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The Early Development of Self-injurious Behavior: An Empirical Study

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Abstract

The early development of self-injurious behavior (SIB) in young children with developmental disabilities was examined by tracking 16 school-age children who had recently started to show ‘early’ SIB over an 18 month period. Naturalistic observations were conducted in each child’s classroom every 3 months and the association between early SIB and environmental events was examined. Results showed that for the 4 children whose early SIB had escalated over the 18 month period, there was a significant association between early SIB and low levels of social contact across observation points, supporting models of the development of SIB. This association might be considered as a risk marker for the exacerbation of SIB. The implications of this finding for targeting early interventions for SIB are discussed.
The Early Development of Self-injurious Behavior:

An Empirical Study

Self-injurious behavior (SIB) shown by people with developmental disabilities has long been recognized as an intransient and stigmatizing behavior, as evidenced by increasing research attention over the last few decades (Carr, 1977; Iwata et al., 1994; Oliver, 1995). Most research into SIB has examined its occurrence at a single point in time, either through studies of prevalence (Oliver, Murphy & Corbett, 1987; Rojahn, 1986; Schroeder, Schroeder, Smith & Dalldorf, 1978), functional analysis (Carr & Durand, 1985; Iwata, Dorsey, Slifer, Bauman & Richman, 1982), or interventions (Carr & Durand, 1985; Durand & Carr, 1991; Howlin, 1993). Less attention however, has been paid to the early development of SIB and its chronicity (Murphy, Hall, Oliver, & Kissi-Debra, 1999; Schroeder, Bickel & Richmond, 1986; Windahl, 1988). Such research could have implications for models of the development of SIB and thus for the early intervention and prevention of SIB.

Data from prevalence studies have indicated that SIB begins in childhood and progresses into the teenage years with a corresponding increase in incidence (Kebbon & Windahl, 1986; Oliver et al., 1987). Prevalence and cohort studies suggest that individuals most at risk for developing SIB are children with a severe or profound degree of developmental disability, a diagnosis of autism, and/or sensory and physical disabilities (Oliver, 1995; Schroeder et al., 1978). Once established however, SIB is notoriously difficult to treat and presents significant problems to the individuals concerned, their carers and service providers (Murphy et al., 1993). It would appear that a possible strategy would be to introduce early interventions for children whose SIB is just
beginning, prior to it becoming established in the child’s repertoire (Oliver, 1995). Before such a strategy can be implemented however, it is important to determine why SIB develops in these children and whether individualized treatments could then be implemented to eliminate SIB at this early stage. Additionally, predictive risk markers might facilitate specific targeting within an early intervention strategy.

Several theories have been advanced to explain the early development of SIB. It is thought that SIB may emerge from stereotypical behaviors commonly seen in childhood (e.g., Lovaas, Newsom & Hickman, 1987), from accidental motor responses (Murphy & Wilson, 1985), as a result of a minor illness (Carr & McDowell, 1980), as a respondent behavior (Romancyck, 1986), or from disrupted neurotransmitter systems (Harris, 1992). In an attempt to integrate some of these accounts, Guess and Carr (1991) have proposed a 3-level model for the emergence and maintenance of SIB. At level 1, internally regulated rhythmic patterns emerge in the child’s repertoire in order to regulate maturation and development. As such, these behaviors are unlikely to be influenced by environmental factors. At level 2, the behaviors begin to modulate arousal levels in response to environmental stimulation. Low levels of arousal result in an increase in rhythmic behaviors, high levels of arousal result in a decrease. At level 3, the behaviors develop into stereotypy and self-injury that has an effect on the behaviors of other people. In this way, SIB is maintained by contingent environmental events through the processes of positive and negative reinforcement (see Oliver, 1995). As yet however, the model remains untested.

