Structural and environmental characteristics of stereotyped behaviors.

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Abstract

In this paper, the structural and environmental characteristics of stereotypic behaviors shown by eight individuals with developmental disabilities are described. Analysis of the structural characteristics showed that the parameters of stereotyped behavior were highly correlated with one another and that 3 participants engaged in the behaviors for a large proportion of the time that were characterized by increased bout durations and bout length variability. Analysis of the influence of environmental variables indicated that stereotyped behaviors were more likely to occur under conditions of low stimulation, and were less likely to occur during conditions that involved social contact with others. Individuals whose stereotyped behaviors were less influenced by environmental factors were more likely to engage in stereotyped behaviors for greater periods of time. These data suggest that an examination of both structural and environmental characteristics of stereotyped behaviors may provide useful insights for understanding the origins of these behaviors.
Many individuals diagnosed with autism and/or developmental disabilities show repetitive stereotypical behaviors (e.g., hand-flapping, body rocking and head rolling) that often appear highly rhythmical, uncontrolled, and maladaptive for the individual concerned (Bodfish et al., 1995; Dura et al. 1987; Rojahn, 1986). For example, over two thirds of individuals living in an institution for people with developmental disabilities were found to engage in stereotyped behaviors ranging from body movements (swaying, rocking and twirling), head movements (shaking, nodding and banging) and arm/hand movements (wringing, flicking, shaking and holding hands before eyes) that did not appear to serve any apparent purpose (Berkson & Davenport, 1962). When severe, these behaviors have been shown to interfere with normal everyday activities (Repp, Singh, Karsh, & Deitz, 1991), limit the educational progress of the individual concerned (Koegel & Covert, 1972) and to pose barriers to the inclusion of the individual into society (Watkins & Kornarski, 1987).

Several theories have been put forward to account for the appearance of stereotyped behaviors in the repertoire of individuals with developmental disabilities. Some researchers for example, have suggested that the behaviors may be similar to the “rhythmic habit patterns” often seen in typically developing infants (Kravitz & Boehm, 1971; Thelen, 1981) and that the appearance of stereotyped behaviors in individuals with developmental disabilities are simply delayed manifestations of these behaviors (Schwartz, Gallagher & Berkson, 1986; Wehmeyer, 1991). Others have shown that some forms of stereotyped behaviors appear to be maintained by the perceptual consequences that arise automatically when the behaviors occur (Lovaas, Newsom & Hickman, 1987).
and that these forms of behaviors can be eliminated from the repertoire when the perceptual consequences presumably maintaining the behaviors are removed (Aiken & Salzberg, 1984; Rincover, 1978; Rincover, Cook, Peoples, & Packard, 1979; Rincover & Devany, 1982; Rincover, Newsom, & Carr, 1979). Other researchers have conducted kinematic analyses of the body rocking movements in individuals with developmental disabilities (Newell et al., 1999; Berkson et al., 2001) in an attempt to determine whether these behaviors may originate from a motor control disorder, possibly as a result of damage to the basal ganglia region in the brain (Newell, 1996; Newell van Emmerik, & Sprague, 1993).

To account for the highly repetitious and rhythmical nature of stereotyped behaviors, several authors have suggested that they may be related to physiological rhythmicity. In a group of typically developing children, for example, Thelen (1979) found that infants engaged in up to 47 distinct forms of stereotyped behavior, and that some of these behaviors occurred in distinct temporal patterns over time. Evidence to suggest that stereotyped behaviors may be linked to the individual’s heart-rate has also been advanced, with some studies finding a direct relationship between body-rocking movements shown by individuals with developmental disabilities and heart-rate variability (Lewis, MacClean, Bryson-Brockman et al., 1984; Young & Clements, 1979). Further analysis of the structural and temporal features of stereotyped behaviors has also indicated that some forms of stereotyped behavior appear to be internally regulated by a “neural oscillator” of some kind. Lewis, MacClean, Johnson & Baumeister (1981) for example found that 27 to 69% of the bouts of stereotyped behaviors shown by individuals with developmental disabilities lasted under 5s, and that in 3 individuals, stereotyped
behavior occurred in 4 hour cycles. Further analysis of the data showed that the bout frequency, mean bout length, and bout length variability of stereotypy, when calculated over successive 2-hour blocks of time, remained fairly constant over time, indicating that the stereotyped behaviors were minimally influenced by external factors. Repp, Karsh, Dietz & Singh (1992) also observed the stereotyped behaviors of individuals with developmental disabilities and found that these individuals engaged in stereotypic behaviors for between 22 to 74% of the time and that the behaviors occurred consistently over several days, again indicating that the behaviors were minimally influenced by external factors.

