Longitudinal Analyses of Affect, Temperament, and Childhood Psychopathology

H. Hill Goldsmith,[1] Kathryn Lemery-Chalfant,[2] Nicole L. Schmidt,[1] Carrie L. Arneson,[1] and Cory K. Schmidt[1]

[1] *Waisman Center and Department of Psychology, University of Wisconsin-Madison, Wisconsin, United States of America*

[2] *Department of Psychology, Arizona State University, Tempe, Arizona, United States of America*

The Wisconsin Twin Panel utilizes the resources of state birth records to study the etiology and developmental course of early emotions, temperament, childhood anxiety and impulsivity, the autism spectrum, and related psychobiological and behavioral phenotypes. The panel currently supports 5 active research studies which involve twins from birth to early adolescence. A range of research methods are employed, including questionnaires and structured interviews with caregivers, home and laboratory-based behavioral batteries, observer ratings, child self-report, psychophysiology, neuroendocrine measures, birth records, genotyping, and cognitive testing. The panel is in the early stages of generating longitudinal findings.

The Wisconsin Twin Project (WTP) is a population-based longitudinal study, based on birth records from the entire state of Wisconsin, United States. The research is conducted primarily at the Waisman Center at the University of Wisconsin-Madison (http://psych.wisc.edu/wtp). The Waisman Center serves as a multidisciplinary center for basic and applied research in human development, developmental disabilities, and neurodegenerative diseases. Activities conducted at the Waisman Center include research, student training at all levels, and clinical and outreach programs. The Wisconsin Twin Panel is one of several research projects in the Waisman Center's Social and Affective Processes Group. Aspects of the research are centered in the Department of Psychology, also at the University of Wisconsin–Madison. The other entity involved in the coordination of this twin panel is the Wisconsin Center for Affective Science, an NIMH-funded center directed by Dr Richard Davidson.

Overview

Like many projects, the WTP grew from a single study into a panel with broader purposes. The WTP is a relatively young research program, beginning in the early 1990s and reaching fruition as a fully-fledged twin panel only in the early 2000s. Here, we do not trace the details of the panel's development, but instead describe its current functioning. However, some of the empirical projects described used earlier versions of current recruitment strategies.

The general research focus is behavioral development during infancy, childhood, and early adolescence. Within the behavioral domain of affective development, both typical and atypical development is emphasized. A range of research methods are employed, including health records, structured interviews with caregivers, home-based behavioral batteries, observer ratings, child self-report, neuroendocrine measures, genotyping, cognitive testing, and questionnaires.

Recruitment of the Panel

Wisconsin is located in the north central portion of the United States, bordering Michigan, Minnesota, Iowa, Illinois, and two of the Great Lakes, Superior and Michigan. About 68% of the population of the state of Wisconsin lives inside metropolitan areas (U.S. Census Bureau, 2000) although only one city has a population over 250,000. Residents of Wisconsin are of predominantly German (42.7%), Irish (10.9%), Polish (9.3%), and Norwegian (8.5%) ancestry (U.S. Census Bureau, 2000). The population is largely Wisconsin native (95.8%). Although the state is well known for agriculture, Wisconsin ranks second in the United States for per cent employment in manufacturing industries (22.2%).

The number of twin pairs born annually in Wisconsin from 1989 to 2004 are presented in Table 1. All families with twins are identified through state birth records. The Waisman Center Research Participation Core recruits families into the panel about 6 months after the twins are born. Six weeks after an initial recruitment letter is sent, a second letter

Received 13 February, 2006; accepted 15 November, 2006.

Address for correspondence: Hill Goldsmith, Department of Psychology, 1202 West Johnson Street, University of Wisconsin–Madison, Madison, WI 53706, USA. E-mail: hhgoldsm@wisc.edu

Table 1

Twin Births in Wisconsin and Sample During Testing Years

	Number of twin pairs born in Wisconsin	Assessment			
		Age 2	Age 7		Sensory defensiveness
Birth cohort			Psychopathology screening	Psychopathology follow-up study	
1989	783	48	38	20	—
1990	756	42	36	6	—
1991	735	144	110	52	—
1992	813	352	432	212	—
1993	764	278	324	152	—
1994	813	214	308	104	—
1995/96[a]	—	—	—	—	—
1997	780	750	458	238	130
1998	831	672	462[b]	158[b]	994[b,c]
1999	883	626	194[b]	42[b]	992[b,c]
2000	940	618	—	—	720
2001	912	592	—	—	346
2002	913	656	—	—	392
2003	1004	510[b]	—	—	286[b]
2004	1005	—	—	—	—
Totals	11,932	> 5502	> 2362	> 984	> 3860

Note: Dashes indicate no data collection to date.

[a] Families not recruited during this period. [b] Testing is on-going. [c] Families were assessed at age 2, 4, and 7 years

reminds parents about the panel and encourages their reply. In general, 75% of families respond and 65% respond favorably. The panel of active participants is representative of Wisconsin demographics (see Table 2), and approximately 44% of families reside in small towns and villages (<10,000 population) or in rural areas. Recruitment is ongoing.

