

Article

The Southern Illinois Twins/Triplets and Siblings Study (SITSS): A Longitudinal Study of Early Child Development

Lisabeth Fisher DiLalla¹ and Matthew R. Jamnik²

¹Family and Community Medicine, Southern Illinois University School of Medicine, Carbondale, IL, USA and ²Department of Psychology, Southern Illinois University Carbondale, Carbondale, IL, USA

Abstract

This article reviews the Southern Illinois Twins/Triplets and Siblings Study (SITSS) and describes some of the findings related to recent projects that were completed using this sample. At this time, the SITSS has enrolled 375 twin pairs, 12 triplet families, 1 family of quadruplets, 98 nontwin sibling pairs and 287 singletons. Testing begins for twins and triplets as young as age 1 and then occurs yearly on their birthdays until 5 years of age. Through age 20, various follow-up studies have been conducted on the SITSS sample to examine their social, emotional, and cognitive development across childhood and adolescence from a behavioral genetic perspective. A variety of methodologies have been used to investigate gene–environment correlations (rGE) and gene–environment interactions (GxE). Advanced statistical procedures (e.g., genetic likelihood indices and multilevel modeling) have been utilized to further investigate genetic underpinnings of behavior. Recent results have indicated genetic influences on the aggressiveness of preschoolers' media preferences, increased problem behaviors related to young children's overestimation of self-competence, and the influence of early life temperament and internalizing problems on adolescent health behaviors. Additionally, the SITSS has provided evidence for evocative rGE for various behaviors (aggression, prosocial and play), as well as findings supporting interactions between the dopamine receptor D4 gene (DRD4) and the environment (peer victimization, prenatal birth complications and parental sensitivity). Together, by use of multitrait and multimethodological investigations, this behavior genetic data set assists in furthering our understanding of biological and environmental influences on children's development.

Keywords: Longitudinal; twins; childhood; adolescence; gene–environment correlation (rGE); gene–environment interaction (GxE); internalizing and externalizing problems

(Received 24 May 2019; accepted 3 July 2019; First Published online 24 July 2019)

The Southern Illinois Twins/Triplets and Siblings Study (SITSS) is a longitudinal study of genetic and environmental effects on early child social development. The SITSS was initiated in 1993 and currently includes twins, triplets, one set of quadruplets, siblings and singletons. Primary topics of study include early childhood aggression, bullying and victimization, prosocial behaviors, parent–child interactions and, more recently, emotional development and health behaviors. The original sample of 127 twin-pairs, 98 sibling pairs and 287 singleton children were tested at age 5 in a peer-play paradigm. Children were tested two at a time in a laboratory playroom, where they were allowed to play freely for 20 min with toys, such as puppets, action figures, tools, kitchen toys and checkers. Play was video-recorded for later rating by trained coders. Twins were separated so that their play did not influence each other. Because all children were tested within 2 months of their fifth birthdays, nontwin siblings were tested in different years. Each child was paired with a randomly chosen, same-age, same-sex child whom they had never before seen until they were led to the playroom for testing. Results of this study have been published

regarding both aggressive (DiLalla & DiLalla, 2018; DiLalla et al., 2009; DiLalla & John, 2014) and prosocial (DiLalla, 2006; DiLalla et al., 2015a) play.

In order to increase enrollment, younger twins, aged 1 through 4 years, were recruited for laboratory testing beginning in late 1995. These children were tested on a variety of cognitive and social tasks in the lab, with the intention of bringing them in for the play study at age 5. The play study has ended; 5-year-old twins now are tested on age-relevant cognitive and social interaction tasks in the lab.

