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Original Research Article

Lateral Bias in Developmental Disability: Evidence from Japan

Surender Kumar[1*], Manas K Mandal[2]

[1]Chikushi Jogakuen University, Japan
[2]Indian Institute of Technology- Kharagpur, India

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Abstract: While most studies indicated atypical (leftwardness or clumsiness) handedness in developmental disability, the present study was designed to test atypical laterality involving long limb (hand, foot) and sense organ (eye, ear) as inability to use both lateral sides in a complimentary manner. The study attempted to examine atypical lateral bias in difficult unilateral task as against simple tasks. Participants with intellectual disability (n=5) and autistic spectrum disorder (n=6) were tested with a 25-item side bias tasks. Performance was examined with controlled observation of unilateral execution of task reaching target. Findings indicated response rigidity for all forms of lateral bias as compared to normal controls. These findings were discussed in light of possible implication in motor training for developmental disability.

Keywords: Lateral Bias Disability atypical.

INTRODUCTION

Studies indicate that children with developmental disorder, involving mental retardation (Mandal, Tiwari, Das & Bryden, 1998; Pipe, 1990), sensory deprivation, autism (Dawson & Lewy,1988) exhibit atypical or left handedness in routine activities, although it is unclear at what age a young child does conform to an adult pattern of handedness (Scharoun & P. J. Bryden, 2014). Empirical findings (see Dutta, Mandal, & Kumar, 2012) and survey of artworks of 10,000 years (Faurie & Raymond, 2004) indicate that approximately 90 - 93% of adult human population is right handed while 7–10% people are left handed (M.P. Bryden, 1982). The incidence of atypical or clumsy handedness in population is reported mostly in children with certain forms of developmental disorder. The Geschwind-Behan-Galaburda (Geschwind & Galaburda, 1985) model suggests that high level of testosterone during embryonic development affects maturation of brain development, especially the left hemisphere resulting in anomalous handedness. The model is tested in some studies but with contradictory findings. While some studies showed atypical or anomalous handedness, others did not observe so (see Berenbaum & Denburg, 1995; Previc, 1994). Two reasons may be attributed for the difference in observation. First, atypical laterality may not be prevalent in all forms of developmental disorder. Second, the phenomenon may be specific to long limb (handedness, footedness) but not to sensory organs (eyedness, earedness).

Keeping these gaps in earlier studies, the present study is designed to test the notion of atypical laterality in children with two groups of developmental disorder, intellectual disability and autistic spectrum disorder. Atypicality is defined as the inability to make use of both lateral sides effectively. The study also aims at testing atypical laterality in two forms of motor behavior, limb (hand, foot) and sense organ (eye, ear) laterality. Put together, these two forms of lateral bias are also referred to as side bias (see, Mandal, Bulman-Fleming, & Tiwari, 2000).

A variety of measurement techniques are used to measure lateral or side bias although most of these fall under handedness that used self-report based preference questionnaire. Relatively fewer studies are conducted with performance measures to determine atypical lateral bias for unilateral activities in children with developmental disability. Performance measures are considered more consistent and reliable indicators of side bias in comparison to preference measures involving subjective judgments. However, both forms of measure of lateral bias are found to have inherent difficulties (see Scharoun & P. J. Bryden, 2014, for a critical review). Besides, performance or self-report measures are considered unreliable for participants involving developmental disorder. Therefore, the present study intends to do behavioural assessments of participants which involved controlled observation of unilateral execution of task reaching target. The method is proven to be unique and effective, and superior to performance or preference measures (Kastner-Koller, Deimann, & Bruckner, 2007).

To ensure reliability of observation, unilateral tasks are designed in simple and difficult versions. It is hypothesized that while simple tasks will induce clear choice of lateral side for any group, the difficult version of routine tasks will prompt side switching (one lateral side to another side) more often for participants with developmental disabilities, who will exhibit more atypicality. Atypicality is reflected when a unilateral task that requires involvement of both sides, with one side for mobilizing and the other side for stabilizing, is executed without the involvement of both sides in a complimentary manner. The study is therefore intended to examine the degree rather than the direction of laterality.

In sum, the aim of the present study is to examine degree of lateral bias (hand, foot, eye, ear) in participants with intellectual disability and with autistic spectrum disorder for unilateral tasks, designed in simple and difficult versions, with degree of laterality and side-switching as outcome measures.

METHODS

Development of Tool

Twenty-five unilateral tasks (9 tasks for handedness, 6 tasks for footedness, 5 tasks for eyedness, and 5 tasks for earedness; see Table 1) were chosen to make behavioural assessment of participants. Tasks were chosen based on familiarity and their routine execution in daily activities. With minor departure from most tasks used in laterality questionnaire (For example, M.P. Bryden, 1982; Coren, 1993) these were carefully chosen to reflect the involvement of non-dominant side.

