THE JOURNAL OF CHILD PSYCHOLOGY AND PSYCHIATRY
ACAMH
Journal of Child Psychology and Psychiatry 51:10 (2010), pp 1105–1114 doi:10.1111/j.1469-7610.2010.02255.x

Sensory processing in internationally adopted, post-institutionalized children

Julia Wilbarger,[1] Megan Gunnar,[2] Mary Schneider,[1,3] and Seth Pollak[3]

[1]Department of Kinesiology, University of Wisconsin-Madison; USA; [2]Institute for Child Development, University of Minnesota-Twin Cities, USA; [3]Department of Psychology, University of Wisconsin-Madison, USA

Background/Methods: Sensory processing capacities of 8–12-year-old internationally adopted (IA) children who experienced prolonged institutional care (> 12 months with 75% of pre-adoption lives in institutional care) prior to adoption into family environments (PI) were compared to a group of IA children who were adopted early (< 8 months) predominantly from foster care with little or no institutional experience (EA/FC) and another group of non-adopted (NA) children raised by their birth parents in the United States. All children had estimated IQs within the normal range and did not evidence major neurodevelopmental disorders (e.g., cerebral palsy, fetal alcohol syndrome, Down's syndrome). Sensory processing was evaluated with a commonly used parent-report measure and a laboratory assessment. **Results:** Children who had experienced prolonged institutionalization showed higher levels of reactivity to sensation and displayed both more aversion and approach to sensory stimuli than the other groups. The comparison groups (EA/FC & NA) did not differ on any of the sensory processing measures. **Conclusions:** These results suggest that early institutional rearing which typically involves both sensory and social deprivation is associated with problems in sensory modulation capacities. **Keywords:** Institutional care, early deprivation, international adoption, sensory processing. **Abbreviations:** PI: post-institutionalized; EA/FC: early adopted-foster care; NA: non-adopted controls; IA: internationally adopted; SSP: Short Sensory Profile; SMD: sensory modulation disorder.

Institutionally-reared infants are often deprived of social nurturance as well as sensory and physical experiences critical for development (Gunnar, Bruce, & Grotevant, 2000; Rutter, Kreppner, & O'Connor, 2001). Deprivation of sensory experience and caregiver support may impair the development of the child's ability to modulate her/his responses to the environment which is a building block for self-regulatory abilities associated with learning, social development, and mental health (Casler, 1965; DeGangi, Breinbauer, Doussard Roosevelt, Porges, & Greenspan, 2000). The few studies examining sensory processing in children adopted from institutions have described a broad range of disruptions (Cermak & Daunhauer, 1997; Lin, Cermak, Coster, & Miller, 2005). Extant studies, however, have lacked appropriate comparison groups and have relied heavily on parent reports. Use of parent reports may overestimate sensory difficulties in post-institutionalized (PI) children as parents appear to report more behavior problems for adopted than for birth children (e.g., Brand & Brinich, 1999). Thus, examination of the sensory processing problems of PI children requires a comparison group of adopted children without substantial institutional care histories and the use of objective indices of sensory responses along with parent-report data. Providing these data and comparisons were the goals of the present report.

Long-term effects of institutionalization

While some countries rely on foster care for orphaned and abandoned children, others place infants in institutions. Although the quality of institutional care varies, most institutions do not typically provide the care necessary to support normative development (Johnson, 2000; Johnson & Nelson, 2000; Mason & Narad, 2005). Children often have multiple and inconsistent caretakers, and spend many hours alone in cribs where they are often noted to engage in self-stimulatory behavior (Mason & Narad, 2005). At adoption, particularly when institutional conditions are severely depriving, almost all children have delays across multiple domains (Beckett et al., 2006; Croft et al., 2007; Morison, Ames, & Chisholm, 1995; Rutter & the ERA Study Team, 1998). While most PI children make significant gains after adoption, a substantial number exhibit persistent deficits, particularly in behavioral, social and emotional regulation. (Beckett et al., 2002; Croft et al., 2007; Gunnar, van Dulmen, & the IAP Team, 2007; Kreppner et al., 2007; MacLean, 2003).

Here, we focus on one aspect of self-regulation: disruptions in sensory processing. Persistent maladaptive behaviors including sensory avoidance and aversion, stereotypic rocking, unusual sensory interests or seeking, self-injury, eating problems, and autistic-like behaviors have been reported among PI children (Beckett et al., 2002; Cermak & Groza, 1998). Indeed, parents report both sensory over-responsiveness with avoidance and unusual

Conflict of interest statement: No conflicts declared.

Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main St, Malden, MA 02148, USA

sensory-seeking behavior (Cermak & Groza, 1998). Specifically, young PI children (3–6 years) were reported by parents to have increased levels of touch responsiveness, movement avoidance, movement seeking, visual responsiveness, and auditory responsiveness relative to non-adopted children (Cermak & Daunhauer, 1997). Behaviorally, these issues were manifested by problems in activity level, feeding, organization, and emotional stability. Similar findings were documented in a slightly older (4–8 years) group of PI children (Lin et al., 2005). Children institutionalized for longer than 18 months exhibited more sensory disruptions than those adopted before 6 months. Both studies noted both increased avoidance and seeking of sensory experiences. The presence of these opposing patterns suggests a weakness in the ability to modulate or regulate responses to sensation.

Sensory modulation

Effective modulation of sensation allows for appropriately graded responses to stimuli in the environment and adaptation to changes in environmental conditions (Stackhouse & Wilbarger, 1998). Adaptation occurs on neurological, physiological, and behavioral levels. Deficits in sensory modulation have been associated with differences in physiological and neurological responses to sensation in both human and animal studies (Davies & Gavin, 2007; McIntosh, Miller, Shyu, & Hagerman, 1999b; Schaaf, Miller, Seawell, & O'Keefe, 2003; Schneider et al., 2008). Disruptions in sensory processing have been noted in numerous clinical populations such as autism spectrum disorders, fragile X syndrome, attention deficits, and anxiety disorders (Baranek, Boyd, Poe, David, & Watson, 2007; Dunn, 2001; Kinnealey & Fuiek, 1999; Mangeot et al., 2001; McIntosh, Miller, Shyu, & Hagerman, 1999b). Sensory processing disorders can result in disruption of daily living skills, academic performance, social interactions and participation in age-appropriate activities (Baranek et al., 2002; White, Mulligan, Merrill & Wright, 2007; Parham, 1998; Reynolds & Lane, 2008).

Present study

In the present study, sensory processing capacities of internationally adopted children who experienced prolonged institutional care (PI) were compared to children who were adopted early predominantly from foster care with little or no institutional experience (EA/FC) and another group of non-adopted (NA) children raised by their birth parents in the United States. Specifically, we examined if PI children differed in sensory processing/modulation from the other two groups as evaluated with 1) a parent-report measure and 2) a laboratory assessment. Further, we examined if there was convergence between the measures and the relationship between the duration of institutionalized care and sensory processing.

The parent-report measure, the Short Sensory Profile (SSP), is commonly used clinically and is one of the only validated, published tools assessing sensory modulation disruptions. A laboratory measure was included to add a more objective measure of sensory processing. Adoptive parents, especially of those adopted at older ages, may be more sensitive to potential difficulties in their children. Further, the procedure provides a direct observation of children's responses to tactile stimuli. The laboratory-based measure was adapted from methods previously used to examine sensory responsiveness in children with developmental disabilities (Baranek, Foster, & Berkson, 1997), children with sensory modulation disorders (SMD) (McIntosh, Miller, Shyu, & Hagerman, 1999b) and non-human primates (Schneider et al., 2008). Both studies found that observational methods were able to identify sensory oversensitivity.

Based on previous studies (Lin et al., 2005), we primarily hypothesized that the PI children would demonstrate more sensory modulation disruptions on both measures than adopted but non-institutionalized children and non-adopted children. Secondarily, given the past literature, PI children were expected to display either more negative/aversion or positive/stimulus-seeking responses. Further, those sensory modulation disruptions would be associated with the duration of institutionalization.

Methods

Participants

Children (N = 297) between 8.0 and 12.5 years of age were drawn from three groups: Post Institutionalized (PI) children adopted after 12 months of age having spent more than 75% of their pre-adoption life in institutionalized care; Early Adoption/Foster Care (EA/FC) children adopted prior to 8 months of age having spent the majority of their pre-adoption lives in foster care with no more than 2 months of institutional care; and Non-Adopted (NA) children raised continuously by their birth families in the United States. Descriptive data are shown in Table 1. Each of the three groups contains approximately equal numbers of females and males. Mean age in the EA/FC group was slightly older than in the other groups. All children had cognitive and developmental functioning within a typical range. While within a normal range, the mean IQ estimate for children in the PI group was a significantly lower than the other two groups. There were no differences in IQ estimates between genders either within or between groups. The adopted children were all born outside of the United States.