Alongside the analysis of the structural or temporal features of stereotyped behaviors, a large body of literature has accumulated concerning the influence of environmental factors on the occurrence of stereotyped behaviors. Researchers have repeatedly demonstrated that stereotypical behaviors appear to increase in frequency when individuals are placed in “barren” environments and that they decrease in frequency when the individuals are placed in enriched environments containing toys or other stimulatory activities (e.g., Berkson & Mason, 1963, 1964; Davenport & Berkson, 1963; Forehand & Baumeister, 1970, 1971; Kaufman, 1967; Warren & Burns, 1970). These early “enrichment” studies have been replicated by studies that have systematically manipulated the antecedents and consequences of stereotyped behaviors during a functional analysis (Durand & Carr, 1987; Iwata et al., 1994). Sturmey, Carlsen, Crisp and Newton (1988) for example, examined whether the stereotyped behaviors shown by three individuals with developmental disabilities occurred more often when the individual was either alone, received social disapproval after a continuous bout of stereotyped
behavior, escaped from tasks after engaging in stereotypic behaviors, or sat in a room playing with toys (c.f., Iwata et al., 1994). As expected, stereotypic behaviors occurred at higher rates during the alone condition relative to the other conditions, suggesting that the behaviors were minimally influenced by social consequences. Importantly, this conclusion did not change when the different topographies of stereotypic behavior for each individual were analyzed separately, indicating that the behaviors were functionally equivalent.

Descriptive analyses of stereotyped behaviors have also been conducted to determine whether social-environmental factors may be associated to stereotyped behaviors in more ecologically valid environments. Repp, Singh, Karsh & Deitz (1991) for example, conducted a descriptive analysis of stereotyped behavior shown by 12 individuals with developmental disabilities as they interacted with their teachers in a classroom setting. These authors found that stereotyped behaviors often occurred during covert task demand situations, suggesting that these particular environmental events may have acted as setting events for the stereotyped behaviors to occur. Unfortunately, in the Repp et al. study, the different topographies of stereotyped behaviors were combined in their analyses, making it difficult to determine whether all stereotyped behaviors were associated to teacher covert demands. Also, the possibility that associations between environmental factors and stereotypic behaviors could have occurred by chance were not considered, particularly since the rate of presentation of these environmental events were uncontrolled.

The overcome some of the problems associated with previous studies, and in an attempt to integrate previous lines of research, in the present study, we provide data on
the parameters of individual forms of stereotyped behaviors (e.g., percentage of time, bout-length and bout-length variability) and also on the extent to which stereotyped behaviors co-varied with levels of environmental stimulation in several individuals with developmental disabilities. Few studies have attempted to integrate both a structural and environmental analyses of stereotyped behavior in order to determine both the impact of social-environmental events and to simultaneously determine whether these behaviors are temporally regulated. It is hoped that such an analysis may shed some new insights into the determinants of stereotyped behaviors and suggest new ways to help ameliorate these behaviors.