The next step is to move from the hypothetical to empirical, and to provide some data on the early development of SIB. In a previous paper, we examined the early development of SIB in 17
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children, aged under 15 years, who had recently started to show particular forms of behavior which could be considered potentially self-injurious (see Murphy et al., 1999). Although the children’s parents were carefully interviewed to determine precisely why and when their ‘early’ SIB had first started, it was difficult to determine the reason for the onset of the behavior. Sixteen of the children were observed in their classrooms at school over a period of up to 2 years at approximately 3-monthly intervals. For four of the children, early SIB had clearly escalated whilst for the other children it had not done so. Whilst the reasons for the onset of early SIB remained unclear in these children, the degree of concern expressed about the children's behavior at time 1 was predictive of an increase in early SIB. Indeed, the critical component of SIB may have been its aversiveness to others, acting as an establishing operation to produce escape behavior which is socially reinforcing (see Oliver, 1993). No relationship was found between the children’s early SIB and other stereotypical behaviors (e.g., body rocking and hand flapping) that were also present in the child’s repertoire. For example, the children whose early SIB had increased were no more likely to show other stereotypical behaviors than those children whose SIB did not increase. Overall, these findings would tend to support level 3 of Guess and Carr's (1991) model of the development of SIB i.e., the social responses of others to the child's SIB could primarily account for the further development and exacerbation of SIB. A descriptive analysis of these data, necessary to examine the relationship between early SIB and environmental events, was not conducted however.

The present paper has two broad aims. Firstly, to determine whether the early SIB shown by these children was associated with socially mediated environmental events. Secondly, to determine whether an association between early SIB and socially mediated environmental events
across successive observation points would predict an increase in early SIB over time. No attempt was made in this study to deliberately manipulate environmental events. Although experimental analyses are generally more powerful than correlational analyses, they carry with them their own threats to validity. The present study therefore provides an opportunity to press the correlational approach to its limits.

**Method**

**Participants**

All 16 of the children observed in the previous study were selected from 22 schools for children with developmental disabilities and/or autism. According to their class teachers, the children had begun to show behaviors within the previous 3 month period which could be considered topographically similar to those shown by individuals with more established SIB (cf. Rojahn, 1986). Table 1 shows the participant characteristics.

+++ Insert Table 1 here +++

Five of the children showed hand biting, five hand-to-head hitting, three head-to-object banging, two hair-pulling, two body hitting, one self-scratching and one showed eye-poking (3 of the 16 showed more than one topography). 11 were boys with the mean age of the children being 5.27 years (SD = 1.94 years). The mean developmental equivalent age of the children (from the Vineland Adaptive Behavior Scales) was 1.31 years (SD = 0.66 years). 4 children were non-
ambulant, 4 had poor ambulation and 8 were ambulant. 6 children had been diagnosed with a specific syndrome i.e., Sturge-Weber (2), Trisomy 6Q (1), Seckel (1), Fragile X (1) and Cornelia de Lange (1) and 6 children had a diagnosis of autism. 4 children suffered from epilepsy, 5 had a visual deficit and 3 had a hearing deficit. On two occasions at the end of the study, one of the children (case 2) was required to wear straight arm splints to prevent her hand biting.