Recruitment and screening

The adopted children were drawn from the Minnesota and Wisconsin International Adoption Project Registries. The non-adopted children were recruited in

Table 1 Descriptive data

Groups	PI	EA/FC	NA	Group Comparisons
Number	123	85	89	
Age				
Mean year-mos (SD in mos)	9–11 (14)	10–5 (15)	9–8 (14)	EA/FC > PI, $p = .01$
Range	8 to 12	8 to 12–5	8 to 11–11	EA/FC > NA, $p = .001$
Percent female	56.1 %	47.1 %	52.8 %	ns
Range of median family income in USD	75,001–100,000	75,001–100,000	75,001–100,000	ns
Age at adoption				
Mean in years-mos (SD in mos)	2–2 (15.5)	4.5 mos (1.7)	NA	PI > EA/FC, $p < .001$
Range	12–80	1 to 8 mos		
IQ estimates				
Mean (SD)	103.5 (16.12)	115.94 (14.67)	121.99 (15.97)	PI < EA/FC & NA $p < .001$
Range	79–148	82–151	84–157	EA/FC < NA, $p = .014$
Birth region percent within group (*N*)				
Asia (with India)	31.7 % (39)	71.8 % (61)		
Latin America	6.5 % (8)	28.2 % (24)		
Eastern Europe	61.0 % (75)	0		
Africa	.8 % (1)	0		

Wisconsin through fliers and advertisements, and in Minnesota from the Institute of Child Development Participant Pool. Prior to participation, inclusion was determined through phone interview and parent questionnaire. Children then participated in an extensive developmental profile. Children were excluded if their estimated IQs were below the normal range (< 78; % excluded: PI = 7.7, EA/FC = 1, NA = 0), parents reported congenital abnormalities (e.g., Downs/Cerebral Palsy; < 1% were excluded in each group), or they failed the fetal alcohol spectrum disorder (FASD) screening (Astley, 2003) (% excluded: PI = 8, EA/FC < 1, NA = 0). The procedures and percentage of children excluded from each group are described in more detail in Loman, Wiik, Frenn, Pollak, and Gunnar (2009). Briefly, estimated IQ was assessed using the Block Design and Vocabulary subtests of the Wechsler Intelligence Scale for Children – 3rd Edition (WISC-III). Both subtests of the WISC-III were converted into scaled scores with a mean scaled score of 10 and standard deviation of 3. The Leiter International Performance Scale-Revised (Leiter-R; Roid & Miller, 1997) was administered to participants (PI: 23.1%, $n = 21$, EA/FC: 7.3%, $n = 8$, NA: 1.4%) who scored more than one standard deviation below the mean on either WISC-III subtest. The Leiter Brief IQ score was used (mean of 100 and standard deviation of 15). All children in this analysis met criteria of estimated IQ > 78. See Table 1 for descriptive data. To screen for FASD, digital pictures of participants were taken and analyzed using the FAS Facial Photographic Analysis Software (Astley, 2003). The 2004 Center for Disease Control guidelines regarding FASD-associated facial dysmorphia (i.e., smooth philtrum, thin vermillion border, and small palpebral fissures) were used. The procedures and percentage of children excluded from each group are described in Loman et al. (2009).

Measures

Parent-report measure – Short Sensory Profile. The Short Sensory Profile (SSP) is a 38-item parent report measuring children's responsiveness to daily sensory experiences (Dunn, 1999). The SSP yields a Total score and seven section scores (Tactile Sensitivity, Taste/Smell Sensitivity, Movement Sensitivity, Under-responsive/Seeks Sensation, Auditory Filtering, Low Energy, and Visual/Auditory Sensitivity). Parents rate behaviors on a 5-point Likert type scale (1 = *always* and 5 = *never*). Lower SSP scores indicate greater sensory processing problems. Based upon the published scoring criteria, scores on the SSP are considered clinically significant if falling into the range of 'probable differences' (between 1 and 2 SD of published normative means) or 'definite differences' (> 2SD published normative means) (McIntosh, Miller, Shyu, & Dunn, 1999a). The internal consistency for of the Total score and section scores range from .70 to .90. Discriminate validity was established in a study comparing children with sensory modulation disruptions and typical children on electrodermal responses (EDR) to sensory stimuli (McIntosh et al., 1999b). The SSP was able to classify 95% of cases into clinical and non-clinical groups. Questionnaires were not completed for two children (EA/FC = 1, NA = 1).

Laboratory-base measure of tactile response. The objective measure of tactile responsiveness developed for this project is based on previous work with children (Baranek, Foster, and Berkson, 1997; McIntosh, Miller, Shyu, & Hagerman, 1999b) and non-human primates (Schneider et al., 2008). Three objects (feather, cotton ball, and baby toothbrush) are stroked six times each along the child's jaw line from just below the ear to the tip of the chin at a rate of 2 seconds with a 10-second pause between each trial, and a 30-second pause between stimulus types. The first author trained research staff at both the Wisconsin and Minnesota sites on administration procedures and monitored testing by videotape. The task was videotaped and later coded by three raters unaware of the group status of the children or the hypotheses of this study. Raters were trained by the first author. Prior to final scoring, reliability of 90% within one point was established between the three coders and 100% within one point of the first

author. Approximately 10% of the videos, 10 from each rater for a total of 30, were independently re-coded by the first author. The percent agreement between the first author and each of the raters was above 80%. Scores are missing for 29 (10%) participants [PI = 11 (9%), EA = 10 (12%), NA = 8 (9%)] because of absent/poor video quality or deviations in administration protocol.