Research Projects

The panel currently supports five studies: (1) behavioral screening of toddlers; (2) a longitudinal study of behavioral development from age 3 months to 3 years, including a follow-up at age 7 years focusing on psychophysiology variables; (3) an age 7 study of child psychopathology; (4) a study of childhood sensory defensiveness, with a longitudinal component; and (5) a study of the autism spectrum (see Figure 1).

Study 1: Behavioral Screening of Toddlers

Goals

The goals of this study are to estimate genetic influence on behavior problems and temperament and their association in the second year of life, to explore whether behavior problem symptoms can be viewed as extremes of normal-range temperament dimensions at this age, and to identify twins for the in-depth follow-up studies described below, as well as for future studies.

Table 2

Demographics of State of Wisconsin and Wisconsin Twin Panel

	State of Wisconsin	Wisconsin Twin Panel
Median household income	$45,315	$50,000-60,000
Mother Education		
Less than high school	6.7%	2.1%
High school	32.6	19.3
Some college or associate's degree	34.1	33.0
Bachelor's degree	17.7	30.0
Graduate/professional degree	6.6	15.6
Not reported	2.3	—
Marital status		
Married	51.3	90.2
Single	24.4	7.1
Divorced	11.1	2.7
Widowed	9.6	<1.0
Other marital status	3.6	—
Employment status		
In labor force	59.2	72.4
Employed	56.0	71.2
Unemployed	3.2	1.2
Not in labor force	40.8	27.6

Note: Wisconsin population 5,536,201 in 2004. Wisconsin female income and education taken from the U.S. Census Bureau 2004 data for age 21 to 64. Wisconsin female marital and employment status taken from the U.S. Department of Labor Bureau Statistics 2004 data for females age 16 and over. Wisconsin Twin Panel figures are taken from demographics at time of assessment, 2000–2005.

https://doi.org/10.1375/twin.10.1.118 Published online by Cambridge University Press

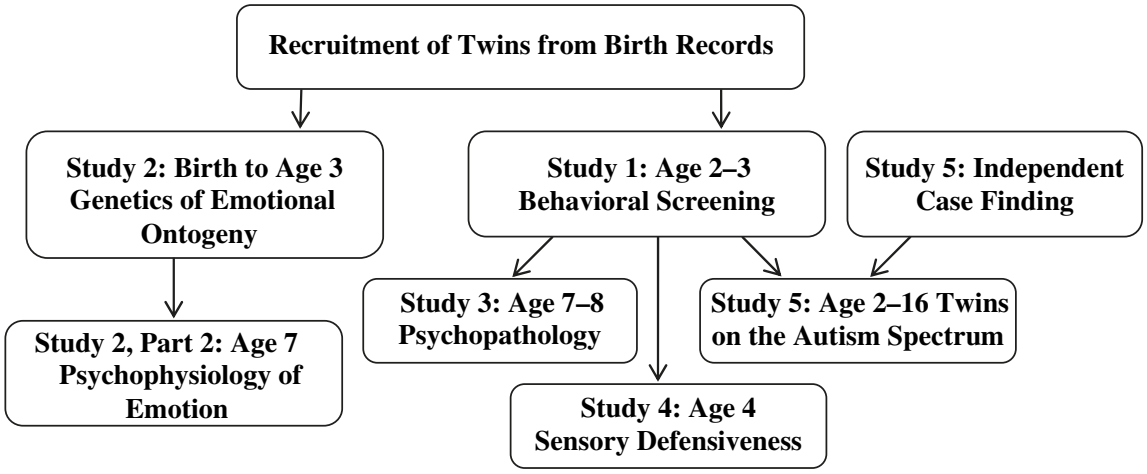


Figure 1

Studies supported by the Wisconsin Twin Panel, showing flow of families longitudinally. Parent and sibling data are collected in studies 2, 3, 4, and 5.

Design

Families are recruited for a nonlongitudinal assessment of the base population when the twins are 2 years old. The twins' primary caregiver completes a telephone interview that assesses zygosity (Goldsmith, 1991), and asks questions related to twin socioemotional development (Infant Toddler Social and Emotional Assessment, ITSEA; Carter & Briggs-Gowan, 2000) and demographics. Both parents also complete a collection of questionnaires, which includes an in-depth questionnaire about the twins' temperament (Toddler Behavior Assessment Questionnaire, TBAQ; Goldsmith, 1996) and language development (Communicative Development Inventory; Fenson et al., 2000). Approximately 60% of families in the panel have agreed to participate in this phase of the research, and data have been collected on over 5502 twins (2751 pairs) and their families as of December, 2005.

