)	57.07 (6.92)	10 (63%)	14 (88%)	11 (69%)
24-Month-olds	9 (10%)	24.10 (0.59)	57.39 (12.23)	8 (89%)	6 (67%)	7 (78%)

Notes: Sib-A = younger siblings of a child with a confirmed ASD or PDD-NOS diagnosis.
[a] SES refers to Hollingshead socioeconomic score (Hollingshead, 1975), this score is derived from both parents' highest level of education and their occupation. Age is reported in months.

2.2.1. *Mullen Scales of Early Learning (MSEL)*

The MSEL is a standardized developmental assessment with 5 Scales (Mullen, 1995): Gross Motor (GM; 35 items); Fine Motor (FM; 30 items); Visual Reception (VR; 33 items); Receptive Language (RL; 33 items); and Expressive Language (EL; 28 items). Standardization of the measure was completed on 1849 children. The MSEL is a shared measure given by researchers who contribute data to the Baby Siblings Research Consortium database (e.g., Ozonoff et al., 2011), and by researchers in the British Autism Study of Infant Siblings (e.g., Gliga, Elsabbagh, Hudry, Charman, & Johnson, 2012). Also, it is widely used in research studies on developmental disabilities (Burns et al., 2013). For the current report, the MSEL was scored as detailed in its assessment manual by obtaining raw scores for each of its scales. The MSEL also allows for calculation of an "Early Learning Composite" score, but no such overall score was used here.

2.2.2. *Peabody Developmental Motor Scales (PDMS-2)*

The PDMS-2 is a standardized motor assessment composed of 2 Scales (Folio & Fewell, 2000): Gross Motor (reflexes, stationary, locomotion, and object manipulation); and Fine Motor (grasping, and visual-manual integration). Scores are available as composite Gross Motor Quotient (GMQ) and Fine Motor Quotient (FMQ), and as an overall Total Motor Quotient (TMQ). Standardization of the measure was completed on 2003 children. The PDMS-2 is used in clinical and research settings (e.g., Provost, Heimerl, & Lopez, 2007; Provost, Lopez, & Heimerl, 2007). Further, the PDMS-2 has good reliability, and concurrent validity with the BSID-III (Connolly, McClune, & Gatlin, 2012). For the current report, the PDMS-2 was scored as detailed in its assessment manual by obtaining subtest raw scores and then combining these raw scores to calculate the composite GMQ and FMQ scales as standard scores.

2.2.3. *Early Motor Questionnaire (EMQ)*

The EMQ is a parent-report measure of early motor development organized around different 'contexts' a child encounters during everyday situations (e.g., sitting at a table, playing on the floor). The items included on the EMQ describe motor behaviors typically emerging within the first 2 years of life (0–24 months) and are similar to items included on the MSEL or other motor assessments. Other primary caregivers (e.g., a grandparent or a nanny) may also complete the EMQ. However, due to the age range assessed by the EMQ, it is not targeted toward teachers.

The EMQ uses a 5-point scale ranging from −2 to +2 to quantify parents' certainty. A behavior is rated -2 if the parent is sure the child does not show the behavior yet, and +2 if parent remembers a particular instance where the child exhibited the behavior in question. Further, the EMQ is divided into 3 sections, a Gross Motor section (GM: 49 items), a Fine Motor section (FM: 48 items), and a Perception-Action section (PA: 31 items). According to optional feedback provided by 49 parents (52%

Table 2
Standardized test scores.

	PDMS-2			MSEL		
	GMQ (SD)	FMQ (SD)	TMQ (SD)	GM (SD)	FM (SD)	VR (SD)
All ages	95.59 (11.42)	101.89 (9.29)	97.89 (10.38)	48.69 (10.09)	52.24 (8.35)	54.13 (10.09)
3-Month-olds	–	–	–	48.65 (7.09)	49.47 (4.91)	56.94 (6.43)
6-Month-olds	105.31 (7.98)	106 (4.90)	106 (6.88)	50.50 (7.21)	53.25 (7.39)	54.19 (6.41)
10-Month-olds	96.71 (8.43)	107.94 (9.60)	101.41 (8.14)	45.77 (11.79)	56.59 (10.82)	56.65 (12.59)
14-Month-olds	96.25 (8.92)	102.44 (7.20)	98.5 (7.29)	52.63 (12.31)	54.81 (6.88)	53.50 (6.04)
18-Month-olds	91.5 (10.74)	97.38 (7.26)	93.25 (8.93)	49.44 (9.13)	49.44 (8.34)	48.19 (12.47)
24-Month-olds	80.625 (10.49)	88.75 (5.50)	82.25 (7.81)	42.79 (11.53)	47.89 (8.43)	55.67 (14.35)