Tactile response coding

Raters coded each child's behavioral responses on a nine-point Likert-type scale ranging from −4 (extremely negative) to +4 (extremely positive). Ratings reflect approach or withdrawal behavior observable in the body, head, or limb movements, and positive or negative affective facial or vocal expressions. Negative responses included moving the head or body away from the stimulus, blocking the stimulus from touching the face or expressing strong negative affect. Positive responses include leaning towards the stimulus and expressing strong positive affect. A response style of Extreme Positive, Extreme Negative or Neutral was assigned for each stimulus type by examining scores of the six trials for each stimulus type. Neutral response style was assigned if the majority of scores (more than 3 of 6) were 0 or +1 and there were no extreme positive or negative scores (−3 or less or 3 or more). A score of +1 was designated as neutral since it appeared to indicate cooperativeness rather than a clear positive response to the stimuli. Positive response style was assigned if the majority of scores were + 2 or greater or there were two or more scores greater than +3. Negative response style was assigned if the majority of scores were −1 or less or there were two or more scores less than −2.

Analysis plan and preliminary analyses

Preliminary analyses of the data indicated unequal numbers and variances between groups for the SSP scores. Therefore the data were analyzed with an ANOVA method that compensates unequal numbers and variance (SS type II in SPSS-16). Post hoc analyses were conducted with Dunnet's C which does not assume equal variance. In addition, given the group differences in IQ scores, all analyses were initially computed as ANCOVAs. None indicated IQ as a significant covariate, thus IQ was not considered further in analyses.

Results

Parent rating of sensory processing

Short Sensory Profile total scores. The means and standard deviations for SSP scores for each group and gender are reported in Table 2. A two-way (Group × Gender) ANOVA for the SSP Total score yielded main effects of Group, $F(2, 295) = 11.12$, $p < .001$, $\eta_p^2 = .07$, and Gender, $F(1,295) = 21.88$, $p < .001$, $\eta_p^2 = .07$, with no interaction effect, $F(2,295) = .44$, ns. Post hoc (Dunnet's C) revealed lower SSP Total scores for the PI group than the EA/FC and NA groups (ps < .05). The EA/FC and NA groups did not differ from each other (Table 2). Across all groups, boys had lower SSP Total scores than girls (ps < .05). Lower SSP scores indicate more problems.

Table 2 Short Sensory Profile Totals scores for groups and gender

Group	Gender	*N*	Mean	(*SD*)
PI	Female	69	159.36	16.28
	Male	54	150.96	25.50
	Total	123	155.67	21.16
EA/FC	Female	39	171.05	18.47
	Male	45	157.51	22.47
	Total	84	163.80	21.68
NA	Female	46	172.09	15.06
	Male	42	161.60	14.46
	Total	88	167.08	15.61
Total	Female	154	166.12	17.51
	Male	141	156.22	22.04
	Total	295	161.39	20.38

Sensory Profile section scores. Similar analyses were repeated for SSP section scores with the addition of corrections for multiple statistical comparisons. As with the total score, there were significant main effects for Group and Gender, but no significant interaction effects. As noted in Table 3, the PI group had significantly lower scores than both the EA/FC and NA groups on the Seeking/Under Responsiveness ($p < .05$ between both groups) and Auditory Filtering subscales ($p < .05$ between both groups). The PI group had lower scores than the EA/FC group for the Movement Sensitivity ($p < .05$) and the NA group for Auditory/Visual Sensitivity ($p < .05$). The EA/FC and NA Groups did not differ from each other in any of the SSP Section scores. Males scored lower for all SSP Section scores except Tactile Sensitivity.

Clinically significant Sensory Profile scores. The frequency of clinically significant scores for the SSP Total score were examined within each group and gender was analyzed using a series of contingency tables. As seen in Table 4, the frequency of scores are reported for two levels as established by the published criteria of the SSP (McIntosh et al., 1999a): Probable Differences (1 SD below the published mean) and Definite Differences (2 SD below the published mean). Probable Differences (PD) scores are examined first. The PI group had a higher percentage of Probable Differences scores than the EA/FC, χ^2 (1) = 8.88, $p = .003$, or the NA group, χ^2 (1) = .7.98, $p = .005$). The EA/FC and NA groups did not differ. Boys had a higher percentage of clinically significant scores than females overall, χ^2 (1) = 11.21, $p = .001$. Follow-up contingency tests for each gender by group indicate that PI girls have a higher frequency PD scores than the EA/FC, χ^2 (1) = 10.14, $p = .001$, and NA, χ^2 (1) = 4.12, $p = .04$, girls and PI boys had a higher percentage of PD scores

