

## ORIGINAL RESEARCH

# The relationship between family environmental factors and child sensory integration

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## ABSTRACT

**Objective:** To investigate the relationship between child sensory integration and family environmental factors.

**Methods:** This was a cross-sectional study. The sample (n = 130) was recruited from children attending the outpatient department of a pediatric hospital located in central part of China. Sensory integration of the child was reported by either parent from using a Chinese version of the Sensory Integration and Praxis Test.

**Results:** Approximately 17.69%-24% of the participating children experienced impairments in different dimensions of sensory integration. Severe impairment occurred in 3%-5% of the participating children. Paternal-child interaction had a significant effect on vestibular function of the child, after controlling for the effect of covariates including maternal obstetric history and low birth weight status of the child. Family functioning was found significantly related to tactile sensation, proprioception, and learning ability of the children.

**Conclusions:** It appears that family environment plays a significant role in sensory integration outcomes of older children.

**Key Words:** Child, Family environment, Sensory

## 1. INTRODUCTION

Sensory integration (SI) refers to brain functionality whereby the nervous system manages incoming sensory information and allows the body to produce adaptive movement or behavior.<sup>[1,2]</sup> Normal SI is the prerequisite for children to process and integrate sensory information in order to develop body awareness in space as well as interact effectively with the environment.<sup>[3]</sup> Sensory integration dysfunction can be classified into two different patterns including poor sensory modulation and poor praxis.<sup>[4]</sup> Children with poor sensory modulation may demonstrate exaggerated or inappropriate responses to everyday sensory input.<sup>[4]</sup> Poor praxis is characterized by difficulty in organizing and carrying out a novel motor performance or acting on the environment.<sup>[4]</sup>

Sensory integration dysfunction is a common characteristic associated with a number of child developmental and behavioral disorders (i.e. Autism Spectrum Disorder, child anxiety disorder).<sup>[5,6]</sup>

Family environment as a primary social microsystem tends to emphasize an individual's role and relations in the immediate setting containing the individual.<sup>[7]</sup> The family in its most common form is a lifelong commitment between mother and father who feed, shelter and nurture their children until they reach maturity. As a primary socialization context, family is considered to be very important for child development.<sup>[8]</sup> There is an established link between family environmental factors (i.e. low-income status, severe inter-

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parental discord) and child psychological problems such as child anxiety.<sup>[9,10]</sup> However, the role of family environment on child SI developmental outcome is rarely mentioned in the literature.

### 1.1 Sensory integration

Sensory integration theory addresses the relationship between brain and behavior. Sensory integration is a theoretical framework widely used by pediatricians and occupational therapists to understand the underlying causes of child learning, behavioral or developmental problems.<sup>[11]</sup> It lays the foundation for high-level cognitive, motor and social development.<sup>[12]</sup> Sensory integration theory or framework continually evolves due to the complexity and controversy of the construct of SI. Ayres originally defined SI as “the ability to organize information for use”.<sup>[13]</sup> The definition was further expanded to include information processing, where the brain receives, interprets and integrates sensory inputs from different sensory modalities. In order to adapt to the changing environment, SI requires functioning in a flexible and constantly changing pattern.<sup>[1]</sup> SI theory contains three major components including the description of normal integrative SI, the definition of sensory integrative disorder, as well as guidance in SI intervention. Learning depends upon the child’s ability to take in sensory information from the external environment and their body movement, and the ability to interpret, process and use the information to plan and organize behavior. Deficits in SI can lead to difficulty in conceptual and motor learning. Proper sensory stimulus may help with the maturation and development of a child’s SI, which may further lead to enhanced learning performance.<sup>[4]</sup> Nowadays sensory-based therapy has been increasingly used by occupational therapists in treating children with developmental and behavioral disorders.<sup>[14]</sup> The therapy includes activities that help the sensory system to organize vestibular, proprioceptive, auditory, and tactile inputs, through the use of specially designed therapeutic equipment (i.e brushes, swings, and balls). Relevant therapy strategies have been accepted as one major component of a comprehensive treatment plan, although relevant research evidence regarding their effectiveness is limited and inconclusive.<sup>[15]</sup>

