Title

Insights about the role of movement in literacy learning based on movement ABC-2 checklist parent ratings for students with and without persisting specific learning disabilities

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Abstract

Movement, which draws on motor skills and executive functions for managing them, plays an important role in literacy learning (e.g., movement of mouth during oral reading and movement of hand and fingers during writing); but relatively little research has focused on movement skills in students with specific learning disabilities (SLDs) as the current study did. Parents completed normed *Movement Assessment Battery for Children Checklist - 2nd edition* (ABC-2), ratings and their children in grades 4 to 9 (*M*=11 years, 11 months; 94 boys, 61 girls) completed diagnostic assessment used to assign them to diagnostic groups: control typical language learning (*N*=42), dysgraphia (impaired handwriting) (*N*=29), dyslexia (impaired word decoding/reading and spelling) (*N*=65), or oral and written language learning disability (OWL LD) (impaired syntax in oral and written language) (*N*=19). The research aims were to (a) correlate the *Movement ABC-2* parent ratings for Scale A Static/ Predictable Environment (15 items) and Scale B Dynamic/ Unpredictable Environment (15 items) with reading and writing achievement in total sample varying within and across different skills; and (b) compare each SLD group with the control group on *Movement ABC-2* parent ratings for Scale A, Scale B, and Scale C Movement-Related (Non-Motor Executive Functions, or Self-Efficacy, or Affect) (13 items). At least one *Movement*

ABC-2 parent rating was correlated with each assessed literacy achievement skill. Each of three SLD groups differed from the control group on two Scale A (static/ predictable environment) (fastens buttons and forms letters with pencil or pen) and on three Scale C (non-motor, movement-related) (distractibility, overactive, and underestimates own ability) items; but only OWL LD differed from control on Scale B (dynamic/unpredictable) items. Applications of findings to assessment and instruction for students ascertained for and diagnosed with persisting SLDs in literacy learning, and future research directions are discussed.

Insights about the Role of Movement in Literacy Learning Based on Movement ABC-2 Checklist Parent Ratings for Students with and without Persisting Specific Learning Disabilities

Many aspects of learning involve movement through time and space. The role of the body's movement through time and space is fundamental to the embodied cognition paradigm in psychology that has informed much research for over two decades on cognitive development and functioning (Pfeifer, & Bongard, 2006; Varela, Thompson, & Rosch, 1991) , emotional development and functioning (Damasio, 1999), and language development and functioning (Sheets-Johnstone, 1992).

Movement draws on both motor and non-motor skills. Oro-motor skills underlie place and timing of articulation of the mouth during speech which supports expression of oral language (Green, Moore, Higashikawa, & Steeve, 2000). Grapho-motor skills underlie hand gestures used in non-speech verbal communication (Cook, Mitchell, & Goldin-Meadow, 2008), which also plays an important role in oral language development, beginning in the preschool years. Grapho-motor skills related to hand position and placement and finger sequencing underlie handwriting

and other letter production modes that support written language learning and use at the word, sentence syntax, and text levels of production during the school years.

Moreover, not only oral-motor skills—for orally pronouncing single words in or out of sentence context, but also ocular-motor skills for the eye movements through time and space while orally or silently reading words in sentence context (e.g., Yagel et al., 2017) are related to reading. However, motor skills alone do not account for movement. For example, research has shown that (a) executive functions for planning serial movement in timed finger sequencing contributes to ordering strokes in forming letters, ordering letters in spelling words, and ordering words in composing syntax (e.g., Richards, Berninger, Stock, Altemeier, Trivedi, & Maravilla, 2009); but (b) developing patterns of movement for treating a letter as a single automatic unit rather than a series of unrelated component strokes is also important in handwriting development (Teulings, Thomassen, & van Galen, 1983). Furthermore, motor systems may interact with cognition as learners develop beliefs about their own writing and reading abilities and with emotions as developing writers experience affective responses to their movement abilities or weaknesses.

Movement Skills and SLDs

On the one hand, the movement skills for literacy learning during the preschool and school years draw on motor skills. Indeed, it has become part of 21st century culture for parents to note and share with medical and educational professionals when their preschool children reach specific motor milestones for gross motor (large muscle) and fine motor (small muscle) skills involving mouth, legs, arms, hands and fingers. Increasingly, it is common to include assessment of gross and fine motor development in school readiness assessments of typically developing children and evaluations of children referred for suspected congenital developmental disabilities

or coordination disorder (Jongmans, Smits-Englesmman, & Schoemaker, 2003) or acquired brain injuries or medical conditions affecting motor functions. On the other hand, school assessments of children struggling with oral and written language learning may not include assessments of oro-motor and grapho-motor functions related to literacy learning, especially during middle childhood and early adolescence. Moreover, such assessment performed by professionals is unlikely to include test measures of the executive functions for self-regulating the movement through space and time during literacy or literacy-related activities.

However, parent ratings of movement (motor related and non-motor related) may provide valuable information about movement skills in students with and without SLDs. The current study involved a collaboration between two cross-country research groups, each with established, longstanding programmatic research on literacy learning problems in English. The research group with a major focus on movement identified three important factors to evaluate in assessment of movement and an assessment tool for supplementing formal tests of movement with parent ratings (Henderson, Sugden, & Barnett, 2007), which has been shown to be valid and reliable for assessing motor skills (Schoemaker, Niemeijer, Flapper, & Bouwien, 2012). The three factors include (a) movement in a static and/or predictable environment, (b) movement in a dynamic and/or nonpredictable environment, and (c) non-motor processes related to the executive functions for self-regulating movement, the learner's self-efficacy, and the learner's affect related to movement. The other research group has applied multidisciplinary methods to study SLDs across the life span (Berninger & Richards, 2010), but in the current study investigated typical controls and students with persisting SLDs despite early intervention during middle childhood and early adolescence.