These tasks were then prepared in two versions, simple and difficult. The difficult tasks were not complex in nature and did not require problem solving capabilities. Instead, this version of the task was prepared after having careful consideration for manual execution. For example, ‘unscrew a bottle’ with the cap loosely placed was easily executable. The difficult version of this task required more effort to unscrew which will induce a tendency for hand switching. Likewise, ‘pick up a pebble using foot fingers’ was manipulated with the size of pebble (footedness); ‘peeping through a keyhole’ with the size of the keyhole (eyedness); ‘listening to dial tone of mobile phone’ with the volume of tone (earedness), etc. Tasks involving long limb (hand, foot) required involvement of both sides; however, the side used to mobilize the act was considered ‘dominant or preferred’ as compared to one that was used to stabilize. For example, tagging a bunch of paper may require one hand to hold (stabilizing) and the other hand to tag (mobilizing).

The difficulty level of each task was quantified after administering on a sample of 65 participants and on the basis of a rating scale ranging from 1 (very easy) to 5 (very difficult). For the final development of test, the middle category was chosen for further administration.

Sample

Two groups of participants with developmental disability, intellectual disability (ID), n = 9, and autistic spectrum disorder (ASD), n = 11, were chosen initially. Based on their ability to complete these tasks, 5 participants with ID and 6 participants with ASD, were finally selected for data analysis. A group of normal controls (n = 22), matched in terms of demographic variables, were chosen for comparison.

Participants with ID had global developmental delay and intellectual disability, as diagnosed by their treating psychiatrists. These participants had deficits in intellectual functioning associated with deficiency in adaptive functioning involving communication and social functioning (mean age 15.5 yr, mean education 2.3 yr). The symptoms were confirmed as per the criteria of DSM V (APA, 2013). However, these participants had the ability to clearly comprehend the instruction for the tasks and were capable of executing routine tasks without difficulty. Participants with ASD were also diagnosed by their treating physicians. They had difficulty in social-emotional reciprocity, restricted range of behaviour of repetitive nature, nonverbal communication (mean age = 14.8 yr; mean education = 4 yr). The symptoms were confirmed as per the criteria of DSM V (APA, 2013). Participants were familiar with tasks and had no problem in motor coordination. Participants with even minor difficulty in motor coordination were not requested to undertake the exercise.

Participants were drawn from Child Development Centres, Fukuoka, Japan, and Seri Mengasih Centre, Kota Kinabalu, Malayasia. The study was conducted with due ethical clearance as per the guidelines of the Ministry of Education, Culture Sports, Science, and Technology, Japan, with onsite surveillance by Research Executive Committee, Chikushi Jogakuen University, Fukuoka, Japan. Participants were examined during their training at different psycho-rehabilitation centres in Japan and Malaysia.

Normal controls (n = 22) were marginally over-aged (mean = 19.2 yr) than their counterparts but had higher levels of formal education (mean education = 10.3). These participants were free from any form of developmental disability. They did not have any form of psychiatric or neurological illness. All participants, normal, ID, and ASD were female. Their parents consented for their participation.

Procedure

The side bias inventory (25-item) was administered to individual participant with one task at a time. Participants were given clear instruction about the whole procedure. An oral demonstration of each task was also given without actually executing it manually. All tasks were arranged on table-top except for footedness that was placed on ground. Participants were asked to execute the simpler version of the side bias questionnaire first, followed by the difficult version. Every task was allotted a maximum time period of 1 minute, simple or difficult.

Behavioural assessment was done by controlled observation for unilateral execution of tasks by three independent observers, who were naïve to the purpose of the study. These behaviours were also video-taped for confirmation. Two outcome measures were noted: degree of laterality for accomplishing simple tasks, and frequency of side-switch for accomplishing difficult tasks. The ability to execute the difficult task was not the dependent measure. The study therefore tested the proposition that normal controls in comparison to ID and ASD will have higher index of laterality quotient (higher the index of laterality quotient, clearer the choice of side), and lesser frequency of side-switching behaviour in difficult tasks.

DATA ANALYSIS

Incidence of lateral bias in accomplishing simple task was noted for each participant and laterality quotients (LQ), Right – Left / Right + Left or Left – Right / Left + Right (M.P. Bryden, 1982) were calculated to examine the degree rather than the direction of laterality. Data were treated with a Group (ID, ASD, Normals) x Side (Hand, Foot, Eye, Ear) factorial design with repeated measures in the Side factor. Groups did differ in their laterality quotients ($F = 36.9$, $df = 2,30$, $p<.001$). Contrary to our proposition, ID and ASD had higher index of laterality quotients. The factor of 'side' did not yield any significant result, $F = 2.34$, $df = 1,30$, $p = .137$. The interaction of group x Side was also nonsignificant, $F = 2.86$, $df = 1,30$, $p = .143$. The nonsignificant interaction suggested that lateral bias was not differential in nature for any of these groups. Data however indicated that normal controls had higher index of laterality quotient for long limb (hand, foot) as compared to sense organ (eye, ear) laterality. ID or ASD participants did not show any variation in their lateral quotient for long limb or sense organs (see Table 2).