Selected Results

Table 3 shows twin similarity correlations for maternal report on the ITSEA scales. As the correlational patterns in Table 3 imply, all of the scales and subscales show some evidence of genetic effects. An extensive differentiated profile of behavioral problems in the toddler age range is rare, especially in twin studies. Additional results, including father report and model fitting, are reported in Van Hulle et al. (2006).

Study 2: The Genetics of Emotional Ontogeny (GEO) Study, Plus Follow-Up at 7 Years

Goals

The chief issues addressed by GEO are the nature, sources, and functional consequences of emotional individuality. The goals of this study are (1) mapping the onset and early developmental course of fully organized affective responses, such as social smile, wary reactions to strangers, initial empathetic responses, guilt, and pride; (2) investigating genetic and environmental sources of individual differences on the timing of emotional development; (3) identifying dependencies among individual difference characteristics from the emotional, physical, physiological, motoric, and cognitive realms; and (4) studying features of the family environment.

Design

The GEO project includes multimodal, comprehensive assessment of emotion and temperament, as well as selective assessment of cognition, motor development, physiology, social interaction, and the home environment from birth to 3 years of age. The final sample size will total about 500 twin pairs. The project incorporates an unusually broad set of methods, including laboratory-based elicitation of behavior, home observation, testing by examiner, telephone interviews, hospital birth records, diaries, narrative constructions, language inventories, and parent–child and sibling interaction episodes. These and other characteristics of the child and family are also assessed by a battery of questionnaires. Major assessment periods are 3 months of age (home visit), 6 months (laboratory visits), 9 months (home visit), 12 months (laboratory visits), four laboratory visits spaced across the second year, and, finally, laboratory visits at 36 months. A recently established Milwaukee, Wisconsin, site has allowed expansion of the minority subsample. The GEO project shares some twin subjects with another project on psychophysiology, which collects cortisol assays, central (EEG), peripheral (cardiac), and nervous system measures.

At age 7, families are recontacted for a study of the psychophysiology of emotion. This follow-up incorporates laboratory-based psychophysiological assessment (EEG, heart rate, and vagal tone) during a series of episodes from the Laboratory Temperament Assessment Battery (Lab-TAB; Goldsmith et al., 1993). Emotion modulated startle is assessed in the laboratory

https://doi.org/10.1375/twin.10.1.118 Published online by Cambridge University Press

Table 3

Correlations Indexing Twin Similarity for Maternal Report of Toddler Social-Emotional Development (ITSEA Scales)

	MZ		DZ		
Mother report	Female (n = 136)	Male (n = 134)	Female (n = 128)	Male (n = 148)	Female/Male (n = 236)
Externalizing	.54	.65	.11	.28	.26
Activity/impulsivity	.61	.57	.02	.21	.15
Aggression/defiance	.45	.61	.18	.24	.26
Peer aggression	.54	.64	.36	.34	.32
Internalizing	.52	.64	.12	.26	.14
Inhibition to novelty	.58	.68	.03	.18	-.03
Separation distress	.43	.64	.26	.36	.33
General anxiety	.62	.58	.32	.29	.35
Depression/withdrawal	.62	.31	.08	.26	.14
Competence	.81	.87	.63	.65	.51
Social relatedness	.63	.65	.46	.41	.34
Dysregulation	.71	.56	.37	.33	.36
Maladaptive	.69	.76	.53	.44	.51
Atypical	.74	.75	.60	.70	.47

as well. A 1.5 hour home assessment includes additional episodes from Lab-TAB. All Lab-TAB episodes are videotaped. Researchers code several facets of emotion elicited during the assessment: social fear/inhibition, anger/frustration, sadness, exuberance, contentment, activity, persistence, inhibitory control/impulsivity, empathy, and compliance, while measuring several emotional qualities including latency, peak intensity, and duration of response. A mailed packet includes materials to collect salivary measures of basal cortisol from each twin, as well as parent report questionnaire measures of temperament (Child Behavior Questionnaire, CBQ; Rothbart et al., 2001), health, and behavior, including internalizing and externalizing symptoms (Health and Behavior Questionnaire, HBQ; Armstrong et al., 2003).

Selected Results

Turning to the physiological data from the study, children's morning basal cortisol sampled at home across 3 days, (a heritable phenotype in these data), was related to more relative right frontal EEG asymmetry at baseline, during a stranger approach paradigm, and also during four other laboratory procedures (Coan et al., 2005a, 2005b). Similarly, home cortisol levels predicted an increase of relative right frontal EEG asymmetry from anticipation of a desirable gift to receipt of an undesirable gift in the laboratory. Cardiac reactivity was associated with EEG asymmetry in very similar ways (e.g., shorter pre-ejection period [PEP] predicted increased right frontal activation as situations became more hedonically negative). Home cortisol levels were related to cross-situational heart rate and PEP, and to startle potentiation across laboratory contexts. Greater relative right prefrontal activation in the EEG signal was associated with startle potentiation and various behavioral — mostly bodily — measures of fearfulness. Interestingly, angry behavioral reactions tended to be associated with relative left frontal activation in the EEG, and the opposite occurred for the internalizing emotion, sadness. This finding suggests that the well-known asymmetry between right versus left frontal activation in the EEG (Davidson, 2004) might map better onto withdrawal versus approach motivation than onto negative versus positive hedonic tone. Although these physiology-behavior links were in the predicted direction, their strength was generally modest in this unselected sample (Coan et al., 2005a). The data showed moderate-to-strong genetic effects on many of the heart rate variables, (as in the literature), and on morning basal cortisol. A novel finding was a genetic effect (heritability = .30) on PEP, indexing the sympathetic influence on cardiac function. In summary, the broad confirmation of a nexus of predictions indicates that a genetically informed understanding of the links among fear endophenotypes in children is feasible (Coan et al., 2005b).