Research Aims

Specific Aim 1. The first research aim was to determine whether for the sample as a whole, which varied in level of reading and writing achievement, the parent-reported movement abilities/weaknesses are related to specific skills in literacy achievement. Significant correlations with reading and writing achievement would show that movement is related to literacy learning. Relationships were examined between (a) the parent ratings on two movement scales—for static/predictable and dynamic/non-predictable environment, and (b) their children's achievement on age normed reading and writing measures. Participants included both those who never showed any struggles in aural or oral language during the preschool years or written language learning during the school years, and those who met criteria, based on prior research, for a persisting SLD in *subword* handwriting, *word* decoding/reading and spelling, or *sentence* syntax in oral and/or written language. These are referred to as specific learning difficulties in UK and specific learning disabilities in US. Thus, in the current study they are referred to as SLDs which is an abbreviation for both terms.

Second specific aim. The second research aim was to determine whether different kinds of SLDs might have different parent-reported movement problems compared to typical language learner controls in static/predictable or dynamic/non-predictable environments or non-motor, movement-related problems (executive functions, self-efficacy, affective). The three SLD groups differed in *level* (unit) of language of their persisting impairment: dysgraphia (impaired *subword* handwriting), persisting dyslexia (impaired *word* reading/decoding and spelling/encoding), and/or persisting oral and written language learning disability—OWL LD (impaired *syntax* in oral and written language skills). OWL LD is also referred to as Specific Language Impairment (SLI) in the research literature and is known to sometimes have co-occurring speech problems,

which are related to motor immaturity (Bishop, 2001). These definitions of dysgraphia, dyslexia, and OWL LD are based on a comprehensive review of the research literature to which multiple investigators contributed (Silliman & Berninger, 2011). To summarize, this synthesis of research across research groups on SLDs in children and youth whose cognitive functioning falls at least within the lower limits of the normal range, supported neither a discrepancy definition (simple difference between achievement on a single measure and a full scale measure of intellectual functioning) or only failure to respond to instruction without diagnostic assessment to identify reasons for failure to respond. Rather the research has supported use of the *Wechsler Scales Verbal Comprehension Index* (VCI) (Wechsler, 2003), an indicator of ability to translate concepts and thoughts into oral language; learning profiles for literacy achievement (patterns of aural and oral language, reading, and writing skills); and profiles for phenotypes (behavioral markers of genetic and brain bases of various SLDs).

A recent research study provided additional validation for this approach to identifying contrasting SLDs. In that study sequential multiple regression, with Verbal Comprehension Index (VCI) entered first accounted for significant variance in reading and writing achievement; evidence-based working memory phenotypes for language learning entered next accounted for additional unique variance; and learning profiles for dysgraphia, dyslexia, and/or OWL LD entered last accounted for yet additional unique variance (Sanders, Berninger, & Abbott, 2017). Not only past (Berninger & Richards, 2010) but also recent brain imaging research (e.g., Berninger et al., 2015) and molecular genetics research (Abbott, Raskind, Matsushita, Richards, Price, & Berninger, 2017) have differentiated these three SLDs on biological-behavioral relationships.

There are two steps to this level of language differential diagnosis of SLDs such as dysgraphia, dyslexia, OWL LD (Berninger, 2015, Chapter 9). First, developmental disabilities (outside the normal range) are ruled out on basis of results of age normed tests for the five domains of development (cognitive, language, sensori-motor, social emotional, and attention/executive functions), parent questionnaires about the child's developmental, medical, and educational history, and parent ratings on normed checklists and inventories for documenting development within the normal range in each of the same five developmental domains. Second, based on normed measures, learning profiles (patterns of specific impaired literacy skills at specific levels/units of language on normed measures) and phenotype profiles (specific behavioral markers associated with genetic and brain research findings) are described to identify specific impaired literacy skills despite otherwise typical development. For learning and phenotype profiles, age or grade norms are used so that (a) the assessed individual can be compared with age or grade peers at the same time in development or within the same individual across development, and (b) individuals in a study in which participants vary in age or grade levels can be compared on scores that control for age and grade differences. For the most part these norms are based on national norming samples but occasionally on research norms from programmatic research. However, for the current study related to movement only learning profiles were constructed.

Method

Participants

Ascertainment over a four-year period. Flyers distributed to local schools announced an opportunity to take part in a university study for children in grades 4 to 9 who have a history of continuing reading and writing difficulties despite earlier intervention or who have never had any

struggles in learning to read and write. An initial screening interview was conducted over the phone for the purpose of determining if the literacy problems were probably related to SLDs in otherwise typically developing individuals or if the child would probably qualify for the control group. If so, informed consent was obtained from parent and assent from the child employing approved procedures by the Institutional Review Board (IRB) at the University and an assessment at the university was scheduled. If it was more likely the literacy problems were related to other reasons, such as severe developmental disabilities outside the normal range, acquired disorders, or medical conditions, for all of which literacy learning problems are likely to occur but for other reasons than for SLDs, the child was excluded from further participation.

The assessment was conducted at the university in compliance with the ethical and professional guidelines of the American Psychological Association. To be included a student had to have a *WISC 4 Verbal Comprehension Index* (VCI) (Wechsler, 2003) at least within the normal range (at or above a standard score of 80 or -1 1/3 SD), but generally VCI scores were higher (see Table 1).

Assignment to diagnostic groups. Based on scores on normed measures and review of parent-reported developmental, medical, family, and educational history on questionnaires and parent ratings on checklists or inventories, four groups were identified. For additional information on procedure beyond that in the introduction to this article, see Berninger et al. (2015) and Sanders et al. (2017).

