

An Update on the Florida State Twin Registry

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The Florida State Twin Registry began in 2002 through a pilot study of personality disorders and executive cognitive functioning in adult twins. Since 2006, the registry has grown substantially as part of the Learning Disability Research Center at Florida State University that recently began its second funding cycle through the National Institute of Child Health and Development. An update on the Florida State Twin Registry sample, focus, and measures is provided, as well as future directions.

■ **Keywords:** Twin, reading, environment, genetic, behavior problem

The Florida State Twin Registry (FSTR; Taylor et al., 2006) was created in 2002 while recruiting adult twins into a pilot study of personality disorders and executive cognitive functioning. Prior to that, most personality disorders other than antisocial had not been widely studied using genetically informative designs (Dahl, 1993). Research had shown that certain personality disorders were inversely correlated with performance on executive functioning measures (Diforio et al., 2000; Mazas et al., 2000; Sprock et al., 2000), but studies of the broad array of personality disorders in relation to executive functioning was lacking. Given these gaps in the literature, a pilot study of personality disorder and executive functioning in adult twins was funded through the National Institutes of Mental Health, and the FSTR was created in the process.

Although the sample size was limited, the original FSTR pilot study produced an interesting finding in regard to executive functioning. The Wisconsin Card Sorting Test (WCST; Heaton, 2000) and the Stroop Color-Word Test (Golden, 1978) were administered to twins who were all free of any history of neurological disorder and head injury according to self-report. While the Stroop Test showed moderate heritability, the WCST showed none, raising some questions about the utility of that widely used measure as an endophenotype for disorders such as schizophrenia (Taylor, 2007). Some studies found moderate heritability on some WCST scores (Anokhin et al., 2003; Godinez et al., 2012), other small studies (e.g., Campana et al., 1996) and two larger studies (Chou et al., 2010; Kremen et al., 2007) are consistent with the FSTR study in finding no genetic influence on traditional WCST scores.

A New Direction for the FSTR

In 2006, the FSTR began to grow again through the Florida Twin Project on Reading (Taylor & Schatschneider, 2010)

that was part of the newly founded Learning Disability Research Center at Florida State University. The Florida Learning Disability Research Center is one of four centers in the United States focused on understanding causes of and intervention for learning problems and disabilities. Although other excellent twin studies of reading and learning disabilities exist in the United States, including the Western Reserve Twin Project (Petrill et al., 2006) and the long-standing Colorado Learning Disability Research Center (DeFries et al., 1997), there was a need for additional ethnic/economic diversity that a twin sample from a large state like Florida could provide.

The first paper from the Florida Twin Project on Reading began to explore the diversity of the sample, examining if estimates of genetic and environmental influences on kindergarten and first grade reading differed by neighborhood income, while controlling for race/ethnicity (Taylor & Schatschneider, 2010). Results suggested additive genetic and shared environmental influences for kindergarten early literacy skills, no matter what the neighborhood income. Differences based on neighborhood income were found for first grade early reading skills, with low neighborhood income children showing substantial effects due to the shared environment, and middle to high neighborhood income children showing large genetic effects. Another report explored the influence of the environment, this time classroom influences labeled as ‘teacher

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quality, measured by twins' classmate gains in oral reading fluency scores over a school year, on twins' oral reading fluency performance (Taylor et al., 2010). Teacher quality moderated the genetic variance associated with early reading, suggesting that with low teacher quality (low classmate gains), genetic variance is restricted, whereas with high teacher quality, genetic variance blooms. Using this same variable of classmate gains, Hart et al. (in press) used a discordant twin design to examine the causal role of teacher quality on reading performance. Results indicated that being in a classroom with lower teacher quality in first grade led to lower reading scores in second and third grade, without any suggestion of genetic or environmental confounding.

Focusing more specifically on reading, Soden-Hensler et al. (in press) explored the genetic and environmental relationship among print awareness, phonological awareness, and word decoding in kindergarten. A common genetic and shared environmental factor accounted for the covariance among the three reading measures, with an additional shared environmental influence above the common effect indicated between phonological awareness and word decoding. Turning toward the etiology of reading comprehension, Soden-Hensler et al. (2010) examined the etiology of reading comprehension in typical readers and dyslexic readers, as well as the relationship between typical reading and dyslexia. High genetic and moderate shared environmental influences were indicated for reading comprehension performance in both typical readers and dyslexic readers. Moreover, there was overlap of genetic factors between reading comprehension in both types of readers, suggesting shared genes influencing reading in the two groups.