Sensory integration begins with fetal development and continues through infancy and early childhood. Most fundamental abilities of SI mature by 7 or 8 years of age.<sup>[12]</sup> Currently the diagnostic framework of sensory integrative disorder is not standardized and hence the disorder has not been included in the Diagnostic and Statistical Manual of Mental Disorders (DSM)-V.<sup>[16]</sup> Although the disorder has been heavily researched in occupational therapy, it has not been substantively integrated into clinical practice including that of nurs-

ing practitioners.<sup>[17]</sup>

### 1.2 Influencing factors of SI development

According to the study of Lin et al. (2013), age was a significant predictor for various stages of SI development. Children in older age groups demonstrated better performance on postural movement, sensory discrimination, sensory seeking, attention and activity than those in younger groups.<sup>[18]</sup>

Children with certain perinatal risks (i.e. pre-term, low birth weight, brain injury) were more likely to develop problems with SI.<sup>[19,20]</sup> In a study of Van Hulle et al. (2015), typically developing twins (N = 978) were recruited and their sensory over-responsivity was measured at age 2 and 7. Based on risk status of sensory outcomes at age 2 and 7, the sample was divided into four trajectory groups including low symptom, remitting, late-onset and chronic. Children in the chronic group tended to deliver at low birth weight and at younger gestational age than those in the low symptom group. It was found that sensory over-responsivity is likely induced by different developmental causes and etiologies.<sup>[21]</sup>

According to Wilbarger et al. (2010), children with experience of prolonged institutionalized care demonstrated higher levels of sensory reactivity and showed more aversion to sensory stimuli, when compared to children who were adopted early and primarily from foster care or those who were raised by birth parents. Therefore, sensory and social deprivation might contribute to future child sensory problems.<sup>[22]</sup>

Liu et al. (2002) investigated a total of 1,526 children aged from 3-6 years from 15 kindergartens and found that parental rejection was a significant influencing factor of SI development.<sup>[23]</sup> Previous literature regarding influencing factors of sensory integration development is limited and inconsistent. These factors were either related to a child’s own stage of development or risk factors associated with pregnancy or birth. Meanwhile some types of families may pose more risks to children than other types. Previous literature has tended to focus on children under 3 years of age.

### 1.3 Study aims

The specific aim of the study was to investigate whether family environmental factors were significantly associated with child SI development.

Specific research questions were:

- (1) What was the the status of SI in children over 3 years of age, including their level of SI and percentage of SI impairments?
- (2) Were SI outcomes of the children significantly related to family environmental factors including family functioning, parental education, parental interaction with the child, and

family socioeconomic status (SES)?

## 2. METHODS

### 2.1 Sample and setting

The study was conducted in a tertiary pediatric health care center located in Wuhan, central part of China. Convenience sampling was used to recruit 130 parent-child dyads from the outpatient department between Apr 2013 to Mar 2014.

The inclusion criterias were: 1) Parents (mother and/or father) accompanying their child for a medical visit to the outpatient clinic of the pediatric health care center; 2) Parents having resided in the same geographic region for at least 5 years; 3) Parents are able to read, write, and comprehend Chinese, and have no difficulty in completing written questionnaires. 4) Children with chronic medical diseases (i.e. renal disease, asthma, blood disorder et al.) attended the medical clinics for regular follow up. Exclusion criteria included: 1) Children younger than 3 years age; or having a history of neurological disease, genetic disorders or psychiatric conditions; 2) Parents having a history of psychiatric conditions, or are illiterate or unwilling to cooperate with the researcher. 3) Parents residing in the city or surrounding area for less than 5 years.

### 2.2 Data collection procedure

Eligible parent-child dyads were approached by a research assistant in the waiting room, where a brief introduction about the study purpose and procedure were provided. The parents who agreed to participate in the study were provided with informed consent and a set of self-report tools to fill out. Parents were given brief guidance about how to complete the following questionnaires. The entire process took about 10-15 mins.

### 2.3 Measurement tools

**1) Child Sensory Integration Scale:** This scale was developed by a Taiwanese psychologist, with items modified from the Sensory Integration and Praxis Test. The scale was introduced to mainland China by researchers at the Beijing Medical University Institute of Mental Health (changed to Beijing University Institute of Mental Health in 2000).<sup>[24]</sup> It contains 58 items, each scoring on a 1-5 Likert scale. The four dimensions include: (1) motor balance and major muscle function (vestibular sense) which is the awareness of the position of one's head in relation to gravity and movement which is used to come down a slide, or ride a playground swing without falling off; (2) tactile defense and emotional instability including an over response to being touched which might be associated with an underlying emotional problem; (3) proprioception: the internal awareness of the position

of one's joints and muscles in space which allows an individual to lift a spoon to the mouth without spilling a liquid; (4) learning deficits including a lack of adequate learning function due to problems in visual perception or visual motor perception.

