Drawing Proficiency Screening Questionnaire (DPSQ): Development, Reliability, and Validity

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MeSH TERMS
- art
- developmental disabilities
- diagnostic techniques and procedures
- psychometrics
- psychomotor performance

OBJECTIVE. We describe the development and preliminary psychometric examination of the DPSQ for identifying drawing difficulties in preschool children.

METHOD. Teachers completed the DPSQ for 78 children ages 3–6 yr from 4 preschools. Children drew age-appropriate geometric forms of the Visual–Motor Integration (VMI) test on a digitizing tablet. We examined psychometric properties of the DPSQ and analyzed group membership.

RESULTS. Internal consistency was high ($\alpha = .82$). Significant correlations were found between DPSQ and VMI scores indicating in-air time ($r = .37$, $p = .002$) and pressure on the writing tool ($r = .32$, $p = .007$). The typical and at-risk groups differed significantly in VMI and DPSQ scores, $t(76) = 5.6$, $p = .001$. The DPSQ mean score differentiated between 76% of children with and without visual–motor deficits.

CONCLUSION. The DPSQ is a useful tool for teachers and occupational therapy practitioners for indicating visual–motor deficits and potential handwriting problems.

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Drawing, or the process of manipulating media and materials to express oneself and create representations (Lipschitz-Elhawi & Yedidya, 2011), is an occupation of young preschool children (Kielhofner, 2008). Before children are developmentally able to express themselves in writing, they may use drawing to show their emotions, ideas, and thoughts, and this process aids cognitive development (Matthews, 2003). During preschool, when proficiency in the use of drawing and writing tools is developing, children draw forms and representations of real-world objects. This early stage is known as the *preschematic stage* of drawing (Sylla, Branco, Coutinho, & Coquet, 2011).

Drawing is a preliminary developmental stage in which young children gain mastery of the drawing instrument and improve visual–motor integration (Bonoti, Vlachos, & Metallidou, 2005; Kaiser, Albaret, & Doudin, 2009). Visual–motor integration can be assessed by having a child copy geometric forms from a diagram (Beery & Beery, 2010), draw a cross in a square, draw two horizontal lines in a confined space, trace or copy forms, and connect dots to form shapes (Hammill, Pearson, & Voress, 1993). According to Dankert, Davies, and Gavin (2003), children's visual–motor skills are highly correlated with drawing and handwriting skills, and fine motor skills are required for manipulating the writing tool. Fine motor skill difficulties have been found in 5%–20% of children and may affect their drawing abilities while these abilities are developing in preschool (Vlachos & Bonoti, 2006).

Difficulties with drawing may indicate difficulties with development of spatial organization (Saundry & Nicol, 2006) and may negatively affect the development of writing skills. Children who have difficulty manipulating symbols, shapes, and forms on paper may have limited opportunities to develop early literacy and thinking skills (Sylla et al., 2011). With increasing age comes comfort with the writing

and drawing tool and proficiency with the finished product (Van Mier, 2006). Drawing is similar to writing in that both tasks require visual–motor skills and fine motor skills, and both tasks develop from the process of forming shapes on a piece of paper (Thelen, 2000).

Grade-level expectations for manipulating drawing and writing tools (fine motor skills) are mandated by each state in the United States beginning in preschool (Gallagher, Clayton, & Heinemeier, 2001). Screening of all children is mandated by the federal Response to Intervention (RtI) guidelines as stated in the Individuals With Disabilities Education Improvement Act of 2004 (IDEA; Pub. L. 108–446; see also Fuchs & Fuchs, 2006; Musgrove, 2010). Therefore, because drawing plays a vital part in a child's fine motor, cognitive, and emotional development, early identification of drawing difficulties is needed to prevent developmental delays (Matthews, 2003).

According to Cunha and Heckman (2007), early accurate attainment of skills is more efficient and cost-effective than remediation at a later time. For example, helping a child master visual–motor skills in preschool is faster and easier than helping the child catch up on those skills when the child is struggling with handwriting in elementary school (Ratzon et al., 2009). The cost of remediation grows over time when help is delayed. The younger the child is when given help, the better the chances for improvement and development of accurate skills. It is thus important to identify children with drawing problems at a young age and to understand the mechanisms of their problems (Cunha & Heckman, 2007).