The FSTR will continue to grow by some 500 twin pairs over the next 5 years through the newly re-funded Florida Learning Disability Research Center. The Florida Twin Project on Reading, Behavior, and Environment will expand the scope of the project to examine genetic influence on reading achievement as it relates to behavior (conduct disorder, ADHD, impulsivity) and the environment (home, neighborhood, classroom, school, friends). The current aims of the project are to track the development of behavior problems and reading problems over 5 years in a twin sample that spans the developmental risk period for both kinds of problems. Prior work on gene-environment interactions related to reading achievement will also be followed up with expanded measures of the twins' environment across various settings. What follows is an overview of the method for the current project in the FSTR. This description is limited to twins that have been added through the Florida Twin Project on Reading, as it forms the basis of the current project using the FSTR. Thus, the description that follows does not include the 153 pairs of adult twins that participated in the original pilot project to create the FSTR.

TABLE 1**Florida State Twin Registry Sample Characteristics**

	MZ (N pairs)	DZ (N pairs)	Total (N pairs)
Male	440	409	849
Female	426	449	875
Opposite sex	–	867	867
Total	866	1,725	2,591
White	401	894	1,285 (50%)
African American	147	344	491 (19%)
Hispanic	237	367	604 (23%)
Mixed/other	83	131	214 (8%)

Note: Race/ethnicity numbers do not sum to totals due to missing information in school records. Twins were age 5–10 (kindergarten through fifth grade) when they were initially recruited in 2006–2010.

Materials and Methods

Registry Membership

Sample characteristics of the FSTR are presented in Table 1. Twins were initially recruited in 2006–2010 if they were in kindergarten through fifth grade (age 5–10 years). Details of the ascertainment method are described elsewhere (Taylor & Schatschneider, 2010). Briefly, twins were identified through a match on last name, date of birth, and school in Florida's Progress Monitoring and Reporting Network (PMRN), a statewide database of standardized achievement tests on children in schools throughout the state of Florida. Parents of potential twins were sent a letter about the Florida Twin Project on Reading and the FSTR and a measure of zygosity (described below) that they completed and returned via the mail. Parents were sent a \$15 gift card for participating. The response rate was 43% with 95% of those responding agreeing to participate and become part of the FSTR. Only 4% indicated that they had been reached in error and that their children were not twins. Florida is one of the largest states in the U.S. in terms of both geography and population. Twins were recruited from 21 counties representing northern, central, and southern regions of the state and including metropolitan, suburban, and rural communities. Notably, this PMRN database provides both the source of ascertainment of the twins and achievement data, which are accessed each year through the Florida Center for Reading Research at Florida State University. Consistent with data reported by the Florida Department of Education for the entire state of Florida, 55% of the present sample qualified for the U.S. Free or Reduced-Priced Lunch Program. As no twin families were excluded from the project for any reason, approximately 20% of the total sample was identified as English as a second language status by the children's school.

Zygosity Diagnosis

Zygosity was determined through parent rating of the similarity of the twins using five items. The measure included two physical characteristics (hair and eye color) and three

TABLE 2**Description of Measures in the Florida Twin Project on Reading, Behavior, and Environment (the Current Project Using the FSTR)****Achievement Tests**

Gates-MacGinitie Reading Tests — 4th Edition (MacGinitie et al., 2000) — Word decoding (for grades 1–2) and vocabulary (for grades 3–8).
 Alphabet Writing Fluency (Wechsler, 2009) — Subtest of written expression (for Kindergarten) from the Wechsler Individual Achievement Test — Third Edition (WIAT-III).
 Narrative Writing Prompt (McMaster et al., 2009, 2011) — Writing sample (for grades 1 +).
 Author Recognition Test — Revised (Martin-Chang & Gould, 2008) — Print exposure and experience (child report).
 Grades — Academic performance (parent and child report).