Notes: PDMS-2 = Peabody Developmental Motor Scales, 2nd edition; MSEL = Mullen Scales of Early Learning; GMQ = Gross Motor Quotient; FMQ = Fine Motor Quotient; TMQ = Total Motor Quotient; GM = Gross Motor scale; FM = Fine Motor scale; VR = Visual Reception scale. PDMS-2 scores have a mean of 100 and a standard deviation of 15. MSEL scores have a mean of 50 and a standard deviation of 10.

Table 3
Sample EMQ items.

Gross Motor Scale	
When placed into a sitting position on the floor, your child is able to. . .	
A	*. . . sit independently without support (hands lifted up).*
B	*. . . use hands and legs to scoot forward on his/her bottom?*
C	*. . . maintain a stable sitting position while turning head and torso to look around?*
Fine Motor Scale	
When sitting on your lap or in a high chair while playing with toys, you notice your child is able to. . .	
A	*. . . successfully hold on to a small object such as a ring or stick?*
B	*. . . reach for a toy with one hand by extending the arm and fingers?*
C	*. . . successfully grasp a toy with one hand following a reach?*
Perception-Action Scale	
While lying on his/her back in a crib, baby gym, or on the floor, your child sometimes will. . .	
A	*. . . turn the head all the way to one side (90°) to follow your face?*
B	*. . . notice his/her own hands and look at them for some time?*
C	*. . . swat at toys hanging from a baby gym or car seat?*

Notes: Parents respond to each item on a 5-point scale, ranging from −2 (parent is sure child does not show behavior) to +2 (parent is sure child shows behavior and remembers particular instance).

of the sample), completion of the EMQ takes about 17 min (M = 16.57, SD = 10.65). Examples of prototypic EMQ items are shown in Table 3. The full EMQ can be obtained from the first author.

2.3. Procedure

The EMQ was mailed to all families with the request to complete the questionnaire prior to their visit to our lab. Nineteen caregivers (25%) failed to complete the EMQ prior to MSEL and PDMS-2 administration and completed it at home following observation of these assessments. Caregivers also completed unrelated experimental and standardized assessments during their visit, but the current report focuses only on the EMQ, MSEL, and PDMS-2 data.

2.4. Data analysis

Correlation analyses were used to investigate concurrent and predictive validity of EMQ scores. In addition, partial correlation was used to control for factors that may influence parent report such as socio-economic status (SES, Hollingshead, 1975), ASD risk group (high-risk sib-As vs. low-risk controls), time of EMQ completion (before vs. after MSEL/PDMS-2 observation), and person completing the EMQ (mother vs. other). Potential influences of these variables include that parents with higher SES might have more knowledge about child development and have higher expectations regarding their child's abilities. Similarly, parents with a child with ASD might pay more attention to the development of their younger child and may be more knowledgeable about development in general. Controlling for these and other factors in our analyses allows for greater generalizability of our findings. Partial correlations also controlled for age when assessing concurrent validity, or for the time gap between assessments when assessing predictive validity. The mother completed the EMQ for 84 children, the father for 6 children, a grandmother for 1 child, and for 3 children it is unknown who competed the EMQ. All concurrent validity results are based on cross-sectional data, predictive validity data is based on longitudinal data.

EMQ scores were computed separately for the GM, FM, and PA domains. For 10 children (11%), EMQ data was incomplete due to missing values. Missing singleton values were replaced with scores of 0 (6 children). For multiple missing values in a row, the affected sub-scale was removed from analyses (4 children).

For the EMQ and MSEL, all analyses were performed using raw scores as EMQ sections can be matched directly onto Scales of the MSEL (PA section matches onto VR of MSEL). In contrast, EMQ sections do not match directly onto PDMS-2 Scales, instead the composite Gross Motor Quotient (GMQ) and Fine Motor Quotient (FMQ) are compared the GM and FM sections of the EMQ respectively. Since GMQ and FMQ are composite scores, we will use standard scores on these Scales to compare to the EMQ. Examining correlations between PDMS-2 standard scores and EMQ raw scores is statistically sound and this approach complements the analytic approach used with the MSEL.