One group was identified who never had any struggles in learning oral or written language (Control Group, *N*=42, 21 boys, 21 girls, M=147.88 months). A second group was identified who scored below the 25th % tile on at least two handwriting measures (*DASH 2 Copy Best*, Barnett, Henderson, Scheib, & Schulz, 2007; *DASH 2 Copy Fast*, Barnett et al., 2007; UW

Automatic Alphabet Writing from Memory, Berninger, 2009) and had a current and past history of ongoing struggles with legible and automatic handwriting and ability to write at age-appropriate speed (Dysgraphia Group, *N*=29, 23 boys, 6 girls, *M*=137.87 months). A third group was identified who scored below the population mean on at least two word reading/decoding measures (*WJ 3 Word Identification*, Woodcock, McGrew, & Mather, 2001; *WJ 3 Word Attack*, Woodcock et al., 2001; *TOWRE Sight Word and Phonemic Efficiency*, Torgesen, Wagner, & Rashotte, 1999) and/or spelling (*TOC Word Choice*, Mather, Roberts, Hammill, & Allen, 2008; *WIAT 3 Spelling*, Pearson, 2009) which also had to be at least a standard deviation below their *WISC 4 VCI* (Dyslexia Group, *N*=65, 37 boys, 28 girls, *M*=137.87 months). This approach, which does not require a rigid criterion of severe discrepancy, supports identification of dyslexia across a range of VCI abilities (Lyman, Sanders, Abbott, & Berninger, 2017). A fourth group was identified who scored at or below the 25th % tile on at least two syntax measures for written expression (e.g., *WJ 3 Writing Fluency*, Woodcock et al., 2001; *WIAT 3 Sentence Combining*, Pearson, 2009) and had a current and past history of ongoing struggles with one or more language skills at the syntax level (listening and reading comprehension and oral and written expression), which began during the preschool years (OWL LD Group, *N*=19, 13 boys, 28 girls, *M*=143.29 months). For review of research relevant to OWL LD/SLI, see Silliman and Berninger, (2011); also see Bishop & Snowling (2004); Bishop (2009); Catts, Adlof, Hogan, and Weismer (2005); Catts, Adlof, Hogan and Ellis Weismar (2005); Scott, (2011).

Sample characteristics. Altogether 155 children (ages 9 to 15, *M*=11 years, 11 months; 94 boys, 61 girls) completed the assessment while their parents rated them on the *Movement ABC-2 Checklist*. Ethnicities for children, as reported by their parents, included European American 70.3%, mixed Ethnicity 19.5%, Asian-American 3.2 %, Hispanic 1.9%, African

American 1.3%, Non-European Caucasian 1.3%, and Other/Non-specified 2.5%. Highest level of completed education reported by parents ranged from less than high school (mothers 0.7%, fathers 2.2%) to high school (mothers 2.8%, fathers 2.9%) to more than high school but less than college degree (mothers 5.6%, fathers 10.8%) to college degree (mothers 43.8%, fathers 43.9%) to more than college degree (mothers 47.2%, fathers 40.3%).

Procedures Related to *Movement ABC-2 Checklist* Parent Ratings

Parents of participating children and youth were asked to complete the *Movement ABC-2 Checklist* (Henderson et al., 2007). Parents have the advantage of observing their child's movement skills and other behaviors within and outside the home in a variety of both school and non-school related activities; and their observations may be as valuable as test scores in understanding how movement skills may be related to their child's literacy learning.

The *Movement ABC-2 Checklist* (Henderson et al., 2007) has two main sections related to everyday movement skills. Section A titled "Movement in a Static and/or Predictable Environment" (15 items) assesses three kinds of skills: Self-Care Skills, Classroom Skills, and Physical Education/Recreational Skills. Section B titled "Movement in a Dynamic and/or Unpredictable Environment" (15 items) assesses three kinds of skills: Self-Care Skills, Ball Skills, and Physical Education/Recreational Skills. For all skills in Scale A and Scale B, parents first decide if their child can perform the skill or not. If the child can perform the skill, the parent rates whether very well (0), or just ok (1). If the child cannot perform the skill, the parent rates whether almost (2) or not close (3). Thus, ratings vary along a 4-point ordinal scale. No is recorded if the skill has not been observed and no rating can be given. In addition, Section C (13 items) requested ratings of non-motor variables such as executive functions, cognitions related to self-efficacy, and affect related to movement on a scale of not at all; a little, or a great deal.

Examples of the executive functions include organization, distractibility, and lacks persistence. Examples of self-efficacy include underestimates own ability. Examples of affect include timid, and anxious. Thus, on all rating scales a higher rating reflected greater difficulty.

Data Analyses

For the first specific aim, the *Movement ABC-2 Checklist* parent ratings were correlated with normed writing and reading achievement measures in the whole sample of children with and without SLDs to evaluate if parent ratings of movement are related to literacy learning. For the second specific aim, between-participant analyses of variance (ANOVA) were used to evaluate significant differences between the means of the typical language learner control group and each of the SLD groups (dysgraphia, dyslexia, or OWL LD) on *Movement ABC-2 Checklist* parent ratings. Separate analyses were performed for each item within each Scale (A, B, C) to identify the items for each Scale that might significantly differentiate each group from the control group.