**Observational response definitions, recording, and interobserver agreement.** Child responses recorded included body banging, head banging, body hitting, head hitting, eye poking, eye pressing, hand mouthing, hand biting, scratching or rubbing of the skin and hair pulling. Operational definitions for each of these responses can be found in Murphy et al., (1999). Five teacher behaviors were also recorded: **demands** (defined as any verbal or physical direction by the teacher in order for the child to complete an action or task); **attention** (defined as any other physical or verbal contact made by the teacher to the child e.g., touching, response blocking, offering drinks or food, reprimanding and commenting); **demand removal** (defined as the discontinuation of demands for 10-s following the occurrence of a demand, or the time between successive occurrences of demands, if demands recurred within 10-s); **attention removal** (defined as the discontinuation of attention for 10-s following the occurrence of attention, or the time between successive occurrences of attention, if attention recurred within 10-s) and **no interaction**, defined as the absence of demands, attention, demand removal and attention removal. The categories no interaction, attention removal and demand removal were automatically coded by the computer at analysis. All teacher behaviors were therefore exhaustive, but not necessarily mutually exclusive i.e., attention could co-occur with demand removal and demands could co-occur with attention removal.
All responses were recorded on a laptop computer (Olivetti Quaderno, Model PT-XT-20) using software that allowed continuous documentation of the frequency and/or duration of each behavior and their interrelations (see Repp, Harman, Felce, VanAcker, & Karsh, 1989). Two observers (one standard observer) independently scored responses during 30 of the total of 304 hours (i.e., 10%) of observational data collected. Observer records were compared on a 10-s interval-by-interval basis, scoring agreements and disagreements on occurrence and non-occurrence for each recorded behavior (Murphy, 1987). For example, for each 10-s interval, an agreement on the occurrence of a behavior would be scored if both observers had scored the behavior. The mean total percentage agreement across behaviors was 88.87% (range, 84.95% to 91.61%). The corresponding mean Kappa statistic was 0.68 (range, 0.59 to 0.74), suggesting that agreement between observers was good.

Procedure

All children were observed in their regular classroom at school at the beginning of the study (time 1) and on a number of subsequent occasions (see below). Classrooms usually contained the child's teacher, one or more teacher assistants and at least 4 but no more than 10 other children. Other children in the class were not included in this study, though some were comparison children (controls) for the first study (see Murphy et al., 1999). Each child in the study was observed for a 3 to 4 hour period at each observation point. Throughout each observation period, the observer followed the child as unobtrusively as possible and did not interact with the child at any time. Teachers were reminded prior to each observation period to ignore the presence of the
observer and to interact normally with the child. Observations included a representative sample of activities: meals, group activities, individual work, and leisure time. The observer stood in the corner of the room and out of the child's line of sight.

The aim of the study was to conduct direct observations in classrooms for each child, once every three months for 18 months. However, the mean length of interval between follow-ups for each child was 3.67 months (range 3.2 months to 6 months). Long follow-up interval lengths (i.e., 6 months) occurred when 1 child (case 8) was admitted to hospital for a treatment unrelated to SIB. The mean total length of follow-up period for each child was 17.69 months (range 12 to 24 months). Longer follow-up periods occurred for those children who were enrolled early in the study, while shorter follow-up periods occurred for those children enrolled later in the study and for no other reason.

**Descriptive analysis.** In order to examine the association between a child’s early SIB and socially mediated environmental events, the conditional probability of SIB given the occurrence of a particular teacher response, $T_i$, was calculated at each observation point for each child: $p(\text{SIB}|T_i)$. This was done by imposing 10-s intervals on the data and then determining the number of times that SIB had occurred given that a particular teacher response had occurred in each 10-s interval. This number was then divided by the number of 10-s intervals during which the particular teacher response occurred. If the base rate of the teacher response was low however, a high conditional probability could occur simply by chance. To control for this possibility, the conditional probability of each teacher response, $T_i$, given SIB was also calculated (see Lerman & Iwata, 1993); $p(T_i|\text{SIB})$. This was done by determining the number of times that a particular
teacher response occurred given that SIB had occurred in each 10-s interval and dividing this number by the number of 10-s intervals during which SIB occurred. To illustrate the analysis, Figure 1 shows occurrences of early SIB and a teacher behavior, T, represented in 10-s interval format. Here, the conditional probability of SIB given the occurrence of T would be 0.75, and the conditional probability of T given SIB would be 0.38.

+++ Insert Figure 1 here +++

The information in these two conditional probabilities can be combined using the $z$ statistic (Bakeman & Gottman, 1997; Bakeman & Quera, 1995). The formula for $z$ is given as follows:

$$z_{ij} = \frac{(x_{ij} - m_{ij})}{\sqrt{m_{ij}(1 - p_i)(1 - p_j)}}$$

where $x_{ij} = \text{observed joint frequency of SIB and T}_i$, $m_{ij} = \text{expected joint frequency of SIB and T}_i$, $p_i = \text{unconditional probability of SIB}$, and $p_j = \text{unconditional probability of T}_j$. A high value for $z$ indicates a significant association between SIB and the teacher response (i.e., higher than would be expected by chance). All conditional probabilities and $z$ statistics were calculated using the SDIS-GSEQ software (Bakeman & Quera, 1995). Only the $z$ statistics will be reported here.

