

Behavioral and Physiological Effects of Deep Pressure on Children With Autism: A Pilot Study Evaluating the Efficacy of Grandin's Hug Machine

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Key Words: anxiety • arousal (physiologic)

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This article was accepted for publication August 27, 1998.

Objective. One symptom common to many persons with autism is a high arousal or anxiety level. This study investigated the effects of deep pressure on arousal and anxiety reduction in autism with Grandin's Hug Machine, a device that allows self-administration of lateral body pressure.

Method. Twelve children with autism were randomly assigned to either an experimental group (receiving deep pressure) or a placebo group (not receiving deep pressure but in the disengaged Hug Machine). All children received two 20-min sessions a week over a 6-week period. Arousal was measured behaviorally with the Conners Parent Rating Scale and physiologically with galvanic skin response (GSR) readings.

Results. Behavioral results indicated a significant reduction in tension and a marginally significant reduction in anxiety for children who received the deep pressure compared with the children who did not. Additionally, children in the experimental group, whose GSR measures decreased, on average, after deep pressure, were somewhat more likely to have higher GSR arousal a priori.

Conclusion. These preliminary findings support the hypothesis that deep pressure may have a calming effect for persons with autism, especially those with high levels of arousal or anxiety.

Edelson, S. M., Edelson, M. G., Kerr, D. C. R., & Grandin, T. (1999). Behavioral and physiological effects of deep pressure on children with autism: A pilot study evaluating the efficacy of Grandin's Hug Machine. *American Journal of Occupational Therapy*, 53, 145-152.

Persons with autism are often described as having relatively high arousal or anxiety levels (Hardy, 1990; Sands & Ratey, 1986; Wing, 1989). Hutt, Hutt, Lee, and Ounsted (1965) noted that children with autism demonstrate a desynchronized electroencephalogram pattern, indicating high levels of arousal. This desynchronization was related to increased environmental stimulation and increased stereotyped (i.e., repetitive) behavior.

The underlying reason for the high levels of arousal in some persons with autism is not entirely known. Some researchers suggested that a high level of arousal may be due to neurological dysfunction, such as sensory processing problems (Delacato, 1974; Grandin, 1995); others posited that the problem relates to faulty information processing (Ornitz, 1985); and others suggested that a myelination defect might lead to increased neuronal arousal (McClelland, Eyre, Watson, Calvert, & Sherrard, 1992).

One method clinicians use to lessen anxiety and arousal in persons with autism is the application of deep pressure. For example, Ayres (1979) and King (1989) reported that wrapping a child with autism in a gym mat produces a calming effect. Persons with autism also have been known to provide themselves with deep pressure in an attempt to calm themselves (Grandin, 1992; Grandin &

Scariano, 1986) and often prefer to provide this stimulation themselves, frequently avoiding tactile stimulation controlled by others (Delacato, 1974).

There has been little empirical research on the efficacy of deep pressure on persons with autism. Inamura, Wiss, and Parham (1990a, 1990b) investigated the effects of Grandin's Hug Machine, a device that provides deep pressure to the lateral parts of the body, on the behavior of nine children with autism. Temple Grandin, a woman with autism, developed the Hug Machine after observing that cattle showed a dramatic decrease in anxiety when receiving deep pressure from a cattle chute, a device used during branding. Grandin modeled the Hug Machine on the cattle chute but modified the design for human use (Grandin & Scariano, 1986). She proposed that persons with relatively high levels of anxiety or arousal are more likely to benefit from the Hug Machine than those with moderate to low levels of anxiety or arousal.

Inamura et al. (1990a, 1990b) noted that, in general, the children in their study did not consistently use the Hug Machine, with duration of use being less than 2 min per session. However, greater use seemed to be related to decreased hyperactive behavior in some children. Although these findings are encouraging, Inamura et al. did not use a control group, did not use physiological measures to see whether there were concomitant physiological changes due to deep pressure, and did not analyze their data statistically.