Results

Descriptive Statistics for the Diagnostic Groups

Table 1 summarizes the means and standard deviations for measures used for assignment to diagnostic groups. The means for *WISC 4 Verbal Comprehension Index (VCI)* (Wechsler, 2003) in the current study illustrate what has been found in past programmatic research on the relationship between this measure and literacy achievement as a function of diagnostic group. In the current study average *WISC 4 VCI* score for the typical control group was in the average range (above the population mean), for the dysgraphia and dyslexia groups slightly higher in the above average range, and for the OWL LD group in the low average range. The lower *WISC 4 VCI* mean score in the OWL LD group does not mean this group has lower cognitive ability but

rather that their oral language skills do not support translation of cognitions into oral language as well as in the other groups. See Table 1.

Insert Table 1 about here.

Those with dysgraphia scored lowest on handwriting measures (*DASH 2 Copy Best and Copy Fast* for sentences with all 26 letters, Barnett et al., 2007; and Alphabet 15—number of legible letters in correct order in first 15 seconds of writing 26 alphabet letters from memory, Berninger, 2009). Those with dyslexia scored lower than the typical control and dysgraphia groups on spelling measures—*TOC Word Choice* for recognition of correct spellings, Mather et al. (2008) and *WIAT 3 Spelling* (Pearson, 2009), and on word reading/decoding measures for accuracy (*Word Identification* and *Word Attack* subtests, Woodcock et al., 2001) and rate (*TOWRE Sight and Phonemic Reading subtests*, Torgesen et al., 1999). The OWL LD group was much lower than any of the other groups on literacy tasks involving their primary area of impairment—syntax, for example, *WJ3 Writing Fluency* (Woodcock et al., 2001) for constructing written sentences from three provided words under time limits or *WIAT 3 Sentence Combining* (Pearson, 2003) for creating one sentence that expresses all the ideas in the two provided sentences. See Table 1.

Correlations between *Movement ABC-2* Parent Ratings and Literacy Achievement

To illustrate that movement is related to literacy achievement, Table 2 summarizes the significant correlations between the parent ratings on specific *Movement ABC-2 Checklist* items and achievement in literacy skills in this sample of children with and without persisting SLDs in middle childhood and adolescence. The text that follows describes the results for these literacy skills organized by level (unit) of language involved: *subword* (handwriting), *word* reading and

spelling, and *sentence syntax* (composing). Negative correlations indicate that the higher the parent ratings in movement difficulties, the lower the achievement in a writing or reading skill.

Insert Table 2 about here.

Subword handwriting. For each of the three handwriting skills, *Movement ABC-2 Checklist* parent ratings were correlated with two items on Scale A (static and/or predictable environment), but not necessarily the same ones. For copying in one's best handwriting the significant correlations were with one Self-Care Skill ("Fastens Buttons") and one Classroom Skill ("Uses Scissors to Cut Paper"). In contrast, sentence copying in one's fast handwriting and automatic writing of the alphabet from memory were correlated with the same two Scale A items—one not shared with copying in one's best handwriting—"Forms Letters Using Pen or Pencil"— and one the same as for copying in one's best handwriting—"Uses Scissors to Cut Paper". See Table 2 for magnitude of significant correlations.

Word reading/decoding (accuracy and rate) and spelling/encoding. Five word level skills were correlated with "Recreational Skills Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons" in Dynamic/Unpredictable Environment: oral reading of real words—accuracy and rate, and pseudowords—accuracy and rate, and dictated spelling. One word-level skill was correlated with these two items " Self Care Skills—Pour Liquid from One Container to Another" and "Classroom Skills—Manipulates Small Objects" in Static and/or Predictable Environment: rate of oral reading of pseudowords. One word-level skill was correlated with "The Self-Care/Classroom Skills item in Dynamic and/or Unpredictable Environment—Keeps Time to Musical Beat by Clapping Hands or Tapping Feet": *WIAT 4 spelling*. Also significantly correlated with *WIAT 4 Spelling* were these two items: "Classroom Skills—Forms Letters Using a Pencil or Pen" and "Uses Scissors to Cut Paper in Static and/or

Predictable Environment" for Static and/or Predictable Environment. These latter two items were also correlated with *DASH2 Copy Fast* and Automatic Alphabet Letter from Memory. Three items—"Participates in Dodging and Chasing Games in Dynamic" and "Maintains Balance in Water among Children (e.g. standing in a swimming pool)" in Dynamic and/or Unpredictable Environment, and "Uses Stationary Gym/Playground Equipment (e.g., climbing frame, slide) in Predictable Movement Environment— were correlated with *TOC Word Choice*. See Table 2 for the magnitude of these correlations for reading and spelling at the word-level and related ones at the subword level.

Syntax-level Composing. The item "Self-Care Skills—Pour Liquid from One Container to Another (e.g., from a jug to a beaker)" in Static and/or Predictable Manner was correlated with both *WJ Writing Fluency* and *WIAT 4 Sentence Combining*. Also significantly correlated with *WJ Writing Fluency* were these items: "PE/Recreational Skills in Predictable Environment—Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons" and "Moves Body in Time with Music or Other People" (e.g., marches in line, dances in a group)" in Dynamic and/or Unpredictable Environment.

Comparing Each SLD Group with Control Group on *Movement ABC-2 Checklist* Ratings

Summary of comparison of each SLD group and control group. The dysgraphia group differed from the control group on four Scale A items and five Scale C items, but not any Scale B items. The dyslexia group differed from the control group on two Scale A items, and five Scale C items, but not any Scale B items. The OWL LD group differed from the control group on six Scale A items, five Scale B items, and six Scale C items. See Tables 3, 4, and 5.

Insert Tables 3, 4, and 5 about here.