3. Results

There were no gender differences on any of the three EMQ sections (GM: M_{male} = 13.48, M_{female} = −3.71, p = .14; FM: M_{male} = −5.13, M_{female} = −11.71, p = .43; PA: M_{male} = 10.90, M_{female} = 8.76, p = .74). Similarly, there were no gender differences in corresponding domains of the MSEL (GM: M_{male} = 15.38, M_{female} = 13.59, p = .23; FM: M_{male} = 14.52, M_{female} = 13.74, p = .59; VR: M_{male} = 15.75, M_{female} = 14.53, p = .45), or on the PDMS-2 (GMQ: M_{male} = 112.37, M_{female} = 109.50, p = .67; FMQ: M_{male} = 100.81, M_{female} = 102.31, p = .81). Therefore, data were collapsed across gender for all further analyses.

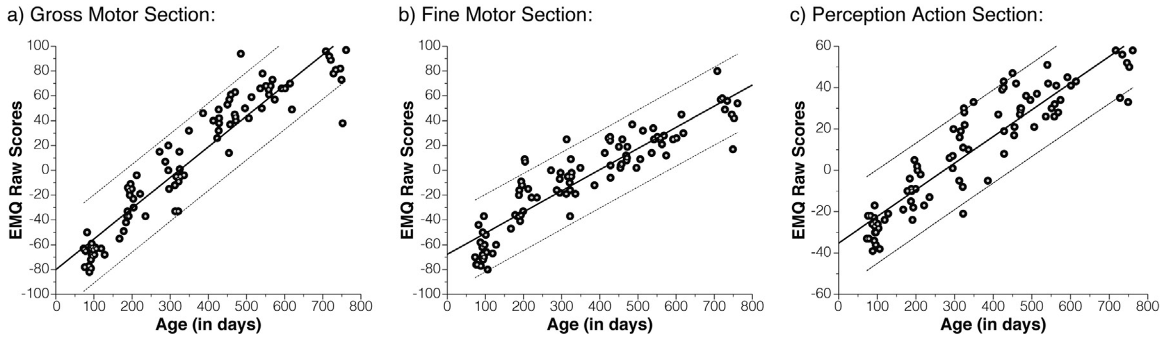

Fig. 1. Correlations between EMQ and age. All three EMQ sections correlate strongly with age. Solid and dashed lines show linear fit with 95% confidence intervals.

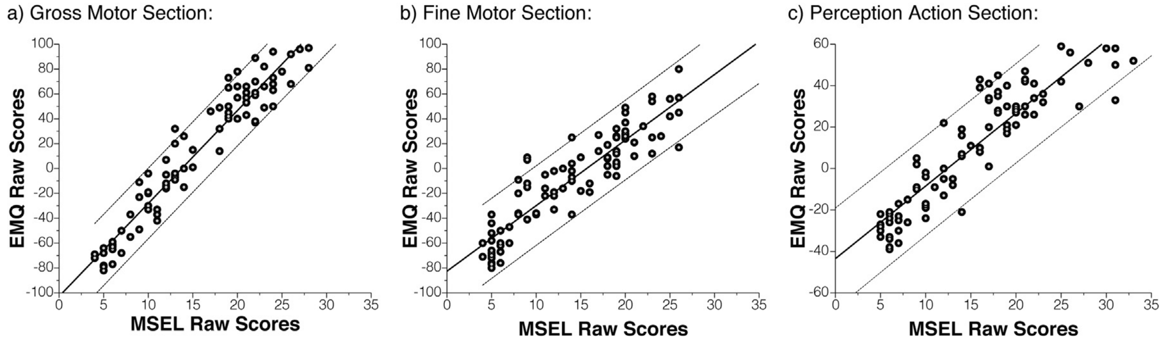

Fig. 2. Concurrent validity of EMQ with MSEL. The EMQ and MSEL correlate strongly with each other on corresponding sections (Perception Action section corresponds to Visual Reception scale on MSEL). Correlations remain strong after controlling for influences of age and other factors. Solid and dashed lines show linear fit with 95% confidence intervals.

3.1. Correlations with age

The relation between raw EMQ scores and age was investigated to determine whether parent ratings on the EMQ increase with age. Raw and partial correlation coefficients between EMQ scores and age were highly significant in all three domains (GM: $r = .94$, $r_{\text{Partial}} = .95$; FM: $r = .91$, $r_{\text{Partial}} = .92$; PA: $r = .92$, $r_{\text{Partial}} = .93$, all $ps < .01$), suggesting that caregivers' responses on the EMQ are sensitive to the incremental changes in motor development over time (Fig. 1).