Method

Participants

Eight individuals who showed multiple forms of stereotypical behaviors participated in the study. Three participants attended residential schools for children with developmental disabilities, four attended non-residential schools for children with developmental disabilities and one participant lived in a local authority residential unit. One participant was female (P7), 3 participants had poor vision (P3, P7 and P8) and 1 participant was nonambulant (P3). The age of the participants ranged from 7 to 26 years (mean = 14.3 years, standard deviation [SD] = 6.03). The developmental age of the participants (calculated from the Vineland Adaptive Behavior Scales; Sparrow, Balla, & Cicchetti, 1984), ranged from 0.8 years to 2.3 years (mean = 1.4 years, SD = 0.48). One participant (P4) had a moderate level of learning disability, four participants had a severe
level of learning disability (P1, P2, P5 and P6) and three participants had a profound level of learning disability (P3, P7 and P8).

25 different topographies of stereotyped behaviors were displayed by the participants. 5 participants displayed 7 topographies, 2 participants showed 6 topographies and 1 participant showed 5 topographies of stereotyped behavior. 7 subjects showed hand mouthing, 6 showed hand flapping, 6 subjects displayed body rocking, 4 placed their hands over their ears, 3 showed object hitting, 2 showed face rubbing, and 2 showed leg kicking. The following topographies were idiosyncratic to a single participant: hand hitting, clapping, sniffing, blowing, bouncing, grimacing, arm flapping, eye pressing, body rolling, body spinning, hand regard, finger placing, lace twiddling, hair touching, object spinning, hand clapping, and head touching.

Procedure

All participants were videotaped in their natural environment during daylight hours. The observers endeavored to remain as inconspicuous as possible, did not interact directly with the participant and remained out of the participant’s line of sight. Observers requested that teachers and carers continued to interact with the participant in their usual manner and to ignore the presence of the observer. The video recording was stopped at any time if it intruded on the participant’s privacy (e.g. toileting or when private body parts were exposed) or if a participant appeared to become distressed due to the recording. The video recordings were conducted in residential school facilities for children with developmental disabilities, local authority managed residential units and non-residential schools for children with developmental disabilities. The observations
included a representative sample of activities such as mealtimes, leisure time, learning tasks, group activities and individual work.

**Observational Response Definitions and Coding**

From informal observations of the videotaped recordings, the stereotyped behaviors displayed by each participant were operationally defined prior to coding. A behavior was labelled “stereotyped” if it could be encapsulated by the following general definition: “highly consistent and repetitious motor behavior or posturing responses which are excessive with respect to rate, frequency and/or amplitude and which do not appear to possess any adaptive significance” (Baumeister, 1978).

Four “environmental stimulation” categories were also operationally defined as follows: 1) **demands** (a teacher or carer asking the participant to do something e.g., a task) 2) **attention** (a teacher or carer giving the participant non-demanding physical or verbal social contact), 3) **auditory stimulation** (loud noises such as vocalisations from other service users or staff members, clapping by others, loud music or singing), and 4) **tactile stimulation** (the participant manipulating objects with his/her hands e.g., a task, puzzle, toy, game or book, that appeared to have some adaptive significance). Delivery of attention or demands from teachers or carers did not require any behavior on the part of the subject to be displayed (e.g., compliance), and none of the participants were physically restrained or prevented from engaging in any form of stereotyped behavior.

Observational data were recorded from the video tapes onto a Pentium lap-top computer using software that allowed the frequency and/or duration of the 25 stereotyped behaviors and the 4 environmental stimulation categories to be recorded in real-time (in
one second intervals) (see Repp, Harman, Felce, VanAcker & Karsh, 1989). Each response category was allocated to a particular key on the computer keyboard and observers recorded both the onset and offset of the response category by depressing the associated key once to record the onset and a second time to record the offset. The software allowed more than one key to be depressed at one time. Thus any behavior could co-occur with any other behavior. Observation times ranged from 1.54 to 4.19 hours for each participant (mean = 2.67 hrs).