Table 3 Short Sensory Profile Section scores by group

	PI	EA/FC	NA		
Group	Mean (SD)	Mean (SD)	Mean (SD)	F	Overall *p*-value
Tactile sensitivity	4.39 (.57)	4.52 (.62)	4.53 (.45)	1.40	.1
Taste/Smell sensitivity	4.24 (.98)	4.30 (1.0)	4.27 (.93)	.12	.89
Movement sensitivity	4.54 (.71)[12]	4.72 (.46)	4.65 (.52)	2.59	.07
Under-responsiveness/sensation seeking	3.60 (.79)[12]	4.01 (.81)	4.19 (.61)	17.27	.000
Auditory filtering	3.45 (.92)[12]	3.83 (.86)	4.00 (.73)	11.96	.000
Low energy	4.57 (.68)	4.63 (.60)	4.75 (.44)	2.22	.1
Visual/Auditory sensitivity	4.21 (.81)[12]	4.38 (.76)	4.49 (.58)	2.14	.02

[1]PI significantly greater than EA/FC; [2] PI significantly greater than the NA Group.

Table 4 Percentages and numbers (*N*) of clinically significant scores on the SSP by groups at the Probable Difference (< 1 SD below published norms) and Definite Difference (< 2 SD below published norms) levels

		PI		EA/FC		NA		Total	
All	Probable Differences	42.3[12]	(52)	22.6	(19)	23.9	(21)	31.0	(92)
	Definite Differences	22.0[2]	(27)	14.3	(12)	8.0	(7)	15.5	(46)
Female	Probable Differences	34.8[12]	(24)	7.5	(3)	17.4	(8)	22.4	(35)
	Definite Differences	15.9	(11)	7.7	(3)	6.5	(3)	11.0	(17)
Male	Probable Differences	51.8[2]	(28)	35.6	(16)	31.7	(13)	40.5	(58)
	Definite Differences	29.6[2]	(16)	20.0[3]	(9)	9.5	(4)	20.6	(29)

[1]PI significantly greater than EA/FC; [2] PI significantly greater than the NA Group; [3] EA/FC and NA groups significantly different from each other. Clinically significant Definite Differences scores are less than 1 SD and 2 SDs (respectively) below the published norms for the SSP. Note that Probable Difference level also in includes Definite Differences scores.

than the NA boys, χ^2 (1) = 4.21, p = .04. A relatively small number of children (N = 46) fell into the Definite Differences scores (DD) range. Overall, the PI group had a higher percentage of DD scores than the NA group, χ^2 (1) = 7.61, p = .006, but not the EA/FC group. Again, there were significantly more boys with DD scores than girls, χ^2 (1) = 5.29, p = .02. Although twice as many PI girls fell in the DD range than girls in the other two groups, the differences were not significant. The PI boys had a significantly higher percentage of DD score than the NA group, χ^2 (1) = 5.79, p = .02, but not the EA/FC group.

Laboratory observation measure of tactile response

Contingency analyses indicated difference in frequencies of extreme negative, neutral and positive response patterns across groups for Feather, χ^2 (2) = 14.64, p < .006, but not Cotton and Brush (Figure 1, a–c). The differences were due to a greater frequency of negative and positive responses (fewer neutral responses) seen in the PI group to the feather stimuli. The PI group had fewer neutral responses than the EA/FC group, χ^2 (1) = 9.78, p = .002, and the NA group, χ^2 (1) = 5.67, p = .02. The PI group had a higher percentage of Positive responses to the Feather than the EA/FC group, χ^2 (1) = 9.84, p = .001. The PI group had only marginally higher percentage of Negative responses than the EA/FC group for the Feather, χ^2 (1) = 2.89, p = .07, but significantly more than the NA group only for the Feather, χ^2 (1) = 6.8, p = .009. The EA/FC and the NA groups did not differ from each other in response patterns for any of the stimuli. Unlike the results for the SSP scores, there were no overall differences between males and females for any of the stimuli.

Associations between parent-reported and laboratory-observed sensory responses

A series of two-way ANOVAs (Response pattern and Group) with SSP Total scores as the dependent measure yielded main effects of Response pattern for the Feather, F(2,266) = 4.259, p < .02, and the Brush, F(2,267) = 6.261, p < .002, but not the Cotton (p < .10). Response patterns for the Feather and Brush were subjected to post hoc analyses (Dunnett's C). The SSP scores were significantly lower for those with Negative versus Neutral/Mild responses to the Feather (Negative, M = 154, SD = 19.9; Neutral, M = 164, SD = 21.7) and to the Brush (Negative, M = 154, SD = 21.5; Neutral, M = 164, SD = 20.2) (ps < .05). The SSP scores did not differ between children with Positive versus Neutral responses to any stimuli. There was a significant main effect of Gender for SSP scores across each of the three stimuli (all p < .001) but there were no significant interactions between gender and response pattern.