3.2. Concurrent validity

Concurrent validity assesses how well a test correlates with a previously established and validated measure (e.g., a gold standard). To establish the concurrent validity of parent report, EMQ scores were compared to scores from the examiner-administered MSEL and the PDMS-2. Raw and partial correlation coefficients between corresponding EMQ and MSEL sections were significant (GM: $r = .97$, $r_{\text{Partial}} = .67$, both $p < .01$; FM: $r = .91$, $p < .01$, $r_{\text{Partial}} = .22$, $p = .04$; PA/VR: $r = .91$, $p < .01$, $r_{\text{Partial}} = .27$, $p = .02$), suggesting that parent report on the EMQ is predictive of MSEL scores above and beyond influences of age and other factors (Fig. 2).

Similarly, raw and partial correlation coefficients between EMQ raw scores and PDMS-2 standard scores were calculated. To our surprise, correlations between EMQ and PDMS-2 scores on corresponding sections were negative (GM-GMQ: $r = -.45$; FM-FMQ: $r = -.43$, both $ps < .01$). This negative relation seems to be caused by a negative correlation between the PDMS-2 and age in our sample (GMQ: $r = -.61$; FMQ: $r = -.62$, both $ps < .01$). The EMQ shows a positive relation with the PDMS-2 once effects of age are controlled for (GM-GMQ: $r_{\text{Partial}} = .47$; FM-FMQ: $r_{\text{Partial}} = .40$, both $ps < .01$). This significant positive relation confirms the concurrent validity of parent report on the EMQ using a second, motor-specific instrument.

The negative relation between age and PDMS-2 itself is noteworthy and remains even after controlling for influences from gender, SES, and ASD risk status (GMQ: $r_{\text{Partial}} = -.55$; FMQ: $r_{\text{Partial}} = -.57$, both $ps < .01$). This pattern may be a feature of our sample. By offering free developmental assessments, it is possible that the current study attracted a larger proportion of parents with concerns about their child's development and consequently more children may have developed mild delays as they grow older and consequently scored lower on the PDMS-2. A slight negative, although non-significant, relation was also observed between MSEL standard scores and age (all $rs > -.08$, $ps > .11$).[1] At the same time, this negative relation could also be due to the structure of the PDMS-2 itself as negative relations between the PDMS-2 and the Bayley Scales of Infant Development II have been reported (Connolly et al., 2006).

3.3. Predictive validity

Scores from a second examiner-administered assessment were available for 50 participants (53%) on the MSEL and for 45 participants (48%) on the PDMS-2. To determine predictive validity of parent report on the EMQ, raw and partial correlations were calculated between EMQ scores at time 1, and MSEL or PDMS-2 scores at time 2. The second visit occurred approximately 4.66 months ($SD = 1.62$) after the first visit.

[1] Correlations between the MSEL and PDMS-2 are not reported here because the examiner always had access to the scores of the MSEL when administering the PDMS-2, leading to potentially inflated correlation scores.

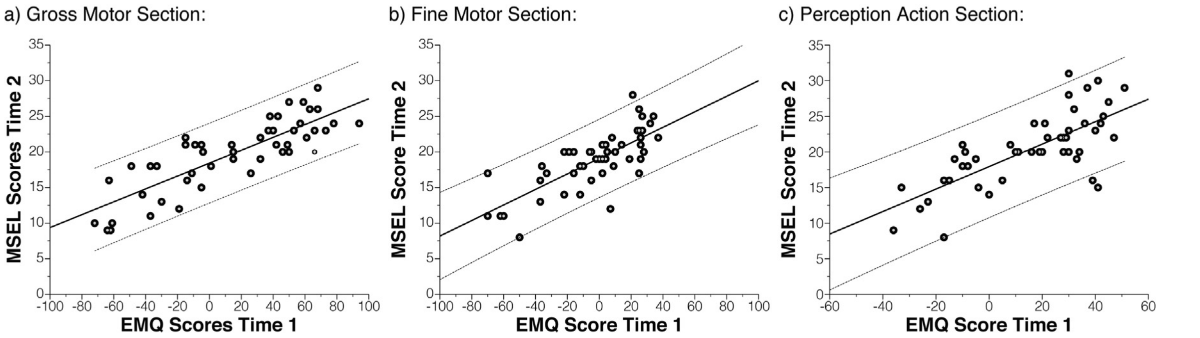

Fig. 3. Predictive validity or EMQ with MSEL. EMQ scores correlate strongly with corresponding MSEL scores obtained approximately 4.7 months later. Correlations remain strong after controlling for influences of the time-gap between assessments and other factors. Solid and dashed lines show linear fit with 95% confidence intervals.