Behavioral Measures

Colorado Learning Difficulties Questionnaire (Willcutt et al., 2011) — Screening for learning disabilities (parent report).
 Motivations for Reading Questionnaire (Wigfield et al., 1996) — Different aspects of reading motivation (child report).
 Positive and Negative Affect Scales (PANAS; Watson et al., 1988) — Positive and negative affect (parent and child report).
 Child and Adolescent Dispositions Scale — (Lahey et al., 2008) — Three dispositions (prosociality, daring, negative emotionality) that influence risk for conduct disorder (parent and child report).
 Eyberg Child Behavior Inventory (Burns & Patterson, 1990) — Conduct-problem behaviors (parent report).
 Strengths and Weaknesses of ADHD-symptoms and Normal-behavior (SWAN; Swanson et al., 2005) — Dimensional measure of inattention and hyperactivity-impulsivity (parent report).
 Disruptive Behavior Disorders (Pelham et al., 1992) — Symptoms of disruptive behavior disorders (parent report).
 Behavior Rating Inventory of Executive Function (Gioia et al., 2000) — Executive function behaviors (parent report).

Environmental Measures

Confusion, Hubbub, and Order Scale (CHAOS; Matheny et al., 1995) — environmental confusion in the home (parent and child report).
 Neighborhood Environment Scale (Bass & Lambert, 2004) — Perceptions of neighborhood disorder and disadvantage (child report).
 My Parents (Lamborn et al., 1991) — Parenting style (child report).
 Child Disclosure (Stattin & Kerr, 2000) — Children's disclosure about whereabouts and activities (parent and child report).
 Class Time (NICHD, 2004) — perception of teaching style (child report).
 What My School is Like (NICHD, 2005) — School attachment and environment (child report).
 Friends (developed by the Minnesota Twin Family Study staff) — Peer environment (child report).
 Home Literacy Environment (Griffin & Morrison, 1997) — Amount of reading materials in the home, frequency of library visits, adult literacy-related behaviors, adult-child reading, and television viewing (parent report).
 Petrill Educational Progress Survey (Petrill et al., 2005) — Environmental influences on early reading (parent report).
 The Barratt Simplified Measure of Social Status (Barratt, 2006) — Parent education and occupation (parent report).

global similarity ratings (e.g., extent to which relatives could not tell the twins apart).

Research Study Procedure and Measures

Data for the Florida Twin Project on Reading relied completely on PMRN achievement data and parents were asked only to complete the zygosity rating and give permission to use their children's PMRN data. In summer 2010, the first behavior and environment data were collected by sending families of same-sex twin pairs in the FSTR a packet of measures through the mail. Parents were asked to complete measures about the environment and about the twins' behavior, and twins age 9 and older were asked to complete measures about their personality and their friends. Responses were received from 351 MZ (170 male) and 340 DZ (171 male) twin families. The new Florida Twin Project on Reading, Behavior, and Environment will utilize a similar procedure beginning in fall 2012 with mailed assessments occurring again in 2014 and 2016 to provide longitudinal data on a sub-sample of 700 same-sex twins. In order to ensure coverage of developmental periods for reading achievement and behavior problems, the fall 2012 assessment will be sent to 200 existing same-sex FSTR families with twins aged 9–13 years and 500 new twin families will be recruited from kindergarten through third grade. The measures that will be included in the fall 2012 assessment for the Florida Twin

Project on Reading, Behavior, and Environment are listed in Table 2.

Data Management, Registry Access, and Collaboration

The FSTR is maintained in a Microsoft Access database. Measures from the Florida Twin Project on Reading, Behavior, and Environment are entered into a Filemaker database. The Florida Twin Project on Reading, Behavior, and Environment is an active federally funded project and access to its data or to the FSTR is limited to the principal investigators.

Future Directions

Although the FSTR is at the beginning of a new project, it is important to consider its future direction. The twins that were recruited during the first project period of the Florida Learning Disabilities Research Center are now in late elementary and middle school, with some beginning high school. An important question that can be addressed through the FSTR is the high school outcomes for children on whom we have grade school achievement data. As such, the future of the FSTR may include tracking the sample into high school with assessments of additional behavior problems (e.g., personality disorder, substance use) and assessments of the home and individual environments as well as collection of DNA (which is not currently obtained). In

addition, due to the large size of the FSTR sample, opportunities may exist to select twins for specific phenotypes (e.g., dyslexia, conduct disorder), and more systematically explore these children.

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