Associations with duration of institutional care and country of origin

In the PI group, the *duration of institutionalization* was only associated with the Response pattern for

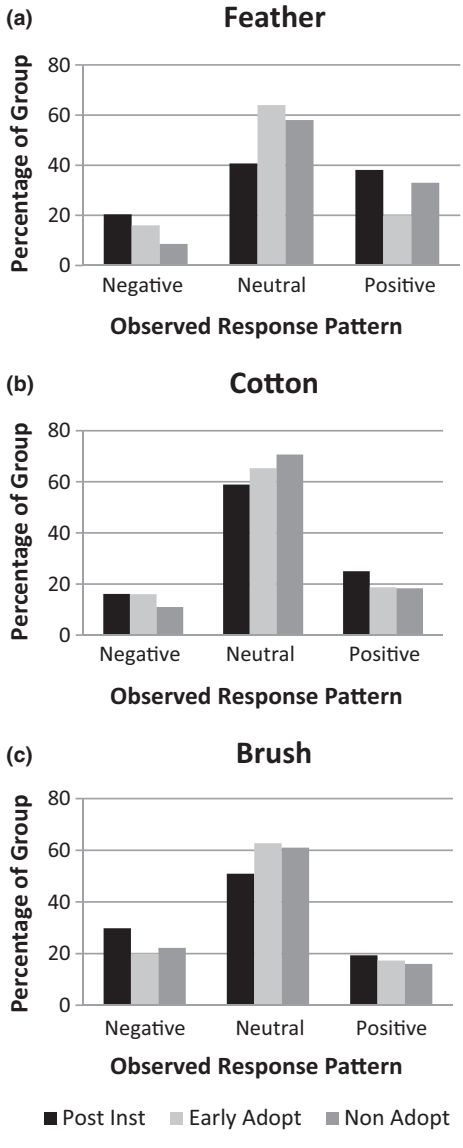

Figure 1 Percentages of extreme response patterns by group

the Feather stimulus but not SSP scores. Children with extreme negative and positive responses were institutionalized longer, $F(2,106) = 3.38$, $p < .03$, (Negative: Mean = 28.7 months, SD 17.4, $p = .034$; Positive: Mean = 28.1 months, SD = 16.2, $p = .018$) than those with neutral responses (Mean = 20.5 months, SD = 12). In contrast, there were significant differences in SSP scores by *region of birth*. Children in the PI group who were born in Eastern Europe (EE) had lower SSP Total score than children born in Asia ($F(1, 121) = 4.75$, $p < .03$). Children from EE and Asia had roughly the same percentages of Negative, Neutral and Positive response patterns.

Discussion

As hypothesized, internationally adopted children who experienced prolonged institutional care showed evidence of more sensory processing disruptions than children who were adopted early, predominantly from foster care with little or no institutional experience (EA/FC), and non-adopted (NA) children. Differences were found on both the parent report (SSP) and the laboratory observation measure. No differences were noted between the EA/FC children and the NA children, indicating that the effect was not solely a function of being an orphaned or abandoned child adopted from overseas. Several additional findings are of note. First, PI children were found to have both more sensory aversions and more sensory-seeking behaviors on the parent report and the laboratory observation measures. Second, across all groups parents reported poorer sensory processing for boys, although there was no gender difference found on the laboratory observation measure. Third, the parent report and the observation measure were only associated with each other for children with negative responses to the stimuli, indicating that the measures may tap different aspects of sensory processing. Finally, there was only partial support for the finding that sensory processing disruptions were associated with length of institutionalization. Only the PI children with highly positive or negative responses to the feather had significantly longer duration of care than those children with neutral responses to the tactile stimuli. Overall, the findings suggest that institutional care prolonged at least across the first year of life increases the vulnerability for sensory processing impairments and has implications for long-term functional development.