Study 3: Age 7 Study of Child Psychopathology

Goals

The goals of this study are to (1) identify and assess twins at risk for internalizing, externalizing, and attentional disorders, including attention-deficit/ hyperactivity disorder (ADHD), conduct problems, anxiety, and depression; (2) characterize these at-risk twins and their co-twins regarding their behavioral problems and risk factors with a structured interview, additional parent report measures, behavioral assessments, observation, and biological measures; (3) assess the twins' parents for current psychopathology; (4) assess the twins' environment, including prenatal effects, to identify features associated with risk; (5) estimate the genetic influence on the measure of the risk factors, on the disorders

https://doi.org/10.1375/twin.10.1.118 Published online by Cambridge University Press

themselves, and on the association between the risk factors and the disorders; (6) use the data to improve nosology of childhood disorders and study comorbidity; (7) consider risk-reducing factors related to resiliency and adaptability, such as the capacity to experience and express pleasure, higher cognitive ability, and emotion regulation capability; (8) lay the foundation for a follow-up when the twins have lived through more of the risk period for the onset of disorders; and (9) genotype potential candidate genes.

Design

At age 7, all twins are screened for child psychopathology through a telephone interview with a primary caregiver. Parents rate each twin's behavior on 84 items of the mood/behavior symptomatology portion of the Health and Behavior Questionnaire (HBQ; Armstrong et al., 2003). Based on parent-rated scores, each twin is identified as (1) at risk for one or more of the eight psychopathology domains (scoring 1.5 *SD* above the mean on depression, anxiety, overanxious, aggression, oppositional defiance, conduct disorder, inattention, and impulsivity scales); (2) a control for all psychopathology (scoring below the mean for all measures); or (3) an unselected individual. Using these criteria, 8.4% of twins are identified as internalizing, 6.9% externalizing, 3.1% inattentive, 9.3% comorbid, and 14.9% are controls. As of June 2006, over 2362 twins have completed the screening process. If either twin is identified as at risk or control, the pair is followed up to assess behavioral problems.

This psychopathology follow-up includes 1.5 hours of additional telephone interviews with parents about child rearing, family climate, and parent psychopathology (World Health Organization's Composite International Diagnostic Interview; Robins et al., 1988). A mailed packet includes materials to collect salivary measures of basal cortisol from each family member, as well as questionnaire measures of child temperament (CBQ; Rothbart et al., 2001), child depression (Child Depression Inventory; Kovacs, 1983), parent personality (Multidimensional Personality Questionnaire, MPQ; Tellegen, 1978), and parent depression (Beck Depression Inventory; Beck et al., 1988). Observational data are collected during a half-day home visit that includes salivary measures of reactive cortisol, as well as an extensive temperament assessment battery of 16 episodes with each twin (Lab-TAB; Goldsmith et al., 1993), the Berkeley Puppet Interview (BPI; Ablow & Measelle, 1993), vocabulary (Peabody Picture Vocabulary Test; Dunn & Dunn, 1981) and spatial cognition measures (Wechsler, 1991), structured diagnostic interviews with the primary caregiver (Diagnostic Interview Schedule for Children, Version IV; Fisher et al., 1997), and two primary caregiver-twin interactions and three twin-twin interactions. This half-day home visit is videotaped. Upon reviewing the videotapes, child examiners globally rate each child's affect, multiple domains of reactivity and regulation, multiple domains of behavior symptoms, the primary caregiver's behavior and affect with the twins, and the twin's behavior and affect with their co-twin. Additional measures of prenatal development are examined with palm and finger print asymmetries, and hospital pregnancy and birth records are coded for neonatal morbidity (Neonatal Morbidity Scale; Pleasure et al., 1997) and obstetrical and neonatal complications (Obstetrical Complications Scale, Neonatal Complications Scale; Littman & Parmalee, 1974).

Selected Results

Results for this project are preliminary, as the data are still actively being collected. Our early analyses examined several facets of early temperament: inhibition, fear, shyness, and sadness. In two independent samples, fear, sadness, and shyness measured at age 4 showed strong stability with the same measures at age 7, *r*s greater than .60 (Goldsmith & Lemery, 2000).