A fifth dimension, special problems of older children, was only assessed for those older than 11 years of age. The scale had established reliability and validity in a Chinese setting. The test-retest reliability was .47-.73, split-half reliability was .68-.77, and Cronbach's  $\alpha$  was .44-.63, the concurrent validity was .49-.94.<sup>[24,25]</sup>

**2) Family APGAR index:** This scale was developed by Smilkstein from the University of Washington and consists of five dimensions of family functioning, including A (Adaptability), P (Partnership), G (Growth), A (Affection), and R (Resolve). The response options are set to describe perceptions about family relationships on a 3-point scale from 0 (hardly ever) to 2 (almost always). The scale can be completed in less than 5 minutes. Cronbach's  $\alpha$  of the scale ranged from .80 to .85.<sup>[26]</sup>

**3) Self-designed questionnaire:** This was developed by the research team and used to obtain demographic characteristics of the participants, perinatal and family environmental factors including family income and parental education level. The interaction between parent and child was assessed by a single item "How often did you interact with your child?". Perinatal factors including maternal history of pregnancy and delivery, and preterm birth and low birth weight status of the child were reported by the parents.

### 2.4 Data analysis

Mean, standard deviation (SD) and percentage were used to describe the distribution of sample characteristics such as age, family income, maternal history of pregnancy and delivery. Pearson's  $r$  or Chi-square test was used to identify the relationship between SI, its subscales, and family environmental factors. Stepwise multiple linear regression was used to identify the effect of family environmental factors on SI, after controlling for the effect of perinatal factors including maternal obstetric history and low birth weight. The default criteria of  $F$  for variable entry is  $< .05$  and  $> .1$  for variable removal.

### 2.5 Ethical considerations

Permission to conduct the study was obtained from the research ethics office of the hospital and the university where the first investigator was employed. Participants' identity (i.e name, address) did not appear on the data collection forms; their confidentiality was maintained throughout the study. All data were collected anonymously and only accessible

to the research team and the participating parents signed the informed consent before data collection was initiated. Potential risks of the study were minimal, despite time and energy involvement of the parents. Since the study was done as part of a developmental check-up, parents tended not to worry about the results. Researchers emphasized that parents could withdraw from the study at any time without posing any consequences to their children's medical care. Data were stored in a password-protected computer and only accessible to the research team.

### 3. RESULTS

#### 3.1 Characteristics of participating children or families

The descriptive characteristics of the participants are shown in Table 1 and Table 2. There were 61 (46.92%) male children and 69 (53.08%) female. Children ranged in age from 3-11 years, with half (49.23%) of them being under 6 (not attending primary school). About 17.69% were pre-term. Mean birth weight was 3.37 kg (SD = 0.64). Approximately 17.7% of the mothers had experienced an abnormal pregnancy (i.e. hypertension of pregnancy), 16.9% experienced an abnormal labor (i.e. prolonged duration), and around 10% of the mothers had a history of delivery complications.

**Table 1.** Characteristics of participating children (n = 130)

	N	%	Mean	Sd
<b>Age range (years)</b>				
< 6 (3-5)	64	49.23	6.30	2.66
≥ 6 (6-11)	66	50.77		
<b>Gender</b>				
Male	61	46.92		
Female	69	53.08		
<b>Birth weight (kg)</b>			3.37	0.64
<b>Gestational age</b>				
< 37 weeks	23	17.69		
37-42 weeks	101	77.69		
> 42 weeks	6	4.61		

According to Table 2, about 46.92% of the mothers were high school graduates and 26.92% were college graduates. Around 43% of the fathers graduated from college. Eighty percent of the mothers reported having often or always interaction with their child; however, the types of interactions only occurred in 50.77% of the fathers. Approximately 46.15% of the participating families had an annual income between 50,000-100,000 RMB.

The mean score of family functioning was 14.56 (sd = 4.25). Normal functioning occurred in 53.85% of the participating families with the rest being either mildly impaired or severely impaired.

#### 3.2 Sensory integration level

According to Table 3, most children in the sample had a normal value of SI. Approximately 24% of the sample had impairments (respective SI subscale score was less than 40) on vestibular function, 17.69% on tactile defensiveness, 22.30% on proprioception, and 24.24% on learning ability. Severe impairment (SI subscale score less than 30) occurred in 3%-5% of the children. According to Table 4, gender was a significant influencing factor of overall SI score. Female children exhibited lower rates of learning ability impairments than male children ( $p = .44$ ).