Two of the Scale A items (movement in static and/or predictable environment) differentiated each of the three SLD groups from the control group: “Self-Care Skills—Fasten Buttons” and “Classroom Skills—Forms Letters with a Pencil or Pen”. Two of the Scale A items differentiated two SLD groups (dysgraphia and OWL LD) from the control group: “Classroom Skills-Uses Scissors to Cut Paper” and “PE Recreational Skills—Hops on Either Foot”. Two of the Scale A items uniquely differentiated the OWL LD group from the control group: “Self-Care Skills—Pours Liquids from One Container to Another” and “Classroom Skills—Manipulates Small Objects”. Although neither the dysgraphia or the dyslexia group differed from the control group on Scale B (movement in dynamic and/or unpredictable environments), the OWL LD group did on five Scale B items: Self-Care Classroom Skills for “Keeps Time to a Musical Beat by Clapping Hands or Tapping Feet” and “Moves Body in Time with the Music”, Ball Skills—“Catches a Ball Using a Two Hand Catch”, and Recreational Skills—“Uses a Nonstationary Gym Playground” and “Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons”.

All three SLD groups differed from the Control Group on three Scale C items (non-motor movement-related executive functions, self-efficacy, and affect): “Distractibility”, “Overactive”, and “Underestimates Own Ability”. “Lacks Persistence” and “Upset by Failure” uniquely differentiated the dysgraphia group from the control group. See Table 3. “Hesitant” and “Forgetful” uniquely differentiated the dyslexia group from the control group. See Table 4. “Anxiety” and “Overestimates Own Ability” uniquely differentiated the OWL LD group from the Control Group. See Table 5.

Discussion

Research Significance of Findings and Future Research Directions

First research aim. Collectively, these findings show that parent ratings on the *Movement ABC-2 Checklist* are related to literacy achievement. At least one item on Scale A or Scale B of checklist was correlated with each writing and reading achievement measure used in the diagnostic assessment. That is, ratings of movement were related to literacy learning, consistent with embodied cognition playing an important role in language development (Sheets-Johnstone, 1992). Future research should further explore the role of both motor skills and related executive functions in managing movement through time and space in literacy learning and achievement.

Second research aim. Of interest, only the OWL LD group differed from the control group on Scale B (dynamic and/or unpredictable environment). All three SLDs groups differed from the control group on Scale A (static and/or predictable environment), sometimes in the same way and sometimes in contrasting ways. So movement issues may be related to some degree and in some ways to the nature of an SLD.

Each of the three SLD groups—dysgraphia, dyslexia, and OWL LD—differed in mean ratings from the control group on the Scale C items for "distractibility" and "overactive". These findings are of interest because only one-third of the sample had been diagnosed with co-occurring ADHD prior to participation in this study for which students in grades 4 to 9 with persisting SLDs in reading, writing, or oral and written language had been recruited, the ADHD diagnosis correlated only with handwriting, and participants also showed difficulties on measures of paying attention to *language* independent of ADHD diagnosis (Berninger, Abbott, Cook, and Nagy, 2016). Future research should examine parent ratings on the *Movement ABC2* for a sample ascertained specifically for ADHD and assessed for co-occurring SLDs in contrast to the current

study that ascertained specifically for SLDs and assessed for co-occurring ADHD. Results might be very different if the primary disorder is ADHD. However, the current study shows that even if students do not qualify for a diagnosis of ADHD, relative weaknesses in self-regulating attention (resulting in distractibility) and activity levels (resulting in overactivity) may affect movement, which in turn, may affect literacy achievement among those whose struggles in literacy learning persist beyond early childhood into adolescence.

It was also the case that all three SLD groups differed from the Control Group in "Underestimates Own Ability". Persistent struggles in language learning may affect one's self-efficacy, that is, belief that one can learn and has the ability to achieve at a higher level. Thus, not only movement but also belief that one has the ability to achieve may affect movement-related literacy learning.

Clinical Significance for Assessing Students with Dysgraphia, Dyslexia, and OWL LD

Although the *Movement ABC-2 Checklist* was developed in one English-speaking country, the UK, the results of the current study provide support for using the parent ratings on this checklist in another English-speaking, country, the US. Similarly, the *DASH-2* (Barnett et al., 2007), which was developed in UK, has proved useful and valid for assessment of handwriting in the US for both students with and without SLDs (see Berninger et al., 2015; Sanders et al., 2017). Both of these handwriting measures can be incorporated into the clinical assessment of students referred for persisting literacy problems. Moreover, the results illustrate the relevance of including parent ratings of movement and not just normed achievement tests in assessing literacy achievement in students with persisting SLDs. The current research is based only on samples of students with and without SLDs in middle childhood and early adolescence. Future research should extend studies of this movement checklist to earlier developmental

periods for SLDs and to disorders other than SLDs that may interfere with literacy learning, including developmental disabilities in the motor functions. For example, the whole checklist (see all items on Scales A, B, and C, Henderson et al., 2007) can be used in practice and future research for screen-intervene literacy prevention models in the early grades (e.g., K to 3 in US) as part of reaching out to parents to create collaborative home-school partnerships to foster literacy learning. The *Movement ABC-2 Checklist* can also be used to for reaching out to parents whose child's motor development during the preschool years was not typical.

Instructional Applications of *Movement ABC-2 Checklist* Parent Ratings

The findings also have potential instructional applications. First, currently multisensory instruction is recommended for students with dyslexia, but the current results show that (a) some motor-related movement skills for static and/or predictable environments are correlated with measures of writing and reading achievement; and (b) the dyslexia group differed from the control group on certain motor-related movement items in Scale A. Although multi-sensory input is necessary, it is not sufficient. Literacy learning also benefits from grapho-motor movements, for example, for formation of the letters stroke by stroke when learning or automatic production units when highly practiced (Teulings et al., 1983) and for dictated spelling and composing. Literacy learning also benefits from oro-motor movements when sounding out unfamiliar words or pronouncing single familiar words out of context or orally reading passages.