We deconstructed the association between early temperament and later behavior problems in two sets of analyses. First, we studied effortful control, a regulatory aspect of temperament and ADHD symptoms. Effortful control and ADHD symptoms measured approximately 2.5 years later appeared to have similar levels of genetic influence (Goldsmith et al., 2004). Furthermore, extreme levels of effortful control contributed to the genetic liability for ADHD symptoms. All three of the sources of variance in effortful control (additive genetic, nonadditive genetic, and nonshared environment) accounted for variance later on in ADHD symptoms. Somewhat surprisingly, all of the genetic variance in later ADHD was also associated with earlier effortful control (see Figure 2). In additional analyses, nonshared environmental influences on early fear and later overanxious behaviors were completely independent (Goldsmith & Lemery, 2000). The association between early fear and later overanxious behavior was entirely due to shared additive genetic influence (see Panel B, Figure 3). In contrast, fear and separation anxiety were linked entirely by shared and nonshared environmental influences.

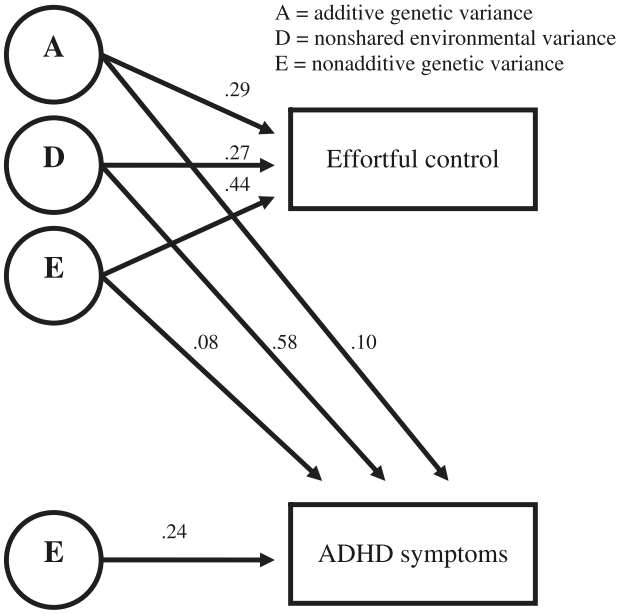
Study 4: Sensory Defensiveness Project

Goals

Sensory defensiveness (also referred to sensory overresponsivity or lack of sensory modulation) involves negative emotional reactions to sensory stimuli that most individuals find to be innocuous. Although the area is severely understudied, sensory defensiveness appears to be a significant impairment. Symptoms may occur independently or in the context of other behavioral challenges (Goldsmith et al., 2006). The goals of this study are to (1) identify the prevalence of sensory defensiveness in an unselected population; (2) identify what disorders co-occur with sensory defensiveness; (3) identify the nature and extent of behavioral problems in families of young children with symptoms of sensory defensiveness; and (4) estimate the heritability of sensory defensiveness, by both

https://doi.org/10.1375/twin.10.1.118 Published online by Cambridge University Press

Panel A. *Bivariate model of ADHD symptoms and effortful control**



Panel B. *Bivariate model of early fear and overanxiousness†*

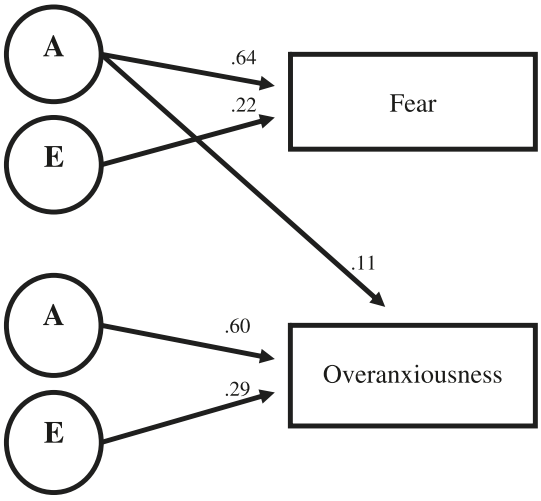


Figure 2

Best-fitting bivariate models for the prediction of later symptoms from earlier temperament in twins (standardized path coefficients and significant paths shown).

Note: *$\chi^2(13) = 10.63$, $p = .64$, AIC = –15.37

†$\chi^2(15) = 16.06$, $p = .38$, AIC = –13.94

the differential concordance of identical and fraternal twins, and by parent–offspring similarity.