In an open clinical study, Creedon (1994) found that children with autism who used the Hug Machine for longer periods and with more sustained pressure on days that were associated with behavior problems made fewer aimless actions, made more adaptive movements, and were able to sit more calmly than children who did not use the Hug Machine regularly. Similar to Inamura et al.'s (1990a, 1990b) study, Creedon's report was based on clinical rather than statistical data.

Another type of intervention involving deep pressure is holding therapy (Welch, 1988). This treatment involves holding the person for long periods while providing deep pressure. Because the person does not control the deep pressure, one criticism of holding therapy is that he or she may not desire the pressure or the amount of pressure applied. Additionally, children often resist the initial holding therapy sessions, which can lead to considerable stress for the child. Therefore, the calming effects noted by Welch may be due to learned helplessness rather than the tactile stimulation. We are unaware of scientific studies assessing the efficacy of this intervention.

Field et al. (1997) investigated the use of touch therapy on 22 preschool children with autism, half of whom received touch treatment and the other half a placebo intervention. The form of touch therapy these researchers used involved providing "moderate pressure and smooth stroking move-

ments on each of the following areas: head/neck, arms/hands, torso, and legs/feet" (p. 334). The results indicated increases in attention to multiple tasks, social and relating behavior, and initiating behavior, and a decrease in general sensory problems. It should be noted that although touch therapy provides tactile stimulation, it is not deep pressure.

Two case studies reported dramatic behavioral changes as a result of other forms of tactile stimulation that more closely resemble deep pressure. In one study, foam arm splints were placed on a child with autism, resulting in a decrease in self-injurious behavior and an increase in social interaction (McClure & Holtz-Yotz, 1991). In another study, a reduction in stereotypic, self-stimulatory behaviors was observed after frequent back rubs and hugs from a therapist (Zissermann, 1992). When the child also wore tight-fitting gloves and a weighted vest, which provided continuous pressure, stereotypic behaviors and hand slapping were further reduced. As clinical reports, these case studies did not empirically test the efficacy of deep pressure.

Finally, Krauss (1987) investigated the effects of deep pressure on college students using a device called the Hug'm Apparatus. Anxiety level was determined with a physiological measure (heart rate) and a self-report measure (State-Trait Anxiety Inventory). Although there was no significant change in heart rate as a result of the deep pressure, the State-Trait Anxiety Inventory indicated a greater reduction in anxiety levels in the experimental group than in the control group. However, this difference was not significant. Krauss speculated that initial low levels of state anxiety may, in part, explain the limited change in anxiety after deep pressure noted in the experimental group.

The aim of the present study was to provide a more controlled empirical investigation of the effects of deep pressure, using Grandin's Hug Machine, on children with autism. In contrast to Inamura et al.'s (1990a, 1990b) study, we used an experimental group receiving deep pressure and a matched (a priori on observable indicators of anxiety, such as jitteriness, shakiness, etc.) placebo group that did not. Unlike the clinical reports of Creedon (1994), McClure and Holtz-Yotz (1991), and Zissermann (1992), we specifically wished to conduct statistical comparisons of children who did and did not receive deep pressure to see whether any observed changes would meet the criteria of significance. Finally, similar to Krauss's (1987) study with college students, we wanted to investigate the relationship between behavioral and physiological indicators of arousal before and after deep pressure in children with autism.

The specific goals of the present study were to determine whether (a) deep pressure affected behavioral indexes of anxiety, (b) deep pressure affected physiological indexes of anxiety; and (c) there were unintended side effects of deep pressure. It should be noted that because of our small sample size, our investigation should be considered a pilot study, an initial attempt to answer these questions.

Method

Sample

Fourteen children who were diagnosed with autism by a physician were recruited from the Portland and Salem areas of Oregon. Two children were excused from the study (both boys) because one did not want to be separated from his parents during the experiment and the other would not allow us to obtain galvanic skin response (GSR) measures. Therefore, our final sample included 12 children (9 boys, 3 girls), ranging in age from 4 to 13 years ($M = 7.58$ years, $SD = 2.91$). Half of the children had meaningful communication skills, and half were either nonverbal or verbally impaired (e.g., echolalic).