Currently, there are 375 twin pairs (232 monozygotic [MZ] children, 298 same-sex and 220 opposite-sex dizygotic [DZ] children), 12 triplet families (1 set all MZ, 5 sets all DZ and 6 sets with 1 MZ pair and a third DZ child), 1 family of quadruplets (4 DZ children), 98 nontwin siblings of either twins or singletons tested in the peer-play study, and 287 singletons enrolled. Together, the overall SITSS sample includes 1175 children (501 males and 674 females) across ages 1–20, and the zygosity breakdown includes 20.8% MZ and 46.5% DZ children, with the remaining children (32.7%) being nontwin siblings or singletons. Basic information concerning recruitment and initial preliminary results are in DiLalla (2002a) and DiLalla et al. (2013). Families have been recruited through newspaper birth announcement listings, purchased state birth records, referrals, local flyers, and letters sent to local daycare centers. Zygosity of multiples has been assessed

Author for correspondence: Lisabeth Fisher DiLalla, Email: Ldilalla@siu.edu

Cite this article: DiLalla LF and Jamnik MR. (2019) The Southern Illinois Twins/Triplets and Siblings Study (SITSS): A Longitudinal Study of Early Child Development. *Twin Research and Human Genetics* 22: 779–782, <https://doi.org/10.1017/thg.2019.48>

Table 1. Summary of SITSS data collected

Age (years)	Construct						
	Biological	Cognitive	Health	Temperament/ personality	Emotional/ behavioral	Home/social environment	Relationships with others
1–4	MO/LT; LA	LA		MO/LT		MO/LT	LA
5	LA	LA		MO/LT	MO/LT; LA; MS	MO/LT; LA	LA
6–10	LA; OB	LA	LA; LQ; OB	LQ	LA; MS; LQ	MO/LT; LA; TI	LA; MS
10–13	LA; OB		LQ; TI	LQ	LA; MS; LQ	MO/LT; LQ	LA; MS
13–16	OB		TI	LQ	LA; MS	MO/LT; LQ	LA; MS
16–20			TI			MO/LT; LQ	

Note: MO/LT = mailed out, then collected when families visit the laboratory for testing; LA = lab assessment; MS = mail survey; LQ = lab questionnaire; TI = telephone interview; OB = observed assessment.

through buccal cell collection (63%) and parent rated questionnaires (100%). A number of SITSS follow-up projects include studies of the children as they age (6 years and older) as well as DNA collection. Families in SITSS are relatively well representative of southern Illinois and surrounding regions.

Overall Methodology

Ongoing SITSS testing includes bringing multiples aged 1–5 years to a campus laboratory every year within approximately a month of their birthday. Table 1 presents a summary of measure constructs from all SITSS testing paradigms. Buccal cell data collection began in 2003, and DNA data are now available for 500 children (233 twin-pairs, 10 triplet sets and 1 quadruplet set). These data have been used to confirm zygosity status (we have a 96.4% agreement between DNA and parent and tester ratings of twin similarity for same-sex pairs), and genotyping is available for dopamine receptor D4 gene (DRD4), DRD2, 5HTTLPR, and CHRM2-rs36210735 and CHRM2-rs1824024 single nucleotide polymorphisms (SNPs) for many of the children. Data are stored for future analyses but are not publicly accessible.

Various follow-up studies have utilized mailed-out questionnaires and telephone interviews or have involved bringing families back to the lab when the children are older. Studies have examined victimization, bullying, psychopathology symptoms, health behaviors and parenting. Each follow-up study also contains extensive information on temperament, family environment, and child behaviors. A detailed summary of some of the measures collected as part of these follow-up projects can be found in DiLalla et al. (2013) and are briefly summarized in Table 1. Our most recently completed follow-up studies of 6- to 13-year-old twins and triplets involved in-depth interviews on emotion skills, theory of mind, and interpersonal functioning, including sleep problems, anxiety during peer interactions, victimization and bullying, and health behaviors. Constructs that we have tested that were not included in the earlier table (DiLalla et al., 2013) are summarized in Table 2.

Study Goals

The initial goal of the SITSS was to examine genetic and environmental causes of early aggression in preschoolers. At the time, we were beginning to understand something about delinquency and criminality, but we knew very little about causes of early aggression and rule-breaking. From the original peer-play paradigm, the SITSS expanded to include early preschool cognitive and social

development. More recently, the focus of SITSS has been on emotional skills from preschool through adolescence, as well as implications for bullying and victimization behaviors. We have also begun exploring related behaviors, such as anxiety and physical health behaviors. Genetic factors have been implicated in some early childhood social behaviors, but less is known about the etiology of emotional intelligence, social perspective-taking, and prosocial and aggressive behaviors in preschoolers (DiLalla, 2002b), although this field is beginning to grow.