Despite the importance of identifying drawing problems at a young age (Ratzon, Efraim, & Bart, 2007), most teachers are not trained in administering the Beery–Buktenica Developmental Test of Visual–Motor Integration (VMI; Beery & Beery, 2010), and it is time consuming to score. Thus, teachers and occupational therapy practitioners working in preschool classrooms need a screening tool they can use to monitor a child's visual–motor and fine motor development. If teachers and practitioners can use drawing to identify visual–motor and fine motor problems, they can provide extra assistance within the classroom, avoiding the need for special education at a later age. Our review of the literature failed to identify a screening tool for evaluating drawing, and we found little research examining the spatial, temporal, and pressure aspects of drawing abilities in preschool children.

The Computerized Penmanship Evaluation Tool (ComPET, previously referred to as POET; Rosenblum, Parush, & Weiss, 2003) has been used to study handwriting. This standardized and validated assessment tool uses a digitizing tablet and online data collection and analysis software. It was developed to provide objective measures of the handwriting process (Rosenblum et al., 2003). This study is the first to use ComPET to examine drawing and visual–motor skills in preschoolers. This article describes the development of the Drawing Proficiency Screening Questionnaire (DPSQ) as a screening tool for drawing deficits in children ages 3–6 yr and discusses establishment of the questionnaire's reliability and validity.

Method

Phase 1: Construction of the Drawing Proficiency Screening Questionnaire

Content Validity. The DPSQ was developed on the basis of results of parent and teacher interviews related to drawing production difficulties among preschool children and the literature on that topic. Children with drawing difficulties may have trouble with accuracy of production and speed, muscle fatigue and effort, and fine motor skills (Olkun, 2003; Smits-Engelsman, Niemeijer, & van Galen, 2001; Van Gemmert & Teulings, 2006; Vlachos & Bonoti, 2006). These characteristics of drawing production deficits are similar to those identified in the literature on nonproficient handwriting; drawing is highly correlated with handwriting problems because they involve similar mechanical and visual–spatial abilities (Bonoti et al., 2005; Sylla et al., 2011; Van Gemmert & Teulings, 2006). Thus, we based the DPSQ on the Handwriting Proficiency Screening Questionnaire (HPSQ; Rosenblum, 2008), a 10-item questionnaire with strong validity and reliability that identifies children with handwriting difficulties. The indicators we considered in the design of the screening tool for drawing difficulties included (1) accuracy and effort, (2) time and speed of performance, and (3) physical and emotional well-being (Rosenblum, 2008).

We concluded that the DPSQ would cover three domains related to drawing proficiency: accuracy and effort (Items 1, 2, 5, and 7), time and speed of performance (Items 3 and 4), and the child's physical and emotional well-being (Items 6, 8, 9, and 10; Bonoti et al., 2005; Olkun, 2003; Rosenblum, 2008; Vlachos & Bonoti, 2006). For each question, the teacher or occupational therapy practitioner evaluates the child's performance using a 5-point Likert scale ranging from 0 (*never*) to 4 (*always*); higher scores indicate poorer performance. The final score is calculated by averaging the scores for all 10 items. Figure 1 lists the questions in the tool.

Expert Validity. The expert validity of the drawing questionnaire was determined by asking five experienced

Figure 1. Drawing Proficiency Screening Questionnaire (DPSQ)

Items	Never 0	Rarely 1	Sometimes 2	Often 3	Always 4
1. Are the child's drawings unrecognizable and inappropriate for his or her age (for example, circles for age 3, squares for age 4, and triangles for age 5)?					
2. Does the child ask for help when drawing or coloring?					
3. Does the child rush when coloring or drawing and finish quickly?					
4. In a learning situation, are there times when the child doesn't have enough time to finish drawing tasks?					
5. Does the child hold the drawing tool tightly or with a fisted grasp?					
6. Does the child complain of pain while drawing or coloring?					
7. Does the child tire while drawing or coloring?					
8. In a learning situation, does the child not want to do his or her schoolwork if it requires drawing or coloring?					
9. Does the child often tear the paper when coloring or drawing?					
10. Does the child express feelings of dissatisfaction with his or her drawings or coloring?					

teachers (who each had 15–35 yr of teaching experience) to rate whether the items were suitable and covered the drawing proficiency concept and whether they were written clearly enough to establish the content validity of the questionnaire. One teacher suggested minor editing changes to Question 1. After this editing, there was 100% agreement that each of the 10 items in the questionnaire was relevant to the concept being evaluated and clear and easily understood by teachers. Finally, these five experienced teachers tested the questionnaire with children whom they identified as nonproficient drawers. The teachers were asked whether the questionnaire was not helpful, somewhat helpful, or very helpful for use in the classroom. All five teachers considered the questionnaire to be very helpful in the classroom.