If possible, the children were matched on the basis of age and gender and two of the authors' independent evaluations of anxiety. In all cases, the two authors were in independent agreement about the matches. After the matches were formed, one member of each match was randomly assigned to the experimental condition, the other to the placebo condition. Unfortunately, both children in one match were mistakenly run in the placebo condition. Thus, there were 5 children in the experimental group and 7 in the placebo group. There was no statistical difference between the children's ages in either group.

Instruments

Hug Machine. The Hug Machine (see Figure 1) is constructed of two padded side boards that are hinged near the bottom to form a V-shape. To use the device, the person lies down or squats between the two side boards. By pulling a lever, the user engages an air cylinder that pulls the boards together. This action provides deep pressure stimulation evenly across the lateral parts of the body. Given Inamura et al.'s (1990a, 1990b) report about the limited use of the Hug Machine by their sample, we encouraged the children in our study to use the device often and helped them to do so, if necessary.

Galvanic skin response. The GSR was used to examine changes in physiological arousal. Although a high arousal level does not necessarily imply a high anxiety level, the two variables are highly correlated (Alexander, White, & Wallace, 1977). The GSR has also been used in other research studies to measure the anxiety of persons with autism (Bernal & Miller, 1971; Stevens & Gruzelier, 1984). The Temperature and Skin Conductance Kit (Model 201T)¹ was used to measure GSR.

Conners Parent Rating Scale (CPRS). Behavioral indicators of anxiety were assessed with the CPRS (Conners, 1970; Goyette, Conners, & Ulrich, 1978). The CPRS contains 93 items relating to numerous behaviors, including

social, anxiety, compliance, obsessiveness–compulsiveness, and hyperactivity, but we were only interested in the items tapping different dimensions of anxiety. Therefore, we formed three anxiety scales by creating linear combinations of questions assessing anxiety-related behaviors. The Anxiety scale examined general indicators of anxiety, including overall physical anxiety, fear, and excitability. It included the following items from the CPRS: afraid of people, afraid of being alone, restless or overactive, excitable or impulsive, cannot stand too much excitement, unable to stop a repetitive activity, and acts as if driven by a motor. The Tension scale included all the items on the Muscular Tension section of the CPRS: gets still and rigid; twitches, jerks, etc.; and shakes. The Restlessness–Hyperactivity scale included the following CPRS items: restless; fails to finish things he or she starts (short attention span) and inattentive, easily distracted (both of which are also on the general anxiety scale); and constantly fidgeting.

The range of possible scores for each item was 1 to 4 (1 = the problem behavior bothered the child not at all, 2 = just a little, 3 = pretty much, 4 = very much). Thus, the total score could range from 7 to 28 for the Anxiety scale, 3 to 12 for the Tension scale, and 6 to 24 for the Restlessness–Hyperactivity scale.

Side effects questionnaire. The side effects questionnaire was developed for the study and used primarily as a measure of possible side effects of the deep pressure. At the beginning of each week, the children's parents were asked to complete the two-item, open-ended questionnaire to report whether they had noticed subtle or dramatic changes in their child's behavior that they could attribute directly to their child being in the Hug Machine.

Procedure

Before the study, each child was placed in the Hug Machine for one session to familiarize him or her with the laboratory room, the GSR electrodes, and the deep pressure device. All the children spent 5 min to 10 min in the device and were encouraged to activate the deep pressure with the lever to ensure that they could tolerate the deep pressure should they be assigned to the experimental condition. A few children who were hesitant to go into the Hug Machine were brought back for a second time to familiarize them again with the device and with the experimental procedures. After this "pretraining," the children received 12, 20-min sessions in the Hug Machine (i.e., twice a week for 6 consecutive weeks).

Children in the experimental group were instructed to use the Hug Machine lever to provide deep pressure as often as they desired. Children in the placebo group also lay in the Hug Machine, but the lever was disengaged so that they were not able to provide themselves with deep pressure. In addition, the side boards were moved apart so that deep pressure could not be provided manually.