**Table 2.** Family environment characteristics of the sample

	N (%)
<b>Maternal education</b>	
Not graduate from high school	34 (26.15)
High school graduates	61 (46.92)
College graduates	35 (26.92)
<b>Interaction between mother and child</b>	
Always	35 (26.92)
Often	69 (53.08)
Sometimes	19 (14.62)
Occasionally	6 (4.62)
Rarely	1 (.76)
<b>Paternal education</b>	
Under high school	33 (25.38)
High school graduates	41 (31.54)
College graduates	56 (43.08)
<b>Interaction between father and child</b>	
Always	17 (13.08)
Often	49 (37.69)
Sometimes	47 (36.15)
Occasionally	16 (12.31)
Rarely	1 (.77)
<b>Family functioning</b>	
Good	70 (53.85)
Mild impairment	45 (34.61)
Serious impairment	15 (11.54)
<b>Annual family income</b>	
Under 20,000	10 (7.69)
20,000 to 50,000	34 (26.15)
50,000 to 100,000	60 (46.15)
100,000 to 300,000	23 (17.69)
More than 300,000	3 (2.32)

#### 3.3 The relationship between family environmental factors and SI

As seen in Table 5, there was a significantly positive association between family income and child learning ability ( $r = .315$ ,  $p = .010$ ), suggesting that children from higher income families had better learning ability than those from lower income families. Family functioning was related to three subareas of SI including tactile sensation, proprioception, and learning ability ( $r = .219$ ,  $p = .017$ ;  $r = .271$ ,  $p = .003$ ).

and  $r = .405$ ,  $p = .001$ , respectively). Interaction between the father/mother and child was found to be significantly associated with child vestibular function and tactile sensation. There was a medium-degree association ( $r$  ranging from .31-.41) between learning ability and three family environmental

factors including family income, family functioning, and maternal education. This suggested that children tend to have better learning ability if raised by more educated, and capable parents, and families with a higher income.

**Table 3.** Sensory integration level of the sample (n=130)

	Vestibular Function n = 130	Tactile Sensation n = 130	Proprioception n = 130	Learning Ability n = 66
Good ( $\geq 40$ )	99 (76.15)	107 (82.31)	101 (77.70)	50 (75.76)
Mild impairment (30-40)	26 (20.00)	16 (12.31)	22 (16.92)	14 (21.21)
Serious impairment ( $< 30$ )	5 (3.85)	7 (5.38)	7 (5.38)	2 (3.03)
<b>Total Score</b>				
Mean	49.08	49.44	49.65	49.90
Sd	11.02	12.01	11.26	11.38

**Table 4.** The association of gender and different types of sensory integration using Chi-square

Gender	Vestibular function		Tactile sensation		Proprioception		Learning ability	
	Good	Dysfunc	Good	Dysfunc	Good	Dysfunc	Good	Dysfunc
Male	43	18	49	12	48	13	17	10
Female	56	13	58	11	53	13	33	6
$\chi^2$	2.029		.309		.051		4.073*	
$p$	.154		.578		.822		.044*	

\* $p < .05$

**Table 5.** Pearson correlation coefficient between sensory integration and family environmental factors

Risk factors	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
<b>Vestibular function</b>						
$r$ value	.100	.169	.002	.059	.255**	.290**
$p$	.256	.066	.986	.514	.003**	.001**
<b>Tactile sensation function</b>						
$r$ value	.076	.219*	.035	.052	.179*	.136
$p$	.388	.017*	.694	.560	.042*	.124
<b>Proprioception</b>						
$r$ value	.165	.271**	.195*	.173	.165	.025
$p$	.061	.003**	.028*	.052	.061	.776
<b>Learning ability</b>						
$r$ value	.315**	.405**	.239	.353**	.234	.098
$p$	.010**	.001**	.059	.005**	.059	.434

Note. Factor 1 = Family income; Factor 2 = Family functioning; Factor 3 = Paternal education background; Factor 4 = Maternal education background; Factor 5 = Paternal interaction with the child; Factor 6 = Maternal interaction with the child; \* $p < .05$ ; \*\* $p < .01$ .

The univariate analysis results indicated that all family environmental factors were significant influencing factors of at least one SI subarea. Therefore, all entered the stepwise multiple regression model. Table 6 shows the influence of family environmental factors on SI after controlling for the effect of covariates including maternal obstetric history and low birth

weight status of the child. Results found that paternal-child interaction had a significant effect on vestibular function of the child. Family functioning was also found to be significantly related to tactile sensation, proprioception, and learning ability of children. Family functioning accounted for 16.5% of the total variance in child learning ability.