Design

The study of child sensory defensiveness includes three primary measurement periods. First, twins are screened for sensory defensiveness in the toddler study with a modified version of the TBAQ (Goldsmith, 1996). Second, twins who are reported in the top 5% as auditory and tactile defensive at age 2 are rescreened for a more in-depth study of sensory defensiveness at age 4 to 5 years. The rescreened sample includes 282 twins, and full follow-up data have been collected on 78 twin pairs and their families. The follow-up sensory defensiveness study of 4- to 5-year-olds includes a 25-minute home observational

https://doi.org/10.1375/twin.10.1.118 Published online by Cambridge University Press

assessment of auditory and tactile responsiveness with each twin (Miller, 2003). A parent interview includes pregnancy, childbirth, early child feeding, sleeping and behavior patterns, parent depression, and parallel child-parent sensory measures from the primary caregiver and twins (Dunn, 2000). A mailed packet of questionnaires includes measures of child health and behavior (HBQ; Armstrong et al., 2003), and parent personality (MPQ; Tellegen, 1978). The questionnaire assessment of sensory defensiveness is included in the screening assessment of all 7-year-old twins (Miller, 2003). Data have been collected on more than 844 twins at age 7.

Selected Results

Using a sample of 1394 toddler-aged twins with mothers' reports of tactile and auditory defensiveness, temperament, and behavior problems, the incidence of defensive symptoms was widely distributed, with some accumulation of cases in the extreme range (Goldsmith et al., 2006). Girls were overrepresented in the extreme tactile defensiveness group. Both auditory and tactile defensiveness were modestly associated with fearful temperament and anxiety, but they were relatively distinct from other common dimensions of childhood behavioral dysfunction. Twin correlations for the full range of scores, and concordance rates for the extremes, suggested moderate genetic influences, with some indication that the tactile domain might be more heritable than the auditory domain.

Our preliminary analyses suggest both stability and change in young children's sensory defensiveness. Fifty per cent (23/46) of the twins who were reported as auditory defensive at age 2 were still auditory defensive at age 4 to 5. Approximately 48% (27/56) of the twins who were reported as tactile defensive at age 2 were still tactile defensive at age 4 to 5. Future longitudinal analyses will link the age 2 and age 7 sensory defensiveness assessments and investigate whether sensory defensiveness is a risk factor for ADHD, anxiety symptoms, or other behavior problem domains.

Study 5: Twins on the Autism Spectrum

Goals

The goals of this study are to (1) identify all twins aged 2 to 16 years, one or both of whom are characterized as being in the autism spectrum; (2) perform a full diagnostic and behavioral assessment of both twins in each set, using a structured interview, supplemental measures, and a review of any prior clinical diagnosis; (3) characterize comorbid medical conditions (e.g., cerebral palsy, seizure disorders, Fragile X, tuberous sclerosis); (4) characterize co-occurring, but nondiagnostic behavioral problems, especially anxiety, motor dyspraxia, and sensory sensitivities; (5) estimate genetic variation on autism, co-occurring behavioral symptoms within the autism spectrum, measures of earlier risk factors, and the association among risk factors, the co-occurring behavioral problems, and autism; (6) identify whether twins are at increased risk of autism relative to singletons using epidemiological data from the state as well as data gathered from a Center for Disease Control-funded surveillance study; (7) conduct structural and functional MRI studies, along with eye tracking and electrodermal measures, as twins reach 8 years, and to implicate certain brain regions as related to either genetic or environmental risks, with differences between discordant monozygotic (MZ) co-twins reflecting noninherited factors; (8) screen the twins' parents and siblings for current psychopathology and personality features, including the 'broader autism phenotype'; (9) assess psychosocial functioning of these families; (10) follow up autistic twins at the end of the project to confirm diagnoses of index cases and confirm/rule out, late-developing autism spectrum cases in co-twins; and (11) consider risk-reducing factors related to resiliency and adaptability, such as the capacity to express pleasure, higher cognitive ability (especially memory and spatial/quantitative skills), emotion regulation capability, and family assets.

Design

The initial study began as case-finding throughout Wisconsin for any twins under the age of 18 years with an autism spectrum diagnosis (autism, Aspergers, or pervasive developmental disorder — not otherwise specified). The study includes an initial telephone screen for behaviors in the autism spectrum. As of December, 2005, we have identified some 204 twins, (most born before the screening of birth cohorts began), and have also begun a second-stage screen of these pairs. Individuals identified both via case-finding and screening of birth cohorts later participate in a home-based behavioral assessment including parent interviews, cortisol measures, and behavioral assessments, including the Autism Diagnostic Observation Scale (ADOS; Lord et al., 2000). In addition, we characterize co-occurring, but nondiagnostic behavioral problems, especially anxiety, motor dyspraxia, sensory sensitivities, and sleep problems. Other aspects of the project include extensive assessment of (1) speech and language, (2) psychosocial functioning of the families, (3) the broader autism phenotype in family members, and (4) behavioral strengths of autistic individuals.