The important focus of twin studies now is to examine how genes and behaviors coact. Particular genes have been identified via molecular genetics studies that are related to a large number of behaviors and disorders, although concerns about replication must be addressed because each gene can only account for a tiny fraction of the variance for any given trait (Dick et al., 2015). The SITSS integrates biological and environmental perspectives in investigating the causes of young children's social development. The early focus was on heritability but has grown to include genotype and a number of developmental and environmental variables, such as daycare experiences, parent-child interaction styles and cognitive ability. We have used a variety of methodologies to investigate gene-environment correlations (rGE) as well as gene-environment interactions (G×E). Genetic likelihood indices have been calculated using methodology described in Jaffee et al. (2005) to help examine rGE. Multilevel modeling (MLM) techniques have been utilized, allowing inclusion of multiple children within each family in a single-multiple regression analysis. MLM analyses have also included measures of zygosity and its interactions with individual twins' deviance scores from the family mean, using methodology described by Turkheimer and Harden (2014), providing estimates of causality and G×E.

Recent Research with the SITSS Sample

Recent studies utilizing children from the SITSS have focused on both internalizing and externalizing problem behaviors, examining data on children from ages 5 to 18 years. Much of our work has included data from our original peer-play study, described above. The most important aspect of our peer-play paradigm was that we controlled for passive rGE, because the parents had no control over their children's randomly chosen peer partners, as well as active rGE, because the children themselves also had no control over their play partners. Thus, correlations between the children had to result from evocative rGE (DiLalla & John, 2014).

Table 2. Recent SITSS follow-up measures administered

Construct		Age (years)	Reporter	Method
Biological	Genotype/zygosity	1–16	PR; TO	Buccal samples
	Eye tracking/operant conditioning	6–16	TO	OB
	Neuroimaging/neurophysiology screening (fMRI/EEG)	11–16	TO	OB
Health	Body-mass index	7–13; 12–20	CR; TO	LA; TI
	Dietary/exercise behaviors	7–13; 12–20	CR; PR	LQ; TI
	Sleep and sleep-related behaviors	5, 7–13	CR; PR	LQ
	Screen time behaviors	5, 12–20	CR	LQ; TI
	Physical health symptoms	12–20	CR	TI
	Somatic problems	5–20	PR; CR	LQ; TI
Emotional/behavioral	Emotional regulation and prosocial behaviors	6–10	CR; PR	TI
	Aggression, bullying, victimization	6–13	CR; PR	TI; LQ
	Internalizing/externalizing	6–13	CR; PR	TI; LQ
	Emotion recognition and expression	6–13	PR; CR	OB; LA; LQ
	Anxiety screen	7–13	CR; PR	LQ
Personality	Child temperament	1–13	CR; PR; TO	LQ; OB
	Parent personality	6–18	CR; PR	LQ
Home/social environment	Parenting behaviors	6–10	CR; PR	TI
	Family climate	1–10	PR	LQ
	Family information	1–20	PR	TI; LQ
	Stressful life events	7–13	PR	LQ
	Social support	6–16	CR	LQ
	Parental discipline	1–18	CR; PR; TO	LQ; OB
Relationships with others	Empathy	7–13	PR	LQ
	Social information processing	7–13	CR; PR	LA
	Relations with cotwin	6–16	CR	LQ
	Relations with parent	1–5	TO	LA
	Relations with peers	6–16	CR; PR	LQ

Note: CR = child report; PR = parent report; TO = tester observed/rated; LQ = lab questionnaire; LA = lab assessment; TI = telephone interview; OB = observed assessment.