¹Manufactured by Lafayette Instruments, 3700 Sagamore Parkway North, PO Box 5729, Lafayette, Indiana 47903.

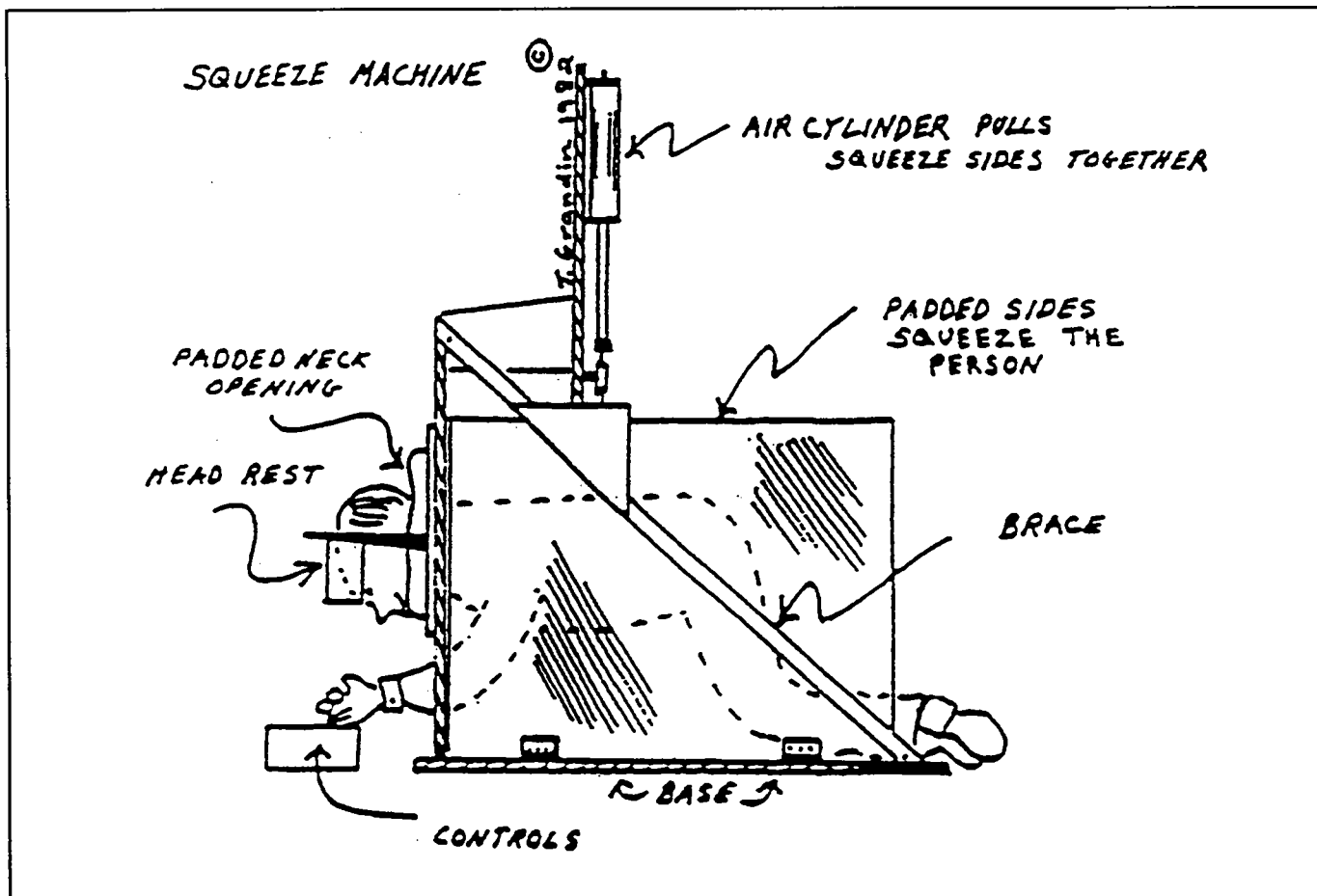


Figure 1. Grandin's Hug Machine. *Note.* Copyright 1982 by Temple Grandin. Reprinted with permission.