Selected Results

Findings are currently at the most tentative stage. We have shown that the initial screening does in fact identify children on the autism spectrum. From the case-finding data, and before needed exclusions for medical comorbidities, and also before confirmation of diagnoses in many cases, the concordance rate for the autism spectrum for MZ twins would appear to be in the range of 50% to 70%, and for dizygotic (DZ) twins, in the range of 15% to 25%. The male: female ratio was somewhat higher than the commonly reported 4:1 value. Buccal cells are being collected for future candidate gene analyses.

https://doi.org/10.1375/twin.10.1.118 Published online by Cambridge University Press

During the behavioral screening for toddlers (the first project discussed in this paper), parents report on behaviors that are characteristic of very young children with autism. For the 1998 to 2003 birth cohorts, we examined 35 autism screening items for 2808 twins (mean age = 27 months). The autism screening items were drawn from the literature on early identification of autism, supplemented with items from the ITSEA (Infant-Toddler Social Emotional Assessment; Carter & Briggs-Gowan, 2000). The items were divided into four subscales: speech, social behavior, restricted interests, and motor impairment. For twins with extreme scores (top 5%) on both the social and speech subscales, a probandwise analysis revealed an MZ concordance rate in the .60s and a DZ rate in the .40s. The autism project is only beginning to generate longitudinal data for future analyses.

Longitudinal Model Fitting

We plan to pursue growth curve approaches to these longitudinal data. Because a full longitudinal, multivariate, twin-family biometric model incorporating measured risk factors becomes extraordinarily complex, we believe that components of the model need to be built separately, and then combined into more complex models that test hypotheses. For instance, within the childhood internalizing domain, anxiety often precedes depression, but not vice versa (reviewed by Burke et al., 2005). Once more data are collected, we will test whether genetic influences on age 7 anxiety levels affect the slope of change in depression from age 7 to 12. However, we will first characterize genetic influences on intercepts and slopes of anxiety and depression separately. To implement this strategy, we will begin with our multisource composite measures of anxiety and depression, and fit biometric growth curves (intercepts and slopes) to the 3-occasion longitudinal data (e.g., McArdle, 1986). A bivariate biometric structure can be imposed on the growth curve parameters (two latent intercepts and two latent slopes), as demonstrated by Finkel et al., (2005), for a slightly more complex model. The full model will incorporate anxiety's influence on depression, as well as exogeneous variables that account for additional variance in depression.

Acknowledgments

This work was supported by the National Institute of Mental Health (R01-MH59785, R01-MH069793, and R37-MH50560), the Wisconsin Center for Affective Science (P50-MH069315), the Wallace Foundation, and the National Alliance for Autism Research. Infrastructure support was provided by the Waisman Center via a core grant from NICHD (P30-HD03352).

References

Ablow, J. C., & Measelle, J. R. (1993). The Berkeley Puppet Interview (BPI) Interviewing and Coding System Manuals. (Tech. Rep.). Berkely, CA: University of California, Department of Psychology.

Armstrong, J. M., Goldstein, L. H., & The MacArthur Working Group on Outcome Assessment (2003). *Manual for the MacArthur Health and Behavior Questionnaire (HBQ 1.0)*. MacArthur Foundation Research Network on Psychopathology and Development: University of Pittsburgh.

Beck, A. T., Steer, R. A., & Garbin, M. G. (1988). Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review, 8*, 77–100.

Burke, J. D., Loeber, R., Lahey, B. B., & Rathouz, P. J. (2005). Developmental transitions among affective and behavioral disorders in adolescent boys. *Journal of Child Psychology and Psychiatry, 46,* 1200–1210.

Carter, A. S., & Briggs-Gowan, M. J. (2000). *Infant–Toddler Social and Emotional Assessment (ITSEA) manual*. New Haven, CT: Yale University and University of Massachusetts, Boston.

Coan, J. A., Davidson, R. J., Goldsmith, H. H., Frye, C., Locke, R., & Zugin, Z. (2005a, June). *The heritability of resting and state frontal EEG asymmetry.* Paper presented at the Behavior Genetics Association, Hollywood, CA.

Coan, J. A., Davidson, R. J., Goldsmith, H. H., Frye, C., Locke, R., & Zugin, Z. (2005b, June). *The Laboratory Temperament Assessment Battery (Lab-TAB) and frontal EEG asymmetry.* Paper presented at the Behavior Genetics Association, Hollywood, CA.

Davidson, R. J. (2004). What does the prefrontal cortex 'do' in affect: Perspectives on frontal EEG asymmetry research. *Biological Psychology, 67,* 219–233.

Dunn, W. (2000). *The Infant Toddler Clinical Edition Sensory Profile*. San Antonio, TX: The Psychological Corporation.

Dunn., L. M., & Dunn., L. M. (1981). *Peabody Picture Vocabulary Test — Revised: Manual for Forms L and M*. Circle Pines, Minnesota: American Guidance Service.

Finkel, D., Reynolds, C. A., McArdle, J. J., & Pedersen, N. L. (2005). The longitudinal relationship between processing speed and cognitive ability: Genetic and environmental influences. *Behavior Genetics, 35,* 535–549.

Fenson, L., Pethick, S. Renda, C., & Cox, J. (2000). Short-form versions of the MacArthur Communicative Development Inventories. *Applied Psycholinguistics, 21*, 95–116.