Increased sensory processing disruptions in PI group

In addition to the primary finding of greater disruptions in sensory processing in the PI children, the pattern of behaviors included both more negative (oversensitivity and avoidance) and positive (seeking and approach) responses to stimuli. On the *Parent-report Measure*, the PI group had significantly lower scores on the Under-Responsive/Sensory Seeking section than the other two groups. Items represented behaviors such as 'seeks all kinds of movement…' and 'doesn't seem to notice when hands or face are messy'. An informal examination of individual items indicated that parents of the PI group endorsed more seeking items than under-responsiveness items. Parents of the PI group also endorsed more items related to sensory aversion, including over-responsiveness to movement, visual and auditory stimuli, such as 'distressed when feet leave the ground' or 'holds hands over ears'. These findings are consistent with previous research by Cermak and colleagues (Lin et al., 2005; Cermak & Daunhauer, 1997). Interestingly, differences were not seen between the groups on the section scores related to tactile or taste and smell sensitivity. Difficulties with touch as well as food aversions are commonly reported problems in

children newly adopted from institutions (Cermak & Groza, 1998). If these behaviors were present in the children in the present study they may have resolved with time in the adopted home (MacLean, 2003). Cermak (2001) has noted that in some cases parents reported a switch from oversensitivity to under-sensitivity or sensory seeking as children got older or had been in adoptive homes longer. The question remains: Is it adaptive to seek out more or 'enriched' stimuli or is this maladaptive pattern behavior? Further study will be needed to address this question.

Post-institutionalized children differed from the other groups' *Laboratory Observation Measure* only in response to the feather stimuli. The PI group had a unique pattern of significantly fewer neutral responses to the tactile stimuli compared to the other groups. The PI children were elevated in positive responses compared to the EA/FC group and elevated in negative responses compared to the NA group. The results suggest that the PI group has an increased reactivity to stimuli both positively and negatively. The negative responses were consistent with sensory aversion or defensiveness (Ayres, 1964). Reactions included physical avoidance such as moving away from or blocking the stimulus, active extinguishing of the stimuli by rubbing the cheek, and displaying negative affective expressions such as frowns and grimaces. Positive behaviors included physical approach such as moving towards the stimuli and highly positive affect such as smiling or laughing, consistent with sensory seeking. While these behaviors could be observed across all three stimuli, only the feather stimuli induced enough of these responses in the PI group for there to be significant differences. The light 'ticklish' quality of the feather as opposed to the firmer input from the cotton and brush may explain the difference. Light touch is commonly reported to be the quality of stimuli that children with tactile defensiveness respond to most strongly (Ayres, 1964; McIntosh et al., 1999b). On the other hand, the feather would be the most pleasant stimulus for a child without sensory defensiveness. A couple of factors may limit the ability of the laboratory observation measure to capture sensory responses. Primarily, it is impossible to completely interpret neutral responses. The children were fairly high functioning and at an age where they should have good behavioral inhibition. Observed behavior may not reflect the felt experience. Further, the demands of the testing environment dictate best behavior. Research using more covert measures such as physiological responses may be more discriminative. While limited, the difference in observed behavior supports the interpretation that atypical sensory processing is related to early experience in institutional care and does not merely reflect adoptive parents' greater willingness to report behavior problems in their children.

Gender difference

The interpretation of the results of the parent report must be tempered by the significant gender differences. Males across all groups had significantly lower scores on the SSP than females. The SSP was primarily designed as a screening tool. Caution may be warranted in interpretation of the parent-report measure as some of the items appear to tap general behavior problems such as high activity level and distractibility, rather than discrete responses to sensation. The questions may be biased towards capturing more overt or disruptive behavior such as a high activity level and externalizing problems that are more commonly reported in boys. Anecdotally, there are greater numbers of males with seen clinically for SMD (Ayres, 1979).

Association between SSP and observed behavior

Only children showing extreme negative reactions on the observational measure differed on parent-report SSP scores from children exhibiting more neutral reactions. Parents did not report poorer sensory processing for children scoring in the extreme positive group, even though extreme positive reactions were frequent among the PI children. While the two measures of sensory processing are related to each other, they may tap unique aspects of sensory processing.

While the SSP contains questions addressing stimulus seeking and not just stimulus aversion, items representing unregulated but positive responses to sensation are underrepresented. Further, parents may be less sensitive to children who react highly positively to stimuli than to those who react highly negatively. Certainly, negative reactions, distress and aversions would command parental attention. One question the present results raise is whether emotionally positive, but highly sensory reactive children are being missed in analyses of sensory processing problems in parents' reports. Given that early and prolonged institutional deprivation was associated with not just more extreme negative reactions, but also positive reactions, we may need to determine whether such children also are at risk for problematic outcomes, even when their parents do not perceive/report them to have problems with sensory processing.

Clinically significant scores

Overall, the PI group also has a higher frequency of clinically significant scores on the SSP at the probable difference (indicating a need for further assessment) and the definite differences levels (indicating a likely need for intervention). Although very few children fell into a range indicating 'definite' differences in sensory processing, the PI group had a significantly higher percentage than the typical children. The lack of difference between the PI and

EA/FC group can be accounted for by an increased percentage of EA/FC boys that fell into the definite differences range (20%). Normative and population-based studies suggest that about 10% of children would score in this range (Ahn, Miller, Milberger, & McIntosh, 2004; Dunn, 1999). It may be that a small percentage of IA children, for reasons other than institutionalization, may have an elevated risk for sensory processing disruptions.