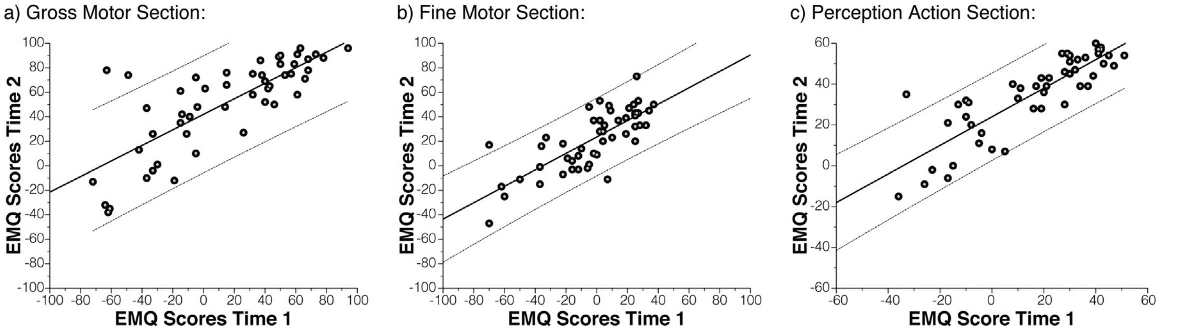

Fig. 4. Test–retest reliability of EMQ over two time points obtained approximately 4.7 months apart. EMQ scores at time 1 correlate strongly with EMQ scores at time 2. Correlations remain strong after controlling for influences of the time-gap between assessments and other factors. Solid and dashed lines show linear fit with 95% confidence intervals.

Raw and partial correlation coefficients between EMQ at time 1 and MSEL at time 2 were significant on all corresponding scales of the two instruments (GM: $r = .83$, $r_{Partial} = .89$; FM: $r = .75$, $r_{Partial} = .83$; PA/VR: $r = .73$, $r_{Partial} = .77$, all $ps < .01$; see Fig. 3). Similarly, raw and partial correlations between corresponding scales on the EMQ at time 1 and PDMS-2 at time 2 were significant (GM-GMQ: $r = -.45$, $r_{Partial} = -.56$; FM-FMQ: $r = -.39$, $r_{Partial} = -.48$, all $ps < .01$). Thus, parent reported EMQ scores show good predictive validity and were significantly correlated with examiner-derived scores on the MSEL or PDMS-2 obtained approximate 4.7 months later.

3.4. Test–retest reliability

Longitudinal EMQ scores were available for 51 participants (54%). To determine the stability of repeated EMQ administrations, raw and partial correlations were calculated between EMQ scores at time 1 and at time 2. The second visit occurred approximately 4.69 months ($SD = 1.60$) after the first visit. Raw and partial correlation coefficients were significant for all three EMQ scales (GM: $r = .78$, $r_{Partial} = .80$; FM: $r = .77$, $r_{Partial} = .79$; PA: $r = .85$, $r_{Partial} = .88$, all $ps < .01$; see Fig. 4), indicating that parent report on the EMQ shows good test–retest reliability over a 4–5 month period.

4. Discussion

The results reported here answer the two research questions raised in our introduction. First, the results provide direct evidence for the validity of parent report by showing that parents provide accurate and reliable accounts of their children's early motor development when using the EMQ. And second, the results show promise for the EMQ as a reliable and valid measure or early motor development: EMQ scores increase linearly with age, show high concurrent validity with two separate examiner-administered measures (MSEL and PDMS-2), have good predictive validity with MSEL and PDMS-2 scores obtained nearly five months later, and have good test–retest reliability. These findings are robust and remain significant even after controlling for influences of age, SES, ASD risk status, and other extraneous variables.

4.1. Validity of parent report on early motor development

This is the first study to compare both concurrent and predictive validity of parent report on early motor development with two standardized, examiner-administered measures of motor ability in the same children. Our results are in agreement other studies comparing parent report to examiner-administered assessments and add further support to the validity of well-designed parent-report measures (e.g., Bricker & Squires, 1989; Bricker et al., 1988; Goldstein, 1985; Knobloch et al., 1979; Wilson et al., 2000).