Fisher, P., Lucas, C., Shaffer, D., Schwab-Stone, M., Dulcan, M., Graae, F., Lichtman, J., Willoughby, S., & Gerald, J. (1997). *Diagnostic Interview Schedule for Children, Version IV: Test–retest reliability in a clinical sample*. Paper presented at the 44th Annual Meeting of the American Academy of Child and Adolescent Psychiatry, Toronto.

Goldsmith, H. H. (1991). A zygosity questionnaire for young twins: A research note. *Behavior Genetics, 21*, 257–269.

Goldsmith, H. H. (1996). Studying temperament via construction of the Toddler Behavior Assessment Questionnaire. *Child Development, 67*, 218–235.

Goldsmith, H. H., & Lemery, K. (2000). Linking temperamental fearfulness and anxiety symptoms: A behavior-genetic perspective. *Biological Psychiatry, 48*, 1199–1209.

Goldsmith, H. H., Lemery, K. S., Buss, K. A., & Campos, J. J. (1999). Genetic analyses of focal aspects of infant temperament. *Developmental Psychology, 35*, 972–985.

Goldsmith, H. H., Lemery, K. S., & Essex, M. J. (2004). Temperament as a liability factor for childhood behavioral disorders: The concept of liability. In L. DiLalla (Ed.), *Behavior genetics principles: Perspectives in development, personality, and psychopathology* (pp. 19–39). Washington, DC: American Psychological Association.

Goldsmith, H. H., Reilly, J., Lemery, K. S., Longley, S., & Prescott, A. (1993). *Preliminary manual for the Preschool Temperament Assessment Battery* (Version 1.0). University of Wisconsin-Madison, Department of Psychology.

Goldsmith, H. H., Van Hulle, C. A., Arneson, C. A., Schreiber, J. E., & Gernsbacher, M. A. (2006). A population-based twin study of parentally reported tactile and auditory defensiveness in young children. *Journal of Abnormal Child Psychology, 34*, 378–392.

Kovacs, M. (1983). *The Children's Depression Inventory: A self-rated depression scale for school-aged youngsters*. Unpublished manuscript.

Littman, B., & Parmalee, A. H. (1974). *Manual for obstetrical complications*. Los Angeles: UCLA, Department of Pediatrics.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Jr., Leventhal, B. L., DiLavore, P. C., Pickles, A., & Rutter, M. (2000). The Autism Diagnostic Observation Schedule — Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30*, 205–223.

McArdle, J. J. (1986). Latent variable growth within behavior genetic models. *Behavior Genetics, 16*, 163–200.

Miller, L. J. (2003). *Sensory Responsivity Scale Inventory: Research edition*. Unpublished measure, University of Colorado Health Sciences, Denver.

Pleasure, J., Gennaro, S., Cnaan, A., & Wolf., F. (1997). An expanded neonatal morbidity scale for premature infants. *Journal of Nursing Measurement, 5*, 119–138.

Robins, L. N., Wing, J., Wittchen, H. U., Helzer, J. E., Babor, T. F., Burke, J., Farmer, A., Jablenski, A., Pickens, R., & Regier, D. A. (1988). The Composite International Diagnostic Interview: An epidemiological instrument suitable for use in conjunction with different diagnostic systems and in different cultures. *Archives of General Psychiatry, 45*, 1069–1077.

Rothbart, M. K., Ahadi, S. A., Hershey, K., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development, 72*, 1394–1408.

Tellegen, A. (1978). *Brief manual of the Multidimensional Personality Questionnaire*. Unpublished manuscript, University of Minnesota, Department of Psychology.

United States Census Bureau. (1999). *Statistical Abstract of the United States*. Retrieved January 28, 2006, from http://factfinder.census.gov

United States Census Bureau. (2000). *Census 2000 Summary File 3*. Retrieved January 28, 2006, from http://factfinder.census.gov

United States Census Bureau. (2004). *2004 American Community Survey*. Retrieved January 28, 2006, from http://factfinder.census.gov

United States Labor Bureau (2004). *Employment status of the civilian noninstitutional population in states by sex, race, Hispanic or Latino ethnicity, martial status, and detailed age: 2004 Annual Averages*. Retrieved January 28, 2006, from the United States Labor Bureau of Labor Statistics Web site: http://www.bls.gov

Van Hulle, C. A., Lemery-Chalfant, K., & Goldsmith, H. H. (2006). *The genetic and environmental influences on socio-emotional behavior in toddlers: An initial twin study of the Infant Toddler Social and Emotional Assessment (ITSEA)*. Manuscript submitted for publication.

Watson, D., Clark, L., & Tellegen, A. (1998). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063–1070.

Wechsler, D. (1991). *WISC-III: Wechsler Intelligence Scale for Children — Third Edition*. Orlando, FL: Harcourt Brace.

https://doi.org/10.1375/twin.10.1.118 Published online by Cambridge University Press