Implications

Taken together, the results of previous studies and the present findings point to a disruption in the modulation of sensation in PI children that includes increased sensitivity or aversion to sensation along with sensory seeking. While the mechanisms underlying sensory processing disruptions are unclear, disruptions in sensory modulation have been shown to be related to differences in physiological and neural regulatory processes. Poor sensory modulation has been linked to increased magnitudes and slow habituation of electrodermal responses (EDR) (sympathetic nervous system activation) (McIntosh, Miller, Shyu, & Hagerman, 1999b), disregulated vagal tone (parasympathetic regulation) (Schaaf, Miller, Seawell, & O'Keefe, 2003), weak and immature gating and modulation of event-related potentials (ERP) in children (Davies & Gavin, 2007) and upregulation of striatal dopamine (D1) receptors using a positron emission tomography (PET) in monkeys (Schneider et al., 2008). Given the finding of sensory processing disruption in PI children, it is important to understand whether the same neural systems associated with sensory modulation disorder in children without institutional histories are also implicated in sensory processing problems in PI children.

The findings of reduced regulation of responses to sensation in PI children also parallel reports of poor regulation in other types of behaviors such as social skills, emotional regulation, and stress reactivity (Gunnar et al., 2007; Gunnar, Morison, Chisholm, & Schuder, 2001; McLean, 2003; Wismer Fries, Shirtcliff, & Pollak, 2008). For example, in the area of social skills, indiscriminant or uninhibited friendliness and dysregulated attachment may parallel some highly positive or sensory-seeking behaviors. On the other hand, increased stress reactivity, emotional dysregulation, aggression and externalizing behaviors may parallel some of the aversive patterns of response. Further, inefficient modulation of sensation has also been associated with functional deficits in basic living and adaptive skills, play and sports participation, decreased academic performance (Reynolds & Lane, 2007; Mulligan, 2008) and some types of developmental psychopathologies such as attention deficit disorder and autism spectrum disorders (Baranek et al.,2007; Mangeot et al., 2001; Tomchek & Dunn, 2007). The relationship between sensory processing disruptions problems in behavior, emotion regulation and adaptive function requires further study of PI children.

Limitations

The children come from a fairly high-functioning group and may not represent all children who are adopted from institutions, particularly those who may have experienced more extreme deprivation. On the other hand, the effects of poor prenatal care, maternal consumption of alcohol, maternal stress, and exposure to toxicants naturally could not be fully controlled in this study. While the children were screened for overt signs of fetal alcohol syndrome, animal studies have linked even relatively low levels of prenatal risk factors to atypical sensory processing (Schneider et al., 2008). Children born in Eastern Europe may be at a higher risk for such prenatal factors. More than half the children in the PI group were adopted from institutions in Eastern Europe and they had lower scores on the SSP.

Conclusions

Children who experience early and prolonged institutionalization as compared to children who were adopted but spent little or no time in institutional care appear to be more vulnerable to disruptions in sensory modulation. These disruptions appear to persist from infancy into middle childhood. Such disruptions have implications for long-term function in post-institutionalized children. Early identification of sensory processing disruptions in post-institutionalized children could direct families towards interventions that could reduce long-term deficits.

Acknowledgements

This project was supported by grants from the National Institute of Mental Health to Seth Pollak (R01 MH068858) and Megan Gunnar (R01 MH068857) with the Wisconsin and Minnesota International Adoption Projects. Infrastructure was supported by the Waisman Center/University of Wisconsin through the National Institute of Child Health and Human Development (P30-HD03352). We appreciate the research assistance provided by Kristen Frenn, Meg Bale, Barb Roeber, Mary Schlaak, Teresa Wiggington, Elyse Anderson, Angela Bartels and Megan Nanke. We are grateful for the participation of the children and their families.

Correspondence to

Julia L. Wilbarger, Department of Kinesiology, University of Wisconsin-Madison, 3176 Medical Science Center, 1300 University Avenue, Madison, WI 53706, USA; Fax: 608-262-1639; Email: jlwilbarger@education.wisc.edu

Key points

- Post-institutionalized (PI) adopted children were found to have an increased risk of sensory processing disruptions compared to non-institutionalized adopted and non-adopted children.
- Post-institutionalized adopted children showed higher levels of reactivity to sensation and displayed both more aversion and approach behaviors to sensory stimuli. These findings parallel findings in social and emotional behavior in PI children.
- Differences were found on a parent report and a laboratory measure of sensory processing.
- A longer period of institutionalization in infancy was associated with more sensory processing disruptions.
- Increased sensory processing disruptions in PI children has implications for long-term function.

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Manuscript accepted 9 March 2010