Phase 2: Analysis of Reliability and Validity

Participants. We sent permission forms to all parents at four randomly selected public and private preschools from the northeast region of the United States. Children with signed permission forms were included in this study. Of the participants, 46 attended public schools, and 32 attended private schools (mean [*M*] age = 4.8; standard deviation [*SD*] = 0.71; range = 3 yr, 5 mo–5 yr, 11 mo; 43 boys, 35 girls); and 66 self-identified as White and 12, as Asian. Seventeen of the children were classified as having developmental delays, 4 as having pervasive developmental disorder, and 3 as having autism.

Instruments. The VMI was developed and standardized by Keith E. Beery, Norman A. Buktenica, and Natasha A. Beery in 1967 and was revised in 1982, 1989, 1997, 2004, and 2010; we used the sixth edition (Beery & Beery, 2010). The VMI has been standardized on more than 13,000 children, and test norms for children ages 2–18 yr have remained stable over time (Beery & Beery, 2010). The assessment consists of an increasingly complex sequence of 24 geometric forms that children copy using pencil and paper. The test reveals visual–motor deficits, and standard scores below 85 indicate a delay. The VMI has high reliability (.96), internal consistency (.93), interscorer reliability (>.90), and validity (.80–.95; Beery & Beery, 2010). The scoring procedure involves tabulating raw scores, which are the number of forms completed until the child has three consecutive scores of 0). Raw scores are converted to standardized scores or percentiles and are compared with a normative population (average standardized scores range from 85 to 115, $M = 100$, $SD = 15$; Beery & Beery, 2010).

The ComPET software program (Rosenblum et al., 2003) is non–language dependent and analyzes every drawing stroke. The VMI tasks were performed on A4-size lined paper affixed to the surface of a Wacom (Vancouver, WA) Intuos 4 x-y digitizing tablet (404 × 306 × 10 mm) using a wireless electronic pen with a pressure-sensitive tip. Displacement, pressure, and pen-tip angle were sampled at 100 Hz via a 1300 MHz Pentium M laptop computer (Intel, Santa Clara, CA). The primary outcome measures were temporal, spatial, and pressure measures for each drawing stroke and overall performance of tasks.

Procedure. Procedure letters were sent to preschool directors from randomly selected public and private schools in Massachusetts requesting consent to participate in this study. School administrators from five schools consulted with their ethics committees and approved this study. To vary the sample population, we selected four of the schools, two public and two private, to participate. Children whose parents signed a permission slip were allowed to participate in the study.

Teachers completed the DPSQ for every child in the four preschools. Each child was seated at a small table that

was appropriate for his or her height. The children drew the VMI shapes with an electronic pen on the test form paper that was attached with tape to the digitizer. All the students completed the performance tasks in the same order. Each child was asked to copy a series of figures that increased in complexity. The children completed only the forms that were expected for their chronological age. The duration of the test was approximately 10–15 min per child. A research assistant numerically coded the VMI testing forms to eliminate scoring bias, and an occupational therapist with more than 15 yr of experience scored the tests. The data were entered for analysis into IBM SPSS Version 22 (IBM Corporation, Armonk, NY).

Results

Reliability and Internal Consistency

To consider the DPSQ a valid instrument for detection of a drawing deficiency, the Cronbach's α level would need to reach ≥.70 to demonstrate significant reliability. For the 16 teachers completing the DPSQ for 78 children in preschool younger than age 6, the DPSQ exhibited high reliability ($\alpha = .82$). Means and standard deviations for each item and for the final DPSQ mean score are listed in Table 1. The removal of any single item did not improve the tool's internal reliability. Correlation analysis revealed significant correlations ($r = .74$, $n = 78$, $p < .001$) between the 10 individual items of the DPSQ and the total questionnaire score.

Construct Validity

To establish construct validity, we examined whether the DPSQ discriminated between children with and without visual–motor deficits. Of our participants, 32 scored below average and were classified as at risk for visual–motor deficits, and 46 scored in the average range (85–115) and were classified as typically developing. We used *t* tests to compare the DPSQ scores of these two groups. Scores for the at-risk ($M = 10.50$, $SD = 6.24$) and typical ($M = 4.28$, $SD = 3.53$) groups differed significantly, $t(76) = 5.6$, $p = .001$. In addition, significant differences were found between the two groups for Items 1, 2, 3, 5, 7, 8, and 10. Children at risk for drawing deficits received higher DPSQ scores than typical children.