Frequency of side switch for each group was treated with a chi-square analysis, which indicated that groups did not differ in side -switch (Chi-square: $p>.01$) for difficult tasks in any form of laterality, hand, foot, eye, ear (Chi-square: $p>.01$). Careful observation of videos and the frequency of side switch (Table 2) indicated that normal controls had much more side switch, especially for hand, as compared to ID or ASD who had very few side switches. Video analysis was done by observers naive to the purpose of study and had high inter-rater correlation ($r=.84$).

Table-1: The 25 - item Side Bias Inventory

Item	Handedness	Footedness	Eyedness	Earedness
1	Unscrew a bottle cap	Pick up a pebble with foot finger	Peep through a key-hole	Listen to tick in wrist-watch
2	Staple a bunch of papers	Shoot a ball on target	Use a camera to click photo	Use an earplug to avoid noise
3	Strike a match	Stamp on floor-mat	Use a telescope	Listen to low-voice in radio
4	Hammer a nail	Hop on one foot	Target a fly with barrel gun	Listen to my heartbeat
5	Screw a nut into bolt	Direct your foot through a maze	Briefly close one eye	Guess the number of sticks in a match box
6	Cut papers with a scissor	Balance yourself on one leg		
7	Use eraser			
8	Peel a cucumber			
9	Needle a thread			

Table-2: Mean (SD) laterality quotient for simple tasks, and average frequency of side-switch for difficult tasks

Groups / Side	Hand	Foot	Eye	Ear
ID: simple task	.85 (.02)	.85 (.03)	.83 (.02)	.83 (.04)
ID: difficult task	3.4	1.8	1.6	1.2
ASD: simple task	.84 (.03)	.79 (.29)	.84 (.01)	.84 (.02)
ASD: difficult task	2.8	1.6	1.5	1.4
Normal: Simple task	.69 (.18)	.60 (.18)	.55 (.16)	.54 (.17)
Normal: difficult task	7.2	5.4	4.8	4.5

Discussion

Findings suggest ID and ASD had higher index of laterality quotient in comparison to normal controls. The proposition that normal controls, in comparison to ID and ASD participants, will have higher index of laterality quotient is rejected therefore. Most studies in developmental disability reported direction of laterality, left, mixed or right (Dawson & Lewy, 1988; Mandal *et al*., 1998; see Pipe 1990) rather than of degree of laterality. The present study operationalized the construct of atypicality as the inability to use both lateral sides in a complimentary manner (dominant side as 'mobilizing' and nondominant side as 'stabilizing'). The tasks were chosen accordingly for the study which observed 'response rigidity' as reflected in very high index of laterality quotient for ID and LSD. Our initial proposition that ID & ASD will have anomalous use of both sides is not confirmed.

It was also hypothesized that there will be a higher incidence of side switch with task difficulty in developmental disability. This hypothesis also did not find any evidence in this direction. None of the earlier studies did utilize 'hand switch' as a function of task difficulty; yet the hypothesis was framed based on the presumption that clumsiness (left or mixed-wardness) may be reflected in the form of higher frequency of side switch during the performance of difficult tasks.

There may be several reasons for this anomaly in findings. First, the present study was conducted on a small sample of participants with developmental disability which may not be enough to document any form of atypicality. However the study was conducted primarily to document the frequency of side-switch in case of task difficulty with the ultimate aim being to examine trainability in motor tasks by these participants. It was presumed that atypicality of side bias will be reflected in terms of higher incidence of side-switch. This was made with the notion that side-switch will increase in the absence of clear lateral bias in developmental disability. Contrary to our expectations, we found that normal controls had a much higher incidence of side-switch for task difficulty as compared to ID or ASD participants.

These findings thus lead us to presume a form of 'response rigidity' in ID or ASD. It is unclear at the moment whether response rigidity is more linked to developmental disability. It is also not known whether response rigidity is tied to certain forms of lateral bias like hand, foot, eye, and ear. These inputs are important from the point of view of motor training in developmental disability. Clinical studies suggest repetitive responses as one of the main symptom for ASD. Possibly side-switching is more reflected in 'response flexibility' and these difficult tasks required a minimum cognitive threshold which participants with ID or ASD could not overcome.

Put together, this is an explorative study with limited number of participants and the study does not make any conclusion about lateral bias in developmental disability. However, within the limits of the present set of data, we simply indicate the possibility of response rigidity for in developmental disability as reflected in higher index of laterality quotient for simple tasks and in lower frequency of side switch for difficult tasks.

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