**Results**

Given that some of the children were followed up for differing lengths of time and that the periods between measurement occasions inevitably varied slightly because of scheduling
Early SIB

constraints (see above), a linear growth model was adopted to characterize change in early SIB over time (see Willett, 1988). Linear regression lines were fitted to each individual’s data using Ordinary Least Squares with the slope parameter, $\beta$, representing the degree of change in SIB over time (see Murphy et al., 1999). A positive value for $\beta$ indicates an increase in early SIB, a negative value indicates a decrease in early SIB.

$Z$-scores indexing the degree of association between early SIB and teacher responses for each of the children at each observation point are shown in Figure 2. The numbers shown in bold above each graph are the slope parameters of the regression line fitted to the duration of early SIB observed across observations for each child (see above).

![Insert Figure 2 here](image)

The figure shows that in 3 cases (i.e., data displays for cases 1, 2 and 8, shown at the top of Figure 2) there was a significant association between SIB and environmental events as evidenced by $z$-scores greater than 5.0 across 4 or more consecutive observation points. For one additional case, $z$-scores were greater than 3.0 across 4 of the observation points. For cases 1, 5 & 8 the association was consistently high between SIB and ‘no interaction’. For case 2, SIB was associated with ‘no interaction’ over the first 4 observation points and then with ‘attention’ at the last observation point. It can be seen from the numbers shown in bold above each graph that

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1 For case 6 at observation 2, case 12 at observation 1 and case 15 at observation 4, the number of intervals containing SIB was less than 10. $Z$-scores for these individuals should therefore be interpreted with caution (see Bakeman & Gottman, 1997, p. 145).
these 4 children also obtained the highest slope parameters, suggesting that an association between SIB and environmental events predicted the subsequent exacerbation of early SIB.

This consistent pattern of association between SIB and environmental events observed in cases 1, 2, 5 & 8 was not observed for the remaining children. These children also obtained lower slope parameters, indicating that their SIB did not increase. However, associations with environmental events (i.e., z-scores greater than 3.0) did occur for some of the children at some observation points. For cases 6 and 12 for example, SIB was associated with demand removal at the third and sixth observation points respectively; for case 11, SIB was associated with teacher interaction at observation 5, and with no teacher interaction at observation 7; for case 3, SIB was associated with no teacher interaction at observations 1 and 2; for case 9, SIB was associated with no teacher interaction at observations 1 and 4 and with attention at observation 2; for case 16, SIB was associated with no teacher interaction at observations 1 and 4 and with demands at observation 5.

These data suggest that if an association with an environmental event is not present across several observation points, SIB does not increase in the child’s repertoire. In order to examine whether this was indeed the case, the observational data were pooled across observation points for each child and a Yule’s Q statistic was computed for the association between SIB and no interaction for each child. A high value for Q indicates a strong association. The Yule’s Q statistic was employed because, unlike z, it is unaffected by the number of tallies in the data (follow-up time) and so is comparable as an index of association across children (see Bakeman & Gottman, 1997). Figure 3 shows change in early SIB (i.e., the slope parameter) plotted as a
function of the Yule’s $Q$ statistic obtained between SIB and no interaction when the data were pooled across observation points for each child.

+++ Insert Figure 3 here +++

The data show that when the data were pooled across observation points, high Yule’s $Q$ values were obtained for those children whose SIB had increased, suggesting that the association between SIB and no interaction was predictive of an increase in SIB.