Inter-Observable Reliability

A second observer independently coded between 20% and 70% of the observational data collected for each participant (34% of the total observational data). Inter-observer agreement between the standard and second observer were compared on a 10 second interval-by-interval basis, with agreements and disagreements scored on occurrence and nonoccurrence for each response category (Murphy, 1987). In each 10-s interval, if the first observer scored an occurrence of a response and the second observer also scored an occurrence of the same response, then an agreement on occurrence was scored. If both observers scored the absence of a response in a particular 10-s interval, then an agreement on nonoccurrence was scored. All other outcomes were scored as disagreements. In order to control for ‘chance’ levels of agreement, Cohen’s kappa was employed (see Hartman, 1977). The mean kappa for the environmental event categories averaged across participants were as follows: attention = 0.80 (range, 0.71 to 0.87), demands = 0.98 (range, 0.93 to 1.00), auditory stimulation = 0.85 (range, 0.44 to 0.99)
and tactile stimulation = 0.90 (range, 0.73 to 0.97). The mean kappa for the stereotypical behaviors, averaged across behaviors and participants, was 0.78 (range 0.40 to 1.00).

Data analysis

The frequency of a response was determined by counting the number of times a particular response occurred during the observation period. The percentage of time during which each response occurred was determined by counting the number of 1-s intervals during which a response occurred and dividing this by the total time of the observation and then multiplying by 100%. The mean bout length of a response was calculated by determining the average number of 1-s intervals during which a response occurred from onset to offset. The bout length variability of a response was determined by dividing the standard deviation of the bout lengths by the mean bout length.

In order to determine the extent to which stereotypical behaviors covaried with changes in environmental stimulation, 4 mutually exclusive and exhaustive categories were defined by the computer at analysis. These were: no contact + no stimulation (the absence of attention, demands, auditory stimulation and tactile stimulation), stimulation only (auditory and/or tactile stimulation only), social contact only (attention and/or demands only), and social contact + stimulation (the combination of demands and/or attention with auditory and/or tactile stimulation. In order to determine the extent to which particular forms of stereotyped behavior were associated to these environmental categories, Yule’s Q statistics were calculated (see Bakeman & Gottman, 1997). Yule’s Q, a transformation of the odds ratio, is a statistical measure of association which ranges from +1 to -1. In this context, a high positive Yule’s Q value would indicate that the
stereotyped behavior occurred at levels that were higher than would be expected by chance whereas a high negative Yule’s Q value would indicate that the stereotyped behavior occurred at levels that were lower than would be expected by chance (Yoder & Feurer, 2000). A Yule’s Q of 0.5 is equivalent to an odds ratio of 3.0 (Bakeman et al., 1997). Yule’s Q values of 0.5 and over were therefore employed to indicate a “significant” positive effect i.e., the stereotyped behavior was 3 times more likely to occur under a given condition than by “chance”. A Yule’s Q value of less than or equal to -0.5 indicated a significant negative effect i.e., the stereotyped behavior was 3 times less likely to occur under a given condition than by “chance”.

Results

Structural Characteristics of Stereotypy

Table 1 shows the frequency, percentage of time, average bout-length, and bout-length variability of each topography of stereotyped behavior shown by each participant. The means for each parameter, averaged across topographies, are also shown in bold for each subject.

+++ Insert Table 1 about here +++

Averaging across topographies, participants engaged in stereotyped behaviors for 11.97% of the time (SD = 7.80), bout lengths lasted on average 9.25s (SD = 7.37s) and the mean bout length variability of the behaviors was 0.84 (SD = 0.10). Inspection of
Table 1 indicated that participants P4, P7 and P8 showed stereotyped behaviors for longer periods of time, that the behaviors had larger mean bout lengths and had greater bout length variability. To determine whether this was true across subjects and topographies in general, data from the three parameters were correlated by collapsing across topographies and subjects. The correlation between the percentage of time parameter and mean bout length parameter was 0.77, whilst the correlation between the percentage of time parameter and the bout length variability parameter was 0.49. These data indicated that responses that occupied the most time, tended to last for longer and to have greater bout length variability.