We took advantage of this peer-play paradigm in a recent study presented initially to the International Society for Twin Studies in Dr. Irving I. Gottesman's honor. (He is the academic grandfather of the SITSS.) We utilized a genetic risk index for rule-breaking behaviors at age 5, created as a function of parent ratings of early rule-breaking and co-twin relatedness (MZ vs. DZ) in a manner similar to Jaffee et al. (2005). We showed that children at genetic risk for rule breaking were more likely to elicit aggression from novel peer-play partners during the peer-play situation, suggesting the importance of evocative rGE in young children's play scenarios (DiLalla & DiLalla, 2018). Similarly, children at genetic risk for behaving aggressively with a peer, coded during the 5-year-old peer play, were more likely to elicit aggression from their play partner (DiLalla & John, 2014). We also demonstrated evocative rGE for prosocial behaviors using this same genetic likelihood index method (DiLalla et al., 2015a). Children with a genetic likelihood for behaving in prosocial ways during the peer play and who are also temperamentally outgoing, as rated by parents, were more likely to evoke more prosocial and easy-going behaviors from an unfamiliar play partner. Thus, these data have been instrumental in demonstrating that young children's behaviors elicit similar

behaviors from same-age peers and that these eliciting behaviors are related to their genetic make-up (i.e., evocative rGE).

Other measures of externalizing behaviors have also been considered. In one study, we showed that parent ratings of 5-year-old children's aggressive behaviors were related to the amount of physical aggression displayed in television shows and computer games that those children preferred, as measured by self-report, and this was partially mediated by shared genes (Jamnik & DiLalla, 2018). Importantly, this study examined children's preferences rather than their responses to manipulations of exposure to shows or games, and in this way is more naturalistic than manipulation studies.

Finally, two recent studies of externalizing behaviors in the SITSS sample have extended earlier findings regarding DRD4 effects. We found evidence for differential susceptibility when examining child-reported victimization and externalizing behaviors in 6- to 10-year-olds (DiLalla et al., 2015b). Children with the 7-repeat allele (DRD4-7r) who did not report having been victimized had the lowest levels of externalizing behaviors, but DRD4-7r children who did report being victimized reported the highest levels of externalizing behaviors. Interestingly, we also

demonstrated that 5-year-old children without the 7-repeat allele for DRD4 (DRD4-no7r) showed differential susceptibility to prenatal environmental stressors. DRD4-no7r children with few moderate birth complications showed low-negative emotionality, but DRD4-no7r children with many moderate birth complications were rated as the highest on negative emotionality (Bersted & DiLalla, 2016). Because prenatal birth complications are different from transactional child–parent or peer interactions, the role of dopamine may be quite different (less related to the brain’s reward pathways during interactions). Therefore, this study may highlight some important new avenues of research for the role of dopamine on the developing brain.

Other aspects of child development have also been examined with the SITSS. One study of children’s perceived competence (Klaver et al., 2014) showed that children who overreported their own self-competence at age 5, as compared to objective ratings, were more likely to have more parent-reported externalizing and internalizing problems. Another study examined parent sensitivity and 4-year-old children’s responsiveness minute by minute during a 10-min interaction in the lab (Elam & DiLalla, 2018). Using latent growth curve models, we found that low parent sensitivity was predictive of child unresponsiveness only in DRD4-7r children, thus demonstrating G×E as well as the importance of understanding minute-by-minute changes in parent and child interactional behaviors. Finally, we showed that age 5 parent-reported internalizing problems predicted youth-reported physical health problems as well as BMI when youth were between the ages of 12 and 20 years, thus demonstrating the importance of including preschool temperament and internalizing problems when predicting adolescent health behaviors (Jamnik & DiLalla, 2019).

Conclusions

The SITSS has proved to be a valuable behavior genetic resource for examining in-depth aspects of child development that are difficult to assess, such as observations of peer interactions and emotion recognition and expression skills. We plan to continue recruiting preschool twins and expanding our data collection of these twins as they grow. Utilization of novel statistical methods, such as genetic likelihood indexes and MLM, as well as the continued use of genetic information and careful measures of the environment, will continue to enhance our understanding of typical child social and cognitive development.