Discussion

In this paper, we have attempted to trace the socially mediated correlates of the development of SIB in young children with developmental disabilities whose SIB had recently started at school. These children were followed-up over a period of up to two years and at each observation point, the association between SIB and socially mediated environmental events (i.e., teacher behaviors) was examined. In order to aid the interpretation of the resultant data and to correct for the problem of "chance" in the descriptive analysis, a statistical measure of association, the $z$-score, was employed for the appraisal of conditional probabilities. Most $z$-scores were low for most children, suggesting that the associations between early SIB and environmental events were at chance levels. However, for 4 of the children, $z$-scores indexing the association between early SIB and ‘no interaction’ were consistently high across 4 or more observation points, indicating that SIB was more likely to occur when these children had been left alone. In a study conducted by Iwata et al., (1982), 3 of the 9 children who had been referred to an inpatient treatment center,
showed the highest rates of SIB when they had been left alone in a room for a period of 15 minutes. Although it was not stated when the self-injury had begun in the children in the Iwata et al., (1982) study, all subjects showed SIB that produced tissue damage, suggesting that the behaviors were well established. The data from the present study suggests that environmental correlates can also be identified in young children showing very early SIB (i.e., SIB which had begun less than a year ago but did not yet produce tissue damage).

It should be noted that only correlations between socially mediated environmental events and early SIB could be ascertained in the present study. Previous descriptive analyses have attempted to identify both the antecedents and consequences of SIB via the calculation of conditional probabilities (e.g., Lalli, Browder, Mace & Brown, 1993; Lerman & Iwata, 1993). That is, these authors attempted to identify three-chain sequences of events in the observational data. For example, Lerman & Iwata (1993) identified a ‘no interaction-SIB-no interaction’ sequence in one individual who lived in a group home whilst Lalli et al., (1993) identified ‘instructions-SIB-instruction removal’ and ‘no interaction-SIB-attention’ sequences in two children aged 10 and 14. However, none of the conditional probabilities were corrected for chance in these studies. The results of the present study therefore need to be set in this context.

In the present study, all four children whose early SIB was found to be associated with socially mediated environmental events across successive observation points had shown increases in early SIB. Inspection of Table 1 indicates that these children were no different from the other children in terms of age, developmental age, clinical condition, or topography of early SIB. In addition, the children whose early SIB had escalated were no more likely to show other stereotypical
behaviors than those whose SIB did not increase. For example, whilst child 1 engaged in body rocking and arm waving, in addition to his headbanging and headhitting, and child 2 engaged in head rolling, body rocking and arm waving, in addition to her hand biting and hair pulling, cases 5 and 8 did not show any other stereotypical behaviors. In addition, case 3, whose SIB did not increase, also showed body rocking, head rolling and arm waving. It appears therefore that stereotypcial behaviors already present in the children’s repertoires were not predictive of an increase in SIB and that it was an association between SIB and no interaction that best predicted the development of SIB in these children. These findings suggest that a descriptive analysis of SIB similar to the one conducted here could be employed as a useful screening device for the assessment of risk in children showing early SIB.

For cases 1, 5, and 8, the association between SIB and no interaction appeared to develop across successive 3 monthly intervals. These data provide support for the transition of early SIB between levels 1 and 2 of Guess & Carr’s (1991) theoretical model i.e., early SIB was unrelated to socially mediated environmental events but subsequently occurred during periods of low interaction. In these children then, SIB may have served to modulate levels of arousal - in this case arousal in the absence (as opposed to an overload) of environmental stimuli. This interpretation is highly speculative however, given that other sources of environmental stimulation e.g., vibrating objects, light sources, loud noises etc. would have been available in the classroom which could also help to modulate an adequate homeostatic level in these children.

A second interpretation to the arousal theory has been put forward by Lovaas et al., (1987) who have suggested that self-stimulatory behaviors such as SIB serve to provide sensory
consequences which arise “automatically” when the behaviors occur. Evidence to support this contention comes from the studies conducted by Rincover and his colleagues (Rincover, 1978; Rincover, Cook, Peoples & Packard, 1979; Rincover & Devany, 1982) who showed that when the sensory consequences of stereotypic and self-injurious behaviors were masked or blocked, they reduced in frequency. Given that no attempt was made in this study to deliberately mask or block the sensory consequences of these behaviors, we were unable to determine directly whether the early SIB of these children served as automatic reinforcement. Further research should be conducted to determine whether blocking the sensory consequences of early SIB (i.e., providing sensory extinction) could provide an effective early intervention strategy for early SIB.