Second, not only explicit instruction in writing and reading but also incorporating movement in learning activities may be beneficial for literacy learning. Many participants in the current study also subsequently enrolled in a literacy instructional program. Their teachers noted that many needed and benefitted from movement breaks when they became distractible and were not paying attention or engaging fully in the literacy instruction. During these movement breaks

the children showing signs of needing them, who were not necessarily diagnosed with ADHD, would do physical exercises or dance. Following these movement breaks, both those with and without SLDs were better able to focus their attention and engage in the language learning activities. Organized recess breaks at school are another way to provide movement breaks. Controlled research is needed on whether movement breaks contribute to learning compared to only sitting still, especially in students with persisting SLDs during middle childhood and early childhood who show signs of distractibility or overactivity. Parent and teacher ratings on the *Movement ABC-2 Checklist* could be used before and after literacy interventions with and without movement components to evaluate benefits of movement for SLDs.

Third, in translating research into instructional practice to meet individual instructional needs, drawing on not only normed measures for age or grade but also parent ratings (and responses to questionnaires and interviews) can be helpful. Parent ratings on their child's movement are useful for educators in individualizing literacy programs for students with relative strengths or relative weaknesses in movement. In working with students who subsequently participated in the instructional intervention the research team noted that many of them with and without SLDs or co-occurring ADHD had relative strengths in movement, which, for example, contributed to their success as athletes, dancers, and actors/actresses, or relative weaknesses in movement, for example, clumsiness and coordination problems, which interfered with their learning in environments requiring various kinds of movement or tool use or sports. The *Movement ABC2 Checklist* has important applications clinically to the person behind the disability who may exhibit strengths and weaknesses not fully captured in a diagnosis related to the nature of an SLD related to literacy learning on the basis of standardized, normed tests.

Moreover, some typical controls who did not struggle in language learning had relative weaknesses in movement that were of concern to them and their parents.

Limitations and Directions for Future Research

The three SLDs investigated in the current study do not include all the kinds of learning difficulties or disabilities that school age children may exhibit. Nevertheless dysgraphia, dyslexia, and OWL LD (also known as SLI) affect a sizable number of school-age children and youth and are among the most investigated SLDs across countries, although not the only ones. Further complicating matters is the lack of consensus among policy makers and researchers across and within countries on how SLDs should be defined.

Also, results of the current study generalize only to (a) a specific developmental period in literacy acquisition (middle childhood and early adolescence) and (b) students recruited for presence or absence of persisting SLDs in literacy despite intervention. They do not generalize to students at other developmental time points in literacy acquisition, students ascertained for ADHD and then assessed for possible co-occurring literacy learning problems, or students with congenital or acquired motor disabilities.

Although the *Movement ABC 2 Checklist* has been investigated in two English-speaking countries, more research with it is needed in multiple countries and for multiple languages to advance knowledge of the interrelationships of motor and executive functions in movement and literacy learning and investigate these issues in various student populations . At a time when advances are being made in handwriting assessment (e.g., Matias, Teulings, Silva, & Melo, 2017) and instruction (e.g., Wawrzyniak, Teulings, Korbecki, Cichy, & Rokita, 2017), it is important to assess and teach both writing and reading skills in reference to movement in both predictable and unpredictable environments, executive functions for coordinating movement,

self-efficacy related to movement, and affective responses to possible problems in movement-related literacy learning.

The current study provides initial evidence supporting wider use of *Movement ABC-2 Checklist* in educational and clinical practice and research. This study, which was seeking differences between each SLD group and control group on movement checklist items, will hopefully stimulate future research on the role of movement in literacy learning. Only if results are replicated and converge across future studies can the scientific foundations of the role of movement in literacy learning be established.

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Table 1

Descriptive Statistics for Each Diagnostic Group

Measure	Typical		Dysgraphia		Dyslexia		OWL LD	
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
Verbal Comprehension Index	109.06	(10.62)	110.23	(15.88)	114.37	(10.05)	89.50	(15.01)
DASH Best	11.59	(2.24)	8.62	(3.16)	9.17	(3.60)	9.07	(3.97)
DASH Fast	10.88	(2.29)	6.42	(2.90)	7.33	(3.37)	6.64	(3.77)

Alphabet 15 z	-.87 (.55)	-1.66 (.68)	-1.36 (.78)	-1.50 (.70)
TOC Word Choice	11.65 (3.08)	11.19 (3.26)	9.11 (2.98)	7.43 (2.03)
WIAT 3 Spelling	108.53 (11.38)	99.92 (19.51)	85.72 (11.57)	81.43 (8.67)
WJ3 Word Identification	110.06 (8.19)	109.08 (11.61)	97.28 (9.54)	87.57 (11.99)
TOWRE Sight	109.94 (13.16)	110.08 (14.73)	94.78 (12.76)	89.50 (12.34)
WJ3 Word Attack	106. 41 (9.05)	106.23 (11.86)	94.63 (8.23)	89.07 (10.01)
TOWRE Phonemic	110.59 (14.04)	107.15 (17.10)	88.20 (11.76)	81.00 (18.92)
WJ3 Writing Fluency	108.29 (8.29)	96.69 (11.30)	95.89 (9.52)	80.36 (15.59)
WIAT3 Sentence Combining	113.65 (10.30)	100.46 (17.51)	97.41 (14.92)	87.86 (10.19)

Table 2

Significant Correlations for Parental Movement Ratings of Their Children on Movement ABC2 Scales A or B and Assessed Achievement in Academic Skills. See Table Note.