**Environmental Characteristics of Stereotypy**

Figure 1 shows the extent to which the various forms of stereotyped behavior shown by each participant occurred during periods of changing environmental stimulation: social contact + stimulation, social contact only, stimulation only and no contact + no stimulation.

+++ Insert Figure 1 about here +++

Averaging across topographies and subjects, the mean Yule’s Q index for these environmental stimulation categories were -0.26, -0.26, 0.04 and 0.11 respectively. A Friedman two-way analysis by ranks (FTWAR) indicated that the mean Yule’s Q index for both the social contact + stimulation and social contact only conditions were significantly lower than the mean Yule’s Q index for the stimulation only and no contact
no stimulation conditions ($X^2(3) = 14.85, p < 0.005$). These data suggested that, in
general, stereotyped behaviors were less likely to occur during conditions that included
social contact. Analysis of the Yule’s Q values in each condition indicated that 10%
(19/52) of the stereotyped behaviors occurred at lower than chance levels (i.e., the Yule’s
Q index for these behaviors was less than -0.5) in the social contact + stimulation
condition, whilst only 2% (3/52) of stereotyped behaviors occurred at higher than chance
levels (i.e., the Yule’s Q index was greater than 0.5) in this condition. A similar pattern
was also evidenced in the social contact only condition where 9% (17/52) of the
stereotyped behaviors occurred at lower than chance levels whereas 0% (0/52) occurred
at higher than chance levels. Very few stereotyped behaviors occurred at significantly
higher or lower than chance levels in the no contact + no stimulation condition and
stimulation only conditions.

Further inspection of Figure 1 indicated that two subjects (P4 and P8) appeared to
have an “undifferentiated pattern” of stereotyped behavior as a function of the different
conditions. For P4, only two topographies of stereotyped behavior (i.e., body rocking and
leg kicking in the social contact + stimulation condition) exceeded chance levels whilst
for P8, only 3 topographies of stereotyped behaviour (body rocking and clasping hands in
the social contact + stimulation condition, and placing hands to ears in the stimulation
condition) exceeded chance levels.

Relation of structural and environmental characteristics

To provide an index of the degree of differentiation between conditions, the
standard deviation of the mean Yule’s Q for the four conditions was computed for each
participant. These data were then correlated with the mean percentage of time subjects spent engaged in the behaviors, to determine whether there was an association between temporal features of stereotyped behavior and environmental characteristics. The resultant correlation coefficient was -0.65, indicating that a low standard deviation across conditions (i.e., stereotyped behavior that was less influenced by ambient environmental events) was associated with higher values for time spent engaged in stereotyped behavior.

Two participants (P4 and P8) had a combination of relatively higher temporal parameters and relatively undifferentiated pattern of association with environmental conditions.

Discussion

Research into stereotypical behaviors over the past few decades has been characterized by lines of enquiry that often proceed independently (Lovaas et al., 1987; Lewis et al., 1987; Newsom & Lovaas, 1987). On the one hand, stereotypical behaviors have been considered the product of “environmental” factors, shaped and maintained by the perceptual consequences that the behaviors produce, being evoked by low levels of environmental stimulation (Lovaas et al., 1987). On the other hand, stereotypical behaviors have been considered the product of an underlying neurobiological disorder (Lewis et al., 1981, 1984). Rarely have researchers considered both possibilities in their analyses i.e., collected data on the parameters of stereotyped behaviors to determine the invariance and rhythmicity of the behaviors and considered the influence that the environment might have on the origin and maintenance of the behaviors.
In the present study, data on the parameters of stereotypical behaviors (i.e., bout-length and bout-length variability) and the extent to which the behaviors were influenced by environmental factors were collected on eight participants who showed multiple forms of high-rate stereotypical behaviors. These behaviors were recorded in the participant’s usual classroom or residential setting in order to measure stereotypical behaviors within the context of a naturalistic experiment. Analysis of the structural features of stereotyped behaviours indicated that the parameters of stereotyped behavior were highly correlated with one another and that three participants engaged in stereotyped behaviors for greater periods of time that were characterized by increased bout lengths and greater bout-length variability. These data suggest that for some individuals, episodes of stereotyped behaviors may be quite variable, occur for long periods of time, and occur in epochs that do not appear to be temporally regulated (c.f. Lewis et al., 1981; Repp et al., 1991).