**Table 6.** Effect of family environmental factors on child sensory integration using step-wise multiple regression

	B	SE	$\beta$	R <sup>2</sup>	Adjusted R <sup>2</sup>	F	p
<b>Vestibular function</b>							
Model 1	—	—	—	.085	.077	10.450	.002*
(Constant)	57.901	2.892	—				
Factor 7	-3.580	1.108	-.292				
<b>Tactile sensation</b>							
Model 2	—	—	—	.051	.043	6.036	.016*
(Constant)	40.083	4.015	—				
Factor 4	.647	.263	.226				
<b>Proprioception</b>							
Model 3	—	—	—	.066	.057	7.879	.006*
(Constant)	39.041	3.805	—				
Factor 4	.701	.250	.256				
<b>Learning ability</b>							
Model 4	—	—	—	.179	.165	12.663	.001*
(Constant)	31.887	4.892	—				
Factor 4	1.148	.323	.423				

Note. Factors 4 = family functioning; Factor 7 = paternal interaction with the child.

## 4. DISCUSSION

### 4.1 Discussion of the results

In this sample, the percentage of mild impairment on vestibular function, tactile sensation, proprioception, and learning ability were 26%, 16%, 22% and 14%, respectively. The percentage for severe impairment was 5%, 7%, 7% and 2%, respectively. These results were slightly higher than those of a recent study conducted in China, where among 2,515 children aged 4-6 years, approximately 24% had mild impairment and 1.4% experienced severe impairment on sensory processing.<sup>[27]</sup> This might be because the current study sample was recruited from a pediatric health center rather than from the general population.

The study results showed that male children were at higher risk for poor learning ability than female children. Results were in accord with previous study findings of Yu et al. (2006), where a significant difference in SI was found between male and female children. Males were more likely to experience SID than females, especially in vestibular function.<sup>[28]</sup> The gender disparity could be because male children tended to develop slower in sensory function than female during school ages.<sup>[23]</sup>

Results indicated that parental interaction with the child was important for child vestibular function and tactile sensation. Coster and Haley (1992) emphasized the need to consider the interactions between children and their families or caregivers and to design interventions to address the needs of children within the broader context of family, home, school, and other environments in which children participate.<sup>[29]</sup> Numerous study results have demonstrated that limited social interac-

tions, exploration, and play could lead to child developmental delay, growth delay, social behavioral problems, and attention and activity problems.<sup>[30-32]</sup> Children who lived in a single family or a stepfamily were vulnerable to SID.<sup>[23,28]</sup> Children raised in an orphanage usually lacked consistent physical, social, and emotional care as provided by mothers, therefore they were at high risk for child developmental delays.<sup>[33]</sup>

This study found that family functioning had significant impact on child tactile sensation, proprioception, and learning function. This was similar to the study results of Liu et al., which found that maternal rejection was a significant predictor of sensory integrative dysfunction. Rejection from parents could lead to a child's low self-esteem and lack of creativity.<sup>[23]</sup> In this study, children's learning abilities were found to be associated with family income. Child learning ability and proprioception level were found to be related to parental educational level. According to Duncan and Brooks-Gunn (1997), children in families with low incomes are at greater risk of poor cognitive, health, and social outcomes than children in families with high incomes.<sup>[34]</sup> Children from resource-limited families lacked the opportunity to be exposed to environmental complexity with regard to sensory-motor experiences.<sup>[35,36]</sup>

Previous study results have demonstrated the negative impact of perinatal factors on SI development.<sup>[37]</sup> The rate of SID in children who were delivered by cesarean section was higher than those born by vaginal delivery.<sup>[38]</sup> Gestational age could explain 5% of the variance in tactile sensitivity. However, these results were not supported by the current study.

## 4.2 Limitations

Two limitations were noted in the present study. The sample was limited to an urban setting and thus the results might not be generalizable to children living in rural areas. The results provide minimum evidence of a causal association between family environment and child SI. Other research methodologies such as a prospective cohort study, should be considered in the future to serve this purpose.

## 4.3 Recommendations

Study results indicated that child SI outcomes were likely affected by family contextual factors, particularly family functioning and family SES. It is recommended that proper interventions should be developed in order to target these

vulnerable families. The development of SI interventions requires interdisciplinary efforts from pediatricians, nurses, occupational therapists, and family members. Routine screening for SI deficits needs to be integrated into pediatric health care practice in outpatient and primary care settings.

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## CONFLICTS OF INTEREST DISCLOSURE

The authors declared no conflicts of interests.

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