Therefore, the only pressure provided to the placebo group was that of the child's body against the floor.

GSR was measured before and immediately after each session. Probes were coated with electrode gel and attached to the index and middle fingers of the child's right hand with hook-and-loop tape. The GSR readings began 15 sec after the electrodes were attached. Three recordings were made during the 15-sec time interval: (a) the GSR reading at the beginning of the interval (GSR-15), (b) the maximum GSR reading within the time interval (GSR-max), and (c) the minimum GSR reading within the time interval (GSR-min).

Parents were instructed to complete the CPRS before the 1st session, after the 6th session, and after the 12th ses-

sion. Because parents were blind to group assignment, they waited in a room adjacent to the laboratory while their child was in the device. In addition, they were not present for the GSR measurements, which were conducted immediately before the children entered the Hug Machine and immediately after they exited the Hug Machine.

Results

Intercorrelations of Behavioral and Physiological Data Before Deep Pressure

Table 1 presents the results of an initial correlational analysis to determine the degree of relationship between the behavioral and physiological indexes of anxiety or arousal before the experimental conditions. As can be seen, these

Table 1
Intercorrelations Among GSR and CPRS Variables Before Experimental Conditions

Variable	GSR-Min	GSR-Max	Anxiety	Tension	Restlessness-Hyperactivity
GSR-min	—	.98*	.58****	.52****	.46****
GSR-max		—	.65***	.48****	.53****
Anxiety			—	.80**	.90*
Tension				—	.64***
Restlessness-hyperactivity					—

Note. $n = 12$ for all correlations. GSR = galvanic skin response; CPRS = Conners Parent Rating Scale.

* $p < .001$. ** $p < .01$. *** $p < .05$. **** $p < .10$.

variables were well correlated. Pearson correlations coefficients among GSR-min, GSR-max, and the three CPRS scales ranged from .46 to .65. These were all at least marginally significant despite the small sample size. Moreover, the two GSR variables were highly correlated with one another, $r(12) = .98, p < .001$. Similarly, the three CPRS scales were well correlated with each other. The correlation between the Anxiety and Tension scales was $r(12) = .80, p < .01$; the correlation between the Anxiety and Restlessness-Hyperactivity scales was $r(12) = .90, p < .001$; and the correlation between the Tension and Restlessness-Hyperactivity scales was $r(12) = .64, p < .05$.

These results indicate that behavioral and physiological indicators of arousal converged. They also validate the usefulness of the three anxiety scales that we created from the CPRS. Interestingly, although the physiological variables remained highly correlated with each other as did the behavioral variables throughout the course of the study, the intercorrelations between the behavioral and physiological indicators of arousal were no longer significant either at the midpoint or the end of the study.

Behavioral Data

The data from the three CPRS scales were analyzed with a 2×3 (group \times time) multivariate analysis of variance using repeated measures. The 3 time points assessed were before the beginning of the sessions (presession), at the midpoint of the study (midsession), and after the last session (postsession). Analysis of Tension scale scores yielded a significant interaction between group and time, Wilks's lambda = .348, $F(2, 9) = 8.43, p < .01$; that is, the amount of tension decreased for the experimental group over the 12 sessions, whereas the results from the placebo group remained relatively constant (see Figure 2). The main effect of time was also significant, Wilks's lambda = .362, $F(2, 9)$