In order to examine the extent to which stereotyped behaviors were influenced by environmental factors, data on the social contact that participants received from teachers and care staff, together with tactile and auditory stimulation that each participant received in their environment were combined to form four mutually exclusive and exhaustive “environmental stimulation” categories. To correct for chance levels of association in the environmental analysis, Yule’s Q statistics were calculated. From this analysis, data showed that most stereotypical behaviors appeared to occur during periods of low stimulation and were less likely to occur during periods that involved social contact with others. These data are consistent with data from previous studies that have examined the effect of environmental enrichment on the occurrence of stereotyped behaviors, namely,
that stereotyped behaviors decrease in frequency when levels of environmental stimulation are increased.

However, in this study, not all forms of stereotyped behaviors displayed by the participants appeared to be reduced by high levels of environmental stimulation. For example, the arm-flapping shown by P2 was more likely to occur during high levels of environmental stimulation, as were the head-touching and hand to ear responses shown by P8. Goodall & Corbett (1982) also found that some forms of stereotyped behaviors shown by children with developmental disabilities increased in response to environmental stimulation and that an increase in these forms was accompanied by a decrease in other forms of stereotyped behavior. Taken together, these results suggest that individual forms of stereotyped behavior may serve different functions, highlighting the need to conduct analyses of the different forms of stereotyped behavior shown by a given individual.

Further analysis of the relationship between the temporal features of stereotyped behaviors and the influence of environmental variables indicated that, in general, stereotyped behaviors that appeared to be unrelated to environmental factors were more likely to occur for longer, to have longer bout lengths, and to have more variable bout lengths. These data suggest that it may be important to integrate structural and environmental analyses in any future studies of stereotyped behavior. It is possible for example that longer duration, temporally variable, and undifferentiated responding may be characteristic of a subtype of stereotyped behavior and that these forms of behavior may require specific treatment efforts.

Whilst the majority of studies have implicated either a stimulus-induction or stimulus-reduction function to stereotyped behavior, a small number of studies have
indicated that stereotyped behavior may be maintained by social-positive and/or social-negative reinforcement. Durand & Carr (1987) for example found that the stereotyped behavior of 4 children with developmental disabilities occurred predominantly during task situations and that when the task was removed for 10-s contingent on the occurrence of the stereotyped behavior, the behaviors were found to increase in frequency, suggesting that the behaviors were influenced by social-negative reinforcement. In this study, we were unable to determine directly whether stereotyped behaviors were influenced by social-environmental events given that we did not experimentally manipulate the antecedents and consequences of stereotyped behaviors. We wanted to investigate the interaction between temporal and environmental features of stereotyped behaviors, and therefore needed to observe stereotyped behaviors occurring under naturalistic conditions. By doing do, we were able to sample a broader range of environmental events and to consider a number of different topographies of behavior in the analysis. We recognise however, that a further test of the association between environmental events and stereotyped behavior is warranted. Future studies could employ experimental functional analysis methodology to validate associations obtained between ambient environmental events and stereotyped behavior in descriptive analyses.

A further disadvantage of the present study is that we were unable to examine the component acts of the stereotyped behaviors themselves. Berkson, Andriacchi & Sherman (2001) for example, obtained measurements of the amplitude of body-rocking in 5 individuals with developmental disabilities by overlaying a square grid on a television monitor and measuring the displacement (in cm) between successive body rocking cycles that were captured on videotape. This was achieved by positioning the camera orthogonal
to the line of the body-rocking when the data were being collected. Unfortunately, for most of our participants, videotapes were made of the participants facing the camera, so that we were unable to measure the amplitude of the body-rocking in this way. It may, however, be important to conduct such analyses in the future to determine whether particular forms of stereotyped behavior may reflect an underlying motor control disorder.