Academic Skill	Parental Rating	*r*	*p*
HANDWRITING PARENTAL MOVEMENT RATINGS			
DASH Copy Best Scale A Predictable Movement Environments			
	Self Care Skills A1.3 Fastens Buttons	*r*= -.327	*p*=.000
	Classroom Skills A.2.3 Use Scissors to Cut Paper	*r*= -.281	*p*=.001
	Classroom Skills A.2.2 Forms Letters Using Pen or Pencil	*r*= -.256	*p*=.002
DASH-Copy Fast Scale A Predictable Movement Environments			
	Classroom Skills A.2.2 Forms Letters Using Pen or Pencil	*r*= -.328	*p*=.000
	Classroom Skills A.2.3 Use Scissors to Cut Paper	*r*= -.287	*p*=.000
	Self Care Skills A1.3 Fastens Buttons	*r*= -.245	*p*=.003
Alphabet 15 **Scale A Predictable Movement Environments**			
	Classroom Skills A.2.3 Use Scissors to Cut Paper	*r*= -.281,	*p*=.001
	Classroom Skills A.2.2 Forms Letters Using Pen or Pencil	*r*= -.260	*p*=.001
	Self Care Skills A1.3 Fastens Buttons	*r*= -.176	*p*=.03

Table 2 continued

Academic Skill	Parental Rating	*r*	*p*
SPELLING AND PARENTAL MOVEMENT RATINGS			
Correlations with WIAT 4 Spelling			
	A.3.5 PE/ Recreational Skills in Predictable Environment—Crosses the Gym/Playground Avoiding Collision with Objects/Persons	*r*= -.195	*p*=.015
	B.1.4 Self-Care/Classroom Skills in Dynamic and/or Unpredictable Environment—Keeps Time to Musical Beat by Clapping Hands or Tapping Feet	*r*= -.172	*p*=.035
	A.3.2 PE/Recreational Skills in Predictable Environment—Hop on Either Foot	*r* = -.181	*p*=.025
Correlations with TOC Word Choice			
	B.3.2 Participates in Dodging and Chasing Games in Dynamic and/or Unpredictable Environment	*r*= .238	*p*=.014
	B.3.3 Maintains Balance in Water among Other Children (e.g. standing in swimming pool) in Dynamic and/or Environment	*r*=.238	*p*=.014
	A.3.4 Uses Stationary Gym/Playground Equipment (e.g. climbing frame, slide) in Predictable Movement Environment	*r*=.236	*p*=.014

Table 2 continued

Academic Skill	Parental Rating	*r*	*p*
COMPOSING WRITTEN SENTENCES AND PARENTAL MOVEMENT RATINGS			
Correlations with WJ3 Writing Fluency			
(timed sentence construction from three provided words)			
	B.3.5 PE/ Recreational Skills in Predictable Environment— Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons in Dynamic and/or Unpredictable Environment	*r*=-.26	*p*=.002
	B.1.5 Moves Body in Time with Music or Other People (e.g., marches in line, dances in a group) in Dynamic and/or Unpredictable Environment	*r* =-.23	*p*=.008
	A.1.5 Self Care Skills—Pour Liquid from One Container to Another (e.g., from a jug to a beaker) in Static and/or Predictable Environment:	*r* = -.22	*p*=.009
Correlations with WIAT 4 Sentence Combining			
(timed new sentence construction from two provided sentences)			
	A.1.5 Self Care Skills—Pour Liquid from One Container to Another (e.g., from a jug to a beaker) in Static and/or Predictable Environment	*r* = -.34	*p*=.000
	A.2.2 Classroom Skills-Forms Letters Using a Pencil or Pen in Static and/or Predictable Environment	*r* = -.30	*p*=.000
	A.2.3 Classroom Skills—Uses Scissors to Cut Paper in Static and/or Predictable Environment	*r* = -.30	*p*=.000

Table 2 continued

Academic Skill	Parental Rating	*r*	*p*
READING AND PARENTAL MOVEMENT RATINGS			
Correlations with WJ 3 Word Identification (real words--accuracy)			
	B.3.5 PE/ Recreational Skills Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons in Dynamic and/or Unpredictable Environment	*r* = -.25	*p*=.002
	A.1.5 Self Care Skills—Pour Liquid from One Container to Another in Static and/or Predictable Environment (e.g., from a jug to a beaker)	*r* = -.22	*p*=.007
Correlations with TOWRE Sight Words (real words—rate)			
	B.3.5 PE/ Recreational Skills Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons in Dynamic and/or Unpredictable Environment	*r* = -.21	*p*=.01
Correlations with WJ3 Word Attack (pseudowords—accuracy)			
	B.3.5 PE/ Recreational Skills – Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons in Dynamic and/or Unpredictable Environment	*r*= -.23	*p*=.004

Table 2 continued

Academic Skill	Parental Rating	*r*	*p*
Correlations with TOWRE Phonemic (pseudowords—rate)			
	B.3.5 PE/ Recreational Skills– Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons in Dynamic and/or Unpredictable Environment	*r* = -.23	*p*=.004
	A.1.5 Self Care Skills—Pour Liquid from One Container to Another (e.g., from a jug to a beaker) in Static and/or Predictable Environment	*r* = -.162	*p*=.046
	A.2.1 Classroom Skills Manipulates small objects in Static and/or Predictable Environment	*r* = -.157	*p*=.05

Note**.** Correlations based on the total sample and performed for each of the assessed academic achievement measures for literacy in reading and writing.

Table 3
Significant Differences between the Dysgraphia Group (N=29) and Control Group (N=42).