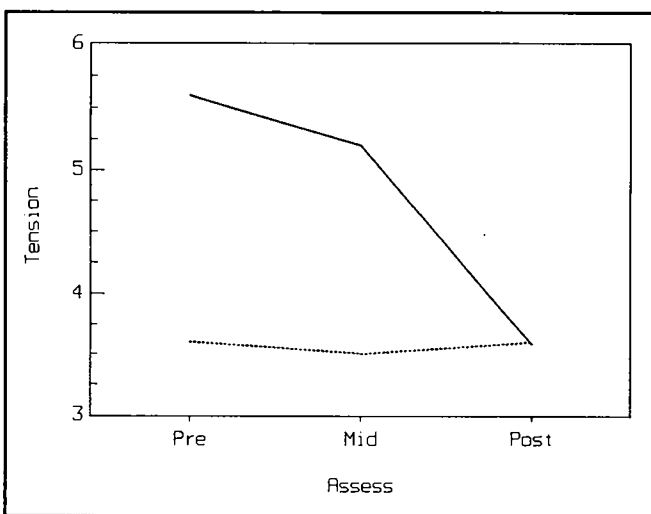


Figure 2. Scores on the tension scale of the Conners Parent Rating Scale for the experimental group (solid line) and the placebo group (dashed line) over time.

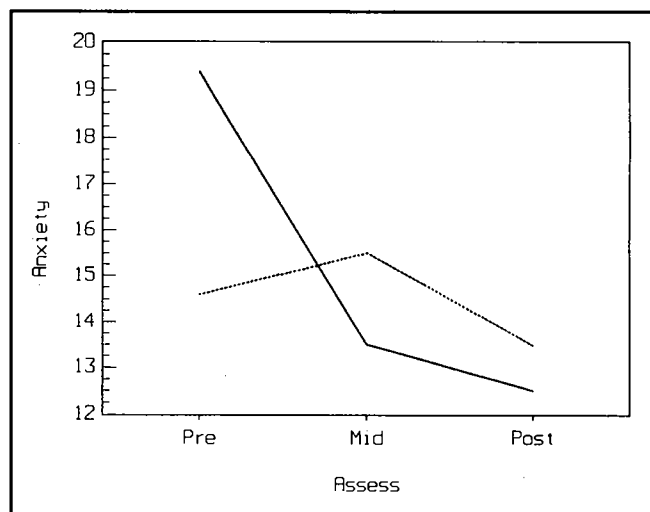


Figure 3. Scores on the anxiety scale of the Conners Parent Rating Scale for the experimental group (solid line) and the placebo group (dashed line) over time.

= 7.93, $p < .05$. Analysis of Anxiety scale scores revealed a marginally significant interaction between group and time, Wilks's lambda = .60, $F(2, 9) = 3.00, p < .10$ (see Figure 3). The main effect of time was also marginally significant, Wilks's lambda = .55, $F(2, 9) = 3.68, p < .10$. Analysis of the Restlessness-Hyperactivity scale scores yielded a significant main effect of time, Wilks's lambda = .324, $F(2, 9) = 9.37, p < .01$, but the main effect of group and the interaction were not significant (see Figure 4).

Despite our random assignment to conditions, there were some a priori differences between the experimental and placebo groups on some of the CPRS scales. The experimental group was rated as significantly higher on the tension scale than the placebo group, $t(10) = 3.124, p < .05$, before the study. The experimental group was also marginally significantly higher on the Anxiety scale a priori

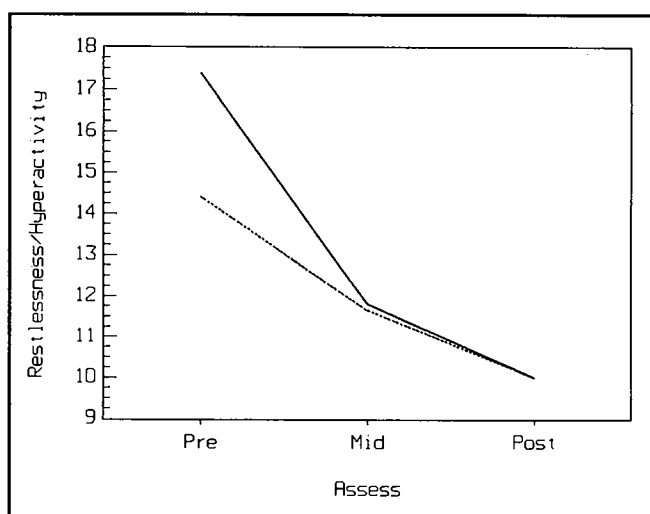


Figure 4. Scores on the restlessness-hyperactivity scale of the Conners Parent Rating Scale for the experimental group (solid line) and the placebo group (dashed line) over time.