It is important to note that one of our subjects (P5) engaged in a repetitive behavior that initially proved very difficult for us to define. The behavior consisted of the participant repeatedly playing the game Connect Four® by picking up the pieces of the game (blue and red plastic disks), biting on them, and then inserting them into the Connect Four® grid. Once the grid was full, the participant would then empty the pieces onto the table and begin to insert the pieces back into the grid as before. Whilst the participant was not playing against a second player, he spent large periods of time playing this modified version of the game. We wondered whether this “Connect Four” behavior should have been defined as stereotyped behavior, or indeed, whether it should have been coded as a “ritual” (see Murphy et al., 2000). In the end, we decided to code this behavior as “tactile stimulation” (i.e., the subject engaging in a task) given that the “adaptive significance” of this behavior appeared to be open to interpretation. This discussion however reflects the difficulty in defining precisely what we mean by the term stereotyped behavior.

In conclusion, the data obtained in this study appear to illustrate the importance of analyzing stereotypical behaviors individually, to include a consideration of their temporal features, and of their relationship to environmental factors in an integrative
analysis. In their model of the development of stereotyped behavior, for instance, Guess & Carr (1991) integrated several lines of research to provide a coherent model of the evolution of stereotyped behaviour over time. Specifically, they speculated that while stereotyped behaviors may originate as rhythmic habit patterns (i.e., behaviors that are primarily internally regulated), their function may change over time, either serving as an adaptive response to increase or decrease environmental stimulation or developing into operant responses that serve to control the behavior of others. Further research is clearly needed to isolate the factors responsible for the origins and maintenance of stereotyped behaviors, both inside and outside the laboratory to test this model. Longitudinal studies of the development of stereotyped behavior in young children with developmental disabilities may be useful in this respect. We hope that this study will move the literature forward a step and encourage investigators to integrate analyses from different theoretical perspectives in their future research efforts.
References


Figure Caption

Yule’s Q values indexing the extent to which topographies of stereotyped behaviour occurred during periods of “social contact + stimulation”, “social contact only”, “stimulation only” and “no contact + no stimulation” for each subject. The numbers in parentheses indicate the number of times each environmental event occurred during the observation period.
Table 1. Frequency, percentage of time, mean bout-length, and bout-length variability (SD/M) of each stereotyped behaviour shown by each participant. The numbers in bold are the means for each participant, calculated across topographies.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Response</th>
<th>Freq.</th>
<th>% time</th>
<th>Bout length</th>
<th>Bout length cov.</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>hand hitting</td>
<td>185</td>
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<td>4.23</td>
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<td></td>
<td>hand flapping</td>
<td>94</td>
<td>3.33</td>
<td>4.80</td>
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<td>3.19</td>
<td>4.97</td>
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<tr>
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<td>body rocking</td>
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<td>1.72</td>
<td>6.74</td>
<td>0.90</td>
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<td>12</td>
<td>0.99</td>
<td>11.33</td>
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**Subject**

**Response**

**Freq.**

**% time**

**Bout length**

**Bout length cov.**

**Subject**

**Response**

**Freq.**

**% time**

**Bout length**

**Bout length cov.**

**P1**

hand hitting

P5

hand flapping

**P2**

body rolling

P6

lace twiddling

**P3**

hand flapping

P7

mouth hitting

**P4**

body rocking

P8

hand flapping

**Subject**

**Response**

**Freq.**

**% time**

**Bout length**

**Bout length cov.**

**P1**

hand hitting

P5

hand flapping

**P2**

body rolling

P6

lace twiddling

**P3**

hand flapping

P7

mouth hitting

**P4**

body rocking

P8

hand flapping