Concurrent validity of parent report in the motor domain was assessed by Goldstein (1985) and Bodnarchuk and Eaton (2004). Goldstein (1985) compared parent report on the motor scale of the Vineland Adaptive Behavior Scales (VABS; Sparrow et al., 1984) to the motor scale of the Bayley Scales of Infant Development (BSID, Bayley, 1969) in 12-month-olds infants who graduated from an intensive care nursery. Similar to our findings, Goldstein (1985) reported strong correlations ($r = .86$) between VABS and the BSID. Bodnarchuk and Eaton (2004) compared the examiner-administered Alberta Infant Motor Scales (AIMS, Piper, Pinnell, Darrah, Maguire, & Byrne, 1992) to a custom-designed parent-report version of the AIMS in 2.5- to 15.7-month-old children and report high concordance between parent report and the examiner-administered AIMS. However, the parent-report version of the AIMS used by Bodnarchuk and Eaton (2004) was structured as a daily diary and assessed only 12 gross motor milestones with dichotomous outcome classifications (present/absent).

Predictive validity of parent report was assessed by Knobloch et al. (1979) using the Parent Development Questionnaire (PDQ) completed at around 7 months of age and the Gesell Developmental and Neurologic Evaluation (GDNE) completed at around 10 months of age. Agreement between parent report on the PDQ and the GDNE was good, but the PDQ questionnaire allows open-ended answers and requires review and scoring by a developmental specialist.

Our results expand these previous findings by investigating concurrent and predictive validity in the same children, by explicitly accounting for influences of age and other factors, and by comparing parent report to two different examiner-administered measures (the MSEL and PDMS-2). Taken together, there is now good evidence supporting the validity of parent-report measures in the domain of early motor development. Consequently, parent report should receive more attention during diagnostic evaluations and during research assessments (Glascoe & Dworkin, 1995).

4.2. Applications

In addition to evaluating validity of parent-report measures, the current study introduces the EMQ. The items included on the EMQ are also commonly assessed on other standardized measures such as the MSEL. As such, the EMQ provides a new tool for clinicians and researchers alike to quickly assess early motor development, offering an alternative to lengthy and expensive in-lab or in-clinic assessments.

A key future application of the EMQ may be in longitudinal research projects. Repeated examiner-administered assessments in longitudinal studies are expensive and may lead to significant training effects over time. Spacing fewer assessments over a longer period of time addresses cost and training-effect issues, but may lead to sparse sampling and degradation of developmental trajectories (Adolph, Young, Robinson, & Gill-Alvarez, 2008). The EMQ can be used repeatedly without risks of training effects in the child (although 'training effects' may be present in the parent) and may even be used in conjunction with other measures, such as the MSEL, to fully evaluate motor development.

Moreover, the EMQ could be used as a first-step screening instrument to identify children who should receive further assessments. For example, children scoring low on the EMQ are also likely to score low on the MSEL. Finally, the EMQ can be used in situations where direct observation is not possible such as for online surveys or telephone-based studies, or as additional assessment in-between lab visits during large scale-longitudinal studies.

4.3. Limitations

The current report provides strong evidence for the validity of parent report. However, several limitations need to be considered with regard to the EMQ as a new assessment tool. First, the EMQ has not yet been standardized and age-equivalence scores are not yet available. Second, no item analysis has been conducted for the EMQ at this point because sample size (especially in individual age group) is relatively small in this preliminary report. Data from more participants and additional longitudinal data from existing participants are currently being collected and this question will be addressed in the future. Finally, parents knew their children would be assessed during this study and may have taken additional care in completing the EMQ.

To determine the clinical value of the EMQ it is necessary to establish its sensitivity to detect delayed motor development. Although children at heightened risk for ASD were included in our study, the majority of children performed within the normal range on standardized scores and no ASD outcome information is available at this time. Whether the EMQ can be used to identify early signs of motor delays or ASD will be investigated once outcome data becomes available for our sample.

5. Conclusion

Parents' ratings on the Early Motor Questionnaire show good concurrent and predictive validity in comparison to objective, standardized, examiner-administered motor development measures. These results suggest that parents can provide dependable reports of their child's early motor development, and that the newly introduced EMQ provides a reliable, valid, and inexpensive parent-report measure of children's early motor development. Future studies will be required to further scrutinize the EMQ and its psychometric profile.

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