than the placebo group, $t(10) = 1.959, p < .10$. There were no significant differences between the groups on the Restlessness–Hyperactivity scale before the study, $t(10) = 1.085, p > .10$. Although these a priori differences might suggest that the observed interactions may be due to a regression toward the mean, this is unlikely given the nature of the observed changes. Whereas the experimental group showed decreases on these scales, the placebo group, which should also show increases if the findings were due to a regression toward the mean, was relatively stable across all 3 time points and, in some cases, even decreased. Thus, it appears that the observed interactions were due to improvement in the experimental group and little change in the placebo group.

Physiological Data

Three GSR measures were used as dependent measures. Besides analyzing the GSR-min and GSR-max readings recorded during a 15-sec interval (which occurred 15 sec after the electrodes were attached), the difference, or range, between the two was also examined (GSR-range). By computing the GSR-range, we could examine the stability of physiological arousal within and across children.

There were no significant interactions or main effects for GSR-min or GSR-max. When analyzing the data across all sessions and children, there was a marginally significant time \times group interaction for GSR-range, $F(1, 142) = 3.38, p < .10$, indicating that from pre-session to post-session, variability in the GSR data decreased for the placebo group and increased for the experimental group. This increased variability in the experimental group appears to indicate that some children in the experimental group were responding to the deep pressure, and others were not. It should be noted that the experimental and placebo groups were not significantly different on any of the GSR measures a priori.

On the basis of this observed interaction and Grandin's (1995) experience that greater arousal may predict greater efficacy of deep pressure, an a posteriori hypothesis was developed and tested to determine which children in the experimental group benefited from deep pressure. It was predicted that the children who should benefit the most by deep pressure (both behaviorally and on the basis of reductions in GSR) would be those who had the highest level of anxiety or arousal at the beginning of the study. In other words, it may be that there was a threshold of anxiety or arousal required for deep pressure to be beneficial. Those children whose initial anxiety was greater than this threshold should benefit from deep pressure, and those whose initial anxiety was below this threshold should not.

To test this threshold hypothesis, the children were classified as either benefitors or nonbenefitors. Benefitors were defined as those children whose GSR readings decreased from pre-session to post-session over the course of the entire study, and nonbenefitors were those children

whose GSR ratings either remained the same or increased from pre-session to post-session. In other words, if the average difference across all sessions between pre-session and post-session ratings was positive (indicating higher arousal before using the Hug Machine than after), the child was a benefitor. If this average difference was zero or negative (indicating that arousal stayed the same or increased after using the Hug Machine), the child was a nonbenefitor.

A two-sample t test was computed, using benefitors and nonbenefitors as the two samples. Children were labeled as such with a dummy coding procedure (1 = benefitors, 0 = nonbenefitors). For children in the experimental group, there was a marginally significant difference between benefitors and nonbenefitors; that is, benefitors were more likely to have had higher baseline anxiety or arousal as indicated by higher GSR ratings than nonbenefitors. This was true for both GSR-min, $t(4) = 2.425, p < .10$, and GSR-max, $t(4) = 2.277, p < .10$, ratings. This was not found for children in the placebo group. There were no significant differences in baseline CPRS scales for benefitors and nonbenefitors in either condition.

Side Effects

There were no consistent reports of adverse reactions to the deep pressure sessions for any of the children throughout the course of the study. Thus, it can be assumed that deep pressure or lying in the Hug Machine is not deleterious.

Discussion

Although this must be considered a pilot study because of the relatively small sample size, the behavioral results seem to support the contention that deep pressure has a calming effect on children who are anxious. The children who received deep pressure demonstrated a significant decrease on the Tension scale and a marginally significant decrease on the more general Anxiety scale.