Acknowledgements. We owe a debt of gratitude to Dr. Andrew Smolen and Dr. John McGeary, who have collaborated with us on all the molecular genetics and zygosity work. This project has been funded by grants to the first author from SIUC Special Research Project Grants, SIU School of Medicine CRC Grants, SIU Center for Integrated Research in Cognitive and Neural Sciences grant, a grant from the SIU School of Medicine RSG and the SIU School of Medicine’s Department of Family and Community Medicine. Special thanks for devoted work to SITSS go to, among many others, Bo Bishop, Lorrie Gehlbach, Brad Gehlbach, Paula Mullineaux, Kit Elam, Kristin Hoffman, Sara Biebl, Sarah Long, Rashida Barner, Jaimi Mathias, Sufna John, Kyle

Bersted, Jacqueline Klaver, Amanda Palo, Megan Trask, Gabriel Casher, Emma Diaz, Riley Marshall and Emily Pali. Of course, very special thanks go to the SITSS families.

References

- Bersted, K., & DiLalla, L. F. (2016). The influence of DRD4 genotype and perinatal environment on preschoolers’ negative emotionality. *Journal of Applied Developmental Psychology, 42*, 71–79.
- Dick, D. M., Agrawal, A., Keller, M. C., Adkins, A., Aliev, F., Monroe, S., . . . Sher, K. J. (2015). Candidate gene–environment interaction research: Reflections and recommendations. *Perspectives on Psychological Science, 10*, 37–59.
- DiLalla, L. F. (2002a). Preschool social and cognitive behaviors: The Southern Illinois Twins. *Twin Research, 5*, 468–471.
- DiLalla, L. F. (2002b). Behavior genetics of aggression in children: Review and future directions. *Developmental Review, 22*, 593–622.
- DiLalla, L. F. (2006). Social development of twins. *Twin Research and Human Genetics, 9*, 95–102.
- DiLalla, L. F., & DiLalla, D. L. (2018). Gene-environment correlations affecting children’s early delinquency and aggressive play behaviors. *Twin Research and Human Genetics, 21*, 285–288.
- DiLalla, L. F., & John, S. G. (2014). Genetic influences on victimization during preschool play with unfamiliar peers. *Merrill-Palmer Quarterly, 60*, 168–192.
- DiLalla, L. F., Bersted, K., & John, S. G. (2015a). Evidence of reactive gene-environment correlation in preschoolers’ prosocial play with unfamiliar peers. *Developmental Psychology, 51*, 1464–1475.
- DiLalla, L. F., Bersted, K., & John, S. G. (2015b). Peer victimization and DRD4 influence problem behaviors in young children. *Journal of Youth and Adolescence, 44*, 1478–1493.
- DiLalla, L. F., Elam, K. K., & Smolen, A. (2009). Genetic and gene-environment interaction effects on preschoolers’ social behaviors. *Developmental Psychobiology, 51*, 451–463.
- DiLalla, L. F., Gheyara, S., & Bersted, K. (2013). The Southern Illinois Twins and Siblings Study (SITSS): Description and update. *Twin Research and Human Genetics, 16*, 371–375.
- Elam, K. K., & DiLalla, L. F. (2018). Minute-to-minute trajectories of child unresponsiveness and parent sensitivity in parent-child interactions: The role of DRD4. *Social Development, 27*, 952–966.
- Jaffee, S. R., Caspi, A., Moffitt, T. E., Dodge, K. A., Rutter, M., Taylor, A., & Tully, L. A. (2005). Nature × nurture: Genetic vulnerabilities interact with physical maltreatment to promote conduct problems. *Development and Psychopathology, 17*, 67–84.
- Jamnik, M. R., & DiLalla, L. F. (2018). A multimethodological study of preschoolers’ preferences for aggressive television and video games. *Journal of Genetic Psychology, 179*, 156–169.
- Jamnik, M. R., & DiLalla, L. F. (2019). Health outcomes associated with internalizing problems in early childhood and adolescence. *Frontiers in Psychology, 10*. <https://doi.org/10.3389/fpsyg.2019.00060>
- Klaver, J. M., Palo, A., & DiLalla, L. F. (2014). Inaccuracy of perceived competence ratings is associated with problem behaviors in 5-year-old children. *Journal of Genetic Psychology, 175*, 363–381.
- Turkheimer, E., & Harden, K. P. (2014). Behavior genetic research methods: Testing quasi-causal hypotheses using multivariate twin data. In H. T. Reis & C.M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 159–187). Cambridge, MA: Cambridge University Press.