	Dysgraphia Group		Control Group	
F (df) *p*	*M*	*SD*	*M*	*SD*
A. Movement in a Static and/or Predictable Environment				
A. 1.3 Self Care Skills—Fasten Buttons				
F(1, 69)=7.37, *p*=.008	.31	.66	.24	.15
A.2.2 Classroom Skills-Forms Letters Using a Pencil or Pen				
F(1, 69)=10.20, *p*=.002	.76	.83	.21	.61
A.2.3 Classroom Skills-Uses Scissors to Cut Paper				
F(1,69)=6.61, *p*=.012	.38	.62	.10	.30
A.3.2 PE/Recreational Skills-Hops on Either Foot				
F(1, 69)=3.98, *p*=.05	.24	.79	.00	.00
B. Movement in Dynamic and/or Unpredictable Environment None				
C. Non-Motor Factors that May Affect Movement				
C7 Distractibility				
F(1, 68)=15.08, *p*<.001	.44	.50	.21	.07
C8 Overactive				
F(1, 68)=4.53, *p*=.037	.36	.49	.14	.35
C10 Underestimates Own Ability				
F(1, 68)= 7.31, *p*=.009	.46	.50	.26	.45
C11 Lacks Persistence *F*(1, 68)=5.35, *p*=.024	.61	.50	.33	.47
C12 Upset by Failure				
F(1, 68)=8.24, *p*=.005	.64	.49	.31	.47

Table 4

Significant Differences between the Dyslexia Group (*N*=65) and Control Group (*N*=42). See note.

	Dyslexia Group		Control Group	
F (df) *p*	*M*	*SD*	*M*	*SD*
A. Movement in a Static and/or Predictable Environment				
A. 1.3 Self Care Skills—Fasten Buttons				
F(1,103)=5.14 *p*=.025	.22	.55	.02	.15
A.2.2 Classroom Skills-Forms Letters Using a Pencil or Pen				
F(1,103)=5.47 *p*=.021	.57	.86	.21	.61
B. Movement in Dynamic and/or Unpredictable Environment None				
C. Non-Motor Factors that May Affect Movement				
C.1 Disorganized				
F(1, 101)=5.92, *p*=.017	.44	.50	.21	.07
C.2 Hesitant/Forgetful				
F(1, 102)=5.20, *p*=.014	.42	.50	.19	.40
C.7 Distractibility				
F(1, 102)=13.62, *p*<.001	.53	.50	.19	.40
C.8 Overactivity				
F(103)=4.92, *p*=.029	.33	.48	.15	.35
C.10 Underestimates Own Ability				
F(1, 103)=4.30, *p*=.041	.46	.50	.26	.45

Note. Two in dyslexia group did not have usable data for each item.

Table 5

Significant Differences between OWL LD (N=19) and Control Group (N=42)

		OWL LD Group		Control Group	
F (df)	*p*	*M*	*SD*	*M*	*SD*
A. Movement in a Static and/or Predictable Environment					
A. 1.3 Self Care Skills—Fasten Buttons					
F(1, 59)=20.49	*p*=.000	.58	.77	.02	.15
A.1.5 Self-Care Skills --Pours Liquids from One Container to Another					
F(1,59)=5.89	*p*=.018	.57	1.02	.10	.37
A.2.1 Classroom Skills—Manipulates small objects					
F(1,59)=5.27	*p*=.025	.37	.96	.02	.15
A.2.2 Classroom Skills-Forms Letters Using a Pencil or Pen					
F(1, 59)=7.33	*p*=.009	.74	.87	.21	.61
A.2.3 Classroom Skills-Uses Scissors to Cut Paper					
F(1, 59)=8.76	p=.012	.47	.84	.10	.30
A.3.2 PE/Recreational Skills-Hops on Either Foot					
F(1, 59)=7.62	p=.008	.16	.37	.00	.00
B. Movement in Dynamic and/or Unpredictable Environment					
B.1.4 Self-Care/Classroom Skills—Keeps time to a musical beat by clapping hands or tapping feet					
F(1,56)=5.42	p=.024	.38	.06	.10	.37

Table 5 continued

		OWL LD Group		Control Group	
F (df)	*p*	*M*	*SD*	*M*	*SD*
B.1.5 Self-Care/Classroom Skills—Moves Body in Time with Music or Other People	$F(1,56)=7.55$ $p=.008$	.56	1.03	.07	.34
B.2.1 Ball Skills—Catches a Ball Using a Two-Handed Catch	$F(1,57)=7.61$ $p=.008$	.53	1.01	.07	.26
B.3.4 PE/Recreational Skills--Uses Non-stationary Gym/Playground Equipment (e.g. swings, scooters)	$F(1,57)=4.81$ $p=.032$	.18	.53	.00	.00
B.3.5 PE/Recreational Skills—Crosses the Gym/Playground Avoiding Collision with Moving Objects/Persons	$F(1, 57)=5.41$ $p=.024$	.12	.23	.00	.00
C. Non-Motor Factors that May Affect Movement					
C.2 Hesitant/Forgetful	$F(1, 58)=4.32$ $p=.042$	.44	.51	.19	.40
C.5 Anxious	$F(1, 59)=7.76$ $p=.007$	.53	.51	,19	.40
C.7 Distractibility	$F(1, 59)=28.75$ $p<.001$	.79	.42	.19	.40

Table 5 continued

	OWL LD Group		Control Group	
F (df) *p*	*M*	*SD*	*M*	*SD*
C.8 Overactive				
F (1, 58)=9.67 *p*=.003	.50	.51	.14	.35
C. 9 Overestimates Own Ability				
F(1, 59)=10.42 *p*=.002	.58	.51	.19	.40
C.10 Underestimates Own Ability				
F(1,59)=6.09 *p*=.017	.58	.51	.26	.45