The data for case 2 showed a different pattern of results. Here, an association between SIB and no interaction was already well-established. Over successive observation points, an association between SIB and teacher attention emerged. These data would appear to support the transition between levels 2 and 3 of Guess & Carr’s (1991) model i.e., early SIB now served to control the behavior of others, being maintained by either positive and/or negative reinforcement. However, this hypothesis is based on a single case and should therefore be interpreted with caution. In the Iwata et al., (1982) study, 2 of the children showed the highest rates of SIB when demands were removed contingent on SIB, indicating that SIB was maintained by negative reinforcement. One participant showed the highest rates of SIB when attention was provided contingent on SIB, indicating that SIB was maintained by positive reinforcement. In the present study, few associations between early SIB and socially-mediated environmental events could be detected, suggesting that level 3 self-injury had not been established in these children.
The fact that an association between an exacerbation of early SIB and low levels of interaction could be consistently detected in 4 of the children in the present study suggests that these children are at high risk for developing SIB and should therefore be targeted for intervention. Individual reports were compiled for each of these children and the reports were subsequently passed on to the child’s parents and teachers. In only one case (i.e., child 5) was help actually sought from services. The problem for preventative or early intervention strategies is that mild or ‘early’ SIB is unlikely to provoke teachers or parents to seek help from services. On many occasions during participant selection, for example, we were directed away from the children who subsequently became participants in the study and toward those children whose SIB was already a prominent feature of their behavioral repertoire. For this reason, it appears that services will have to be proactive and seek to actively identify children showing the early signs of SIB.

In addition, a lack of behavioral knowledge and understanding of the causes of SIB in schools may contribute to the emergence and development of the behavior. Hall and Oliver (1992) have suggested that the critical component of SIB may be its aversiveness to others. For instance, parents and/or teachers of children engaging in SIB adopt strategies to escape the aversive quality of the child’s SIB. The behaviors adopted by parents and/or teachers (e.g., providing attention, removing demands) may serve to reinforce the child’s SIB which may subsequently increase in frequency and/or intensity. Parents and/or teachers may therefore be engaged in a behavioral trap. Further research should attempt to delineate this sequencing of events in early SIB.

Finally, Oliver, Hall, Hales and Head (1996) found that those working in close contact with individuals who showed SIB were more likely to choose a strategy to stop SIB which would
ultimately reinforce the SIB. These data suggest that the dissemination of research on SIB is not at present filtering down into practice. Because of this, it would appear that any early identification strategy should be supplemented with training and support for teachers and parents in the management of behavior problems.
References


**Acknowledgements**

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**Figure Captions**

**Figure 1.** Hypothetical data showing occurrences of SIB and a teacher behavior $T$ in 10-s intervals.

**Figure 2.** Z-scores indexing the degree of association between early SIB and environmental events. The numbers in bold above each graph indicate the degree of change in observed SIB over the duration of the study where positive values indicate an increase in SIB, negative values, a decrease.

**Figure 3.** Change in early SIB plotted as a function of the Yule’s $Q$ value for the association between early SIB and no interaction when observations were pooled for each child.
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<th>Child no.</th>
<th>Gender</th>
<th>Age in years</th>
<th>Developmental age in years$^1$</th>
<th>Physical disability</th>
<th>Clinical condition</th>
<th>Topography of ‘early’ SIB</th>
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<td>3$^{7/12}$</td>
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<td>Head banging, head hitting</td>
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$^1$ adaptive behaviour composite of Vineland Adaptive Behavior Scales
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Early SIB

Association between SIB and:
- attention
- demands
- attention removal
- demand removal
- no interaction

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Time of Observation (months)