The findings from the GSR measures further suggest that five children in the experimental condition seemed to benefit from deep pressure sessions. These benefitors were those who had the highest initial levels of physiological arousal. Ayres and Tickle (1980) noted that sensory integration therapy was also more effective for children with autism who had normal or overaroused sensory responsiveness than for children whose systems were underaroused. Thus, interventions directed at changing the sensory system might be more efficacious for persons with higher levels of arousal. Anecdotally, the child who had the highest a priori GSR level in our study and had been assigned, at random, to the experimental group showed the most dramatic decrease in arousal over the 12-session intervention period.

Interestingly, the concordance between the behavioral and physiological indicators of arousal, noted before the children were in either Hug Machine condition, did not

remain throughout the course of the study. The reason for this may be that some children improved behaviorally but not physiologically. Furthermore, the small sample size may have either sufficiently reduced the statistical power of our analyses or weakened the correlations between the behavioral and physiological measures. It should be noted that even though the correlations between these two classes of variables were no longer significant by the midpoint and end of the study, the pattern of positive correlations was largely unchanged.

It seems possible that the behavioral CPRS data reflected the positive effects of the Hug Machine, whereas the physiological GSR data reflected either discomfort with the skin probes or the stress involved in having the GSR measured. Van Engeland, Roelofs, Verbaten, and Slangen (1991) reported an inability to distinguish hyperarousal in children with autism from their reactions to the stress of being tested. Moreover, James and Barry (1984) found abnormal autonomic reactions to repeated stimulation of persons with autism. It is possible that subjecting the children to repeated GSR measurements resulted in increasingly abnormal physiological reactions over time. This might also explain the failure to find many physiological changes in response to the Hug Machine.

This study has several limitations. Although we tried to recruit children who were highly anxious, the majority had moderate levels of anxiety. Future studies might screen participants for anxiety level a priori to further explore the threshold hypothesis that persons with high levels of anxiety will benefit the most from the Hug Machine. Additionally, the children's use of the Hug Machine was arbitrarily scheduled for two sessions a week for 6 weeks, yet Grandin was able to use the Hug Machine during times when she was most anxious (Grandin & Scariano, 1986). It is not known whether the efficacy of the Hug Machine was reduced by scheduling arbitrary sessions rather than by allowing the children to have access to the device during periods of heightened arousal or anxiety. Inamura et al. (1990a, 1990b) noted that greater Hug Machine use seemed to produce greater positive effects for some of the children in their study, and Creedon (1994) noticed that children with autism used the Hug Machine more and for a greater duration on the days they displayed more behavioral problems. Therefore, increasing access to the Hug Machine as well as allowing for its use during self-determined times may possibly increase its efficacy. Although it was not feasible to test this possibility in our study, ideally the Hug Machine would be more accessible when used clinically.

As already stated, another limitation was the small sample size, which greatly reduced the power of the statistical analyses. The final limitation was the nature of our sample. Because half the sample was functionally noncommunicative, we were not able to obtain self-report data

regarding these children's subjectively experienced anxiety or arousal. Self-reports would have provided further insight into their feelings before, during, and after the deep pressure sessions. Because of the communication impairments, it is not known whether deep pressure had any effect on these children's subjective feelings of anxiety or arousal as would be expected from Krauss's (1987) findings.

Conclusion

The results of this pilot study are encouraging. Deep pressure appears beneficial for children with high levels of anxiety or arousal, and there may be a threshold of anxiety or arousal required for deep pressure to be beneficial. Thus, our research supports the reports of clinicians and parents of children with autism who have noted the calming effects of deep pressure for this population (Ayres, 1979; Creedon, 1994; King, 1989; McClure & Holtz-Yortz, 1991; Zissermann, 1992). Because of the limitations noted, more research is needed to replicate and extend our results. ▲

Acknowledgments

This research was partially supported by a Carson Undergraduate Research Grant from Willamette University awarded to David C. R. Kerr under the supervision of Stephen M. Edelson and Meredyth Goldberg Edelson. A portion of these results was presented at the Oregon Academy of Science Conference, Portland, Oregon, February 1996, and at the Autism Society of America National Conference, Reno, Nevada, July 1998.

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