Concurrent Validity: VMI Scores

A significant moderate correlation was found between DPSQ scores and VMI total scores ($r = -.50$, $n = 78$, $p < .01$) in the entire sample.

Table 1. Drawing Proficiency Screening Questionnaire Scores, by Group

	Combined ($N = 78$)		At Risk ($n = 32$)		Typical ($n = 46$)	
Item	*M*	*SD*	*M*	*SD*	*M*	*SD*
1. Produces unrecognizable drawing	1.00	1.22	1.69	1.35	0.52	0.83
2. Asks for help	0.95	0.94	1.38	1.00	0.65	0.76
3. Rushes when drawing	1.01	1.12	1.66	1.26	0.57	0.75
4. Lacks time to finish drawing	0.69	0.86	0.81	0.99	0.61	0.74
5. Uses awkward pencil grip	1.22	1.26	1.72	1.27	0.87	1.12
6. Complains about pain	0.08	0.31	0.16	0.44	0.02	0.14
7. Tires when drawing	0.65	0.91	1.22	1.07	0.26	0.49
8. Avoids drawing tasks	0.74	1.00	1.16	1.16	0.46	0.75
9. Tears the paper	0.10	0.35	0.16	0.37	0.07	0.33
10. Is not satisfied with drawings	0.38	0.67	0.56	0.80	0.26	0.53
Total Final mean score	0.68	0.57	1.05	0.62	0.43	0.35

Note. Final score range = 0.00–2.40. *M* = mean; *SD* = standard deviation.

Concurrent Validity: ComPET Measures

Pearson product–moment correlation coefficients were computed to assess the relationships between the temporal, spatial, and pressure measures of the VMI drawings and the DPSQ scores:

1. Duration of the stroke in air and on paper
2. Length, height, and width of the stroke's path
3. Pressure applied to the writing surface.

A significant correlation was found between DPSQ scores and in-air time ($r = .37$, $n = 68$, $p = .002$) and mean pressure ($r = .32$, $n = 68$, $p = .007$). Students with higher DPSQ scores had higher in-air times and applied more pressure. We found no significant correlation between DPSQ scores and the other measures of the ComPET (Table 2).

Predicting Group Membership

Discriminant analysis was used to determine what fraction of the children were correctly classified as being at risk for visual–motor deficits on the basis of DPSQ final mean scores (Table 3). According to the results, 76% of the entire sample, 83% of the typical children, and 66% of the at-risk group were correctly classified on the basis of DPSQ mean final score ($p < .001$).

Discussion

The results of this study show the DPSQ to be a reliable and valid tool that teachers and occupational therapy practitioners can use to detect drawing difficulties in young children. This study is the first to confirm the utility of a screening tool for early detection of drawing difficulties in preschool children. The HPSQ is a quick and

Table 2. Correlations Between Drawing Proficiency Screening Questionnaire and Computerized Penmanship Evaluation Tool Scores ($N = 68$)

Variable	Correlation
Duration of in-air time	.36*
Duration of ground strokes	.05
Mean height	−.07
Mean width	−.10
Mean length	.05
Mean pressure	−.32*

*$p < .01$.

practical screening tool consisting of 10 questions intended to be used by teachers within the classroom to identify elementary-age children with handwriting difficulties (Rosenblum, 2008). Drawing difficulties are highly correlated with handwriting difficulties, and therefore we compared the DPSQ with the HPSQ (Bonoti et al., 2005; Sylla et al., 2011; Van Gemmert & Teulings, 2006). The reliability of the DPSQ ($\alpha = .82$) is similar to that of the HPSQ ($\alpha = .90$), suggesting that the DPSQ will be equally useful in identifying drawing problems.

Handwriting develops from the combination of many factors, such as visual–motor integration, pencil grip, fine motor skills, eye–hand coordination, kinesthesia, motor planning, and visual–perceptual skills all working together (Dankert et al., 2003). Development of visual–motor integration and eye–hand coordination is necessary to learn handwriting (Kaiser et al., 2009). Some studies have indicated that visual–motor integration is predictive of the quality of handwriting (Cornhill & Case-Smith, 1996; Weintraub & Graham, 2000). However, it is still unclear whether a child having difficulty in preschool with drawing skills will in fact have difficulty with handwriting in later years. Nevertheless, visual–motor abilities are important for early child development, and young children develop their visual–motor abilities in part through drawing, copying, and tracing (Kaiser et al., 2009). Therefore, a need exists for the DPSQ to enable teachers and occupational therapy practitioners to identify children with drawing difficulties in preschool.

The DPSQ demonstrated good construct validity. Significant differences were found between DPSQ scores in children considered at risk for drawing problems and children considered typical on the basis of their VMI scores. Lower VMI scores and higher DPSQ scores indicated that a child was at risk for visual–motor deficits. Visual–motor development has been shown to give information about a child's readiness for handwriting (Goyen & Duff, 2005; Marr & Cermak, 2002).

In addition, the DPSQ demonstrates good concurrent validity. Children who scored poorly on the DPSQ also demonstrated more in-air time and more pressure when drawing. Correlation has been established between biomechanical factors such as increased pressure and difficulties with the handwriting process (Rosenblum, Goldstand, & Parush, 2006). Increased pressure may result from difficulties with posture, pencil grip, positioning of the pencil, and repositioning of the pencil grip. Consistent with the finding in this study, in-air time has been shown to be a factor in nonproficient hand writers (Rosenblum et al., 2003).

Discriminant analysis showed that high DPSQ scores were a significant indicator of children at risk for drawing difficulties. Early detection of drawing problems provides vital insight into a child's difficulty with cognitive development and learning difficulties (Galli et al., 2011). Occupational therapy intervention has been shown to improve visual–motor skills in preschool children (Dankert et al., 2003). The DPSQ gives teachers and occupational therapy practitioners an objective way of measuring drawing development in children in the natural school environment and at an early age.

Limitations and Future Research

Limitations of this study include the limited sample size and the single geographic (northeastern) region of the United States. Further validation of the DPSQ is needed with larger sample sizes and diverse populations from different regions of the world. The DPSQ differentiated between the children with and without visual–motor deficits; however, it is still unclear whether these deficits predict future handwriting difficulties. Some children may benefit from close monitoring of their visual–motor development to prevent

Table 3. Group Classification by DPSQ Scores Versus VMI Classification

Group (Classified by VMI Scores)	DPSQ Scores		Absolute Count			Normalized Count, %		
	M	*SD*	At Risk	Typical	Combined	At Risk	Typical	Combined
At risk	10.50	6.24	21	11	32	66	34	100
Typical	4.28	3.53	8	38	46	17	83	100
Total	6.83	5.69	29	49	78	37	63	100

Note. Percentages represent normalized counts. $p < .001$. DPSQ = Drawing Proficiency Screening Questionnaire; *M* = mean; *SD* = standard deviation; VMI = Beery–Buktenica Developmental Test of Visual–Motor Integration.

future handwriting problems (Marr, Windsor, & Cermak, 2001). To more fully understand the development of drawing and its relationship to handwriting, a follow-up study is needed to determine the longitudinal changes that occur over time in the visual–motor skills of the children at risk for drawing difficulties. Such a longitudinal study would indicate whether those children having drawing difficulties are able to outgrow their difficulties with time.

Implications for Occupational Therapy Practice

The findings of this study have several important implications for occupational therapy practice and research:

- The DPSQ is a quick and practical tool for teachers and occupational therapists to use to identify children who may be at risk for drawing difficulties.
- The development of the DPSQ gives teachers and practitioners a tool to use in gathering information about students who might otherwise not receive needed services.
- Early identification of children with drawing difficulties may create opportunities for these children to receive early intervening services while they are still in preschool.
- The DPSQ enables public school personnel to screen entire classrooms, thereby meeting requirements for federal RtI initiatives.

Conclusion

Preliminary results indicate that the DPSQ is a standardized tool that accurately predicts risk of drawing difficulties in preschool children. Teachers and occupational therapy practitioners can use this tool as a screening questionnaire to indicate need for further assessment. In addition to its demonstrated reliability and validity, the DPSQ is cost effective and relatively easy to administer. Moreover, the DPSQ may be administered simply by having the teacher or practitioner observe the child and answer the questionnaire. These factors support use of the DPSQ in early detection of drawing difficulties while children are still in preschool. ▲

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