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VISUAL COMMUNICATION PATHWAYS FOR SENSORY-RESPONSIVE INTERACTION: AUDITORY-ADAPTED FUNCTIONAL COMMUNICATION TRAINING IN AUTISM

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Abstract

The aim of this study is to assess the effectiveness of auditory adapted Functional Communication Training (A-A FCT) on reducing auditory hypersensitivity, self-injurious behaviours (SIBs) and self-stimulatory behaviours (SSBs), and to improve functional communication among children with autism spectrum disorder (ASD). A true experimental repeated measures design with pre-test, mid-test and post-test was employed with 30 children aged 6–12 years who were randomly assigned to either an experimental group that received A-A FCT or a control group that received a treatment as usual. The intervention used PECS "ear" card to support alternative communication when the child is uncomfortable to hear. Linear Mixed-Effects Models were used for the primary analyses, and Pearson correlation analysis was conducted to examine the association between changes in auditory hypersensitivity and maladaptive behaviours. The experimental group showed higher levels of decrease in auditory hypersensitivity, SIBs, and SSBs as compared to the control group throughout the 12 weeks of the intervention (all significant group × time interactions were $p < .001$). Independent PECS communication success rose significantly for both groups in both conditions, from 18.4% at baseline to 82.5% post-intervention, and from 17.9% at baseline to 28.7% post-intervention, respectively. The reduction in auditory hypersensitivity was positively correlated with reduction in maladaptive behaviours ($r = .61$, $p < .001$). The results indicated that auditory-adapted Functional Communication Training is an effective and aversive-free intervention for children with ASD to improve sensory regulation, decrease challenging behaviour, and increase functional communication.

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder, which is marked by impairments in the domain of communication (both expressive and receptive), social interaction and limited, repetitive patterns of behavior, interests or activities (Iwata et al., 1994; Lam and Aman, 2007; Ozonoff and Jensen, 1999). In conjunction with these main characteristics, those who have ASD normally possess other problems,

such as anxiety, depression, sleeping and eating problems, attention problems, aggression, self-stimulation, and self-harm (Carr, 1977; Zoghbi, 2003).

Auditory hypersensitivity is a well-reported sensory difficulty in children with ASD everywhere in the world. In the United States, one study indicates that these visual communication problems can potentially impair classroom engagement (Baranek et al., 2018; Tomchek and Dunn, 2007), and interventions usually involve sensory accommodations in Individualized Education Programs (IEPs) in conjunction with occupational therapists (American Occupational Therapy Association, 2020). Conversely, the educational system in Pakistan has limited resources and has no standard sensory intervention protocols.

This cross-contextual difference brings out the worldwide significance in testing auditory-adapted functional communication training (FCT). Although the current research was done in Pakistan, its results can be potentially applicable to a variety of educational institutions, such as multicultural and under-equipped classrooms in the United States (Schaaf et al., 2014; Tomchek and Dunn, 2007).

In the context of multicultural education, access to and participation in education is inextricably connected with communication. PECS is one of the types of visual communication systems that can be used as alternative linguistic paths that help a learner with a different communicative profile express needs and communicate socially when the demands of a spoken language surpass the expression capabilities of a learner. Visual symbols have the potential to contribute to inclusive engagement and learning in neurodiverse learners by offering the common semiotic expression in a multilingual, multicultural learning environment that helps reduce language barriers and tutor neurodiscrimination against them.

Literature Review

Treatments of a patient with an autism spectrum disorder (ASD) range along the behavioral, pharmacological, and complementary spectrums such as dietary adjustments, vitamins, psychotherapy, occupational therapy, speech and language therapy, psychological treatments, developmental models and family based programs (Coday et al., 2005; Zwaigenbaum et al., 2007; Mabry et al., 2008). Behavioral and developmental interventions are among them and have become dominant since they have proven to be effective in improving social communication, adaptive functioning, and behavioral outcomes of children with ASD (Lauritsen, 2013). The interventions are highly structured and therapist-led discrete trial training on one end and naturalistic and child-centered approaches that involve daily routines on the other end (Bellg et al., 2004; Onken et al., 2014). Although intensive programs of some 40 hours per week are widespread, there is still a debate on the ideal intensity and relative effectiveness of various strategies. The systematic reviews reported that the strength of the conclusion in this area is weak due to methodological limitations, including small sample size and risk of bias (Woolf, 2008; Manning-Courtney et al., 2013).

There is a considerable amount of literature that has been conducted on the causes of challenging behavior in those with intellectual disabilities and ASD. The subject of intellectual impairment severity is closely associated with the presence of self-injury behaviours (SIBs) and self-stimulating behaviours (SSBs) (McClintock et al., 2003; Holden and Gitlesen, 2006). Reduced expressive and receptive communication is always linked to increased incidences of SIBs and SSBs such as self-kicking, self-hitting, self-bouncing, hand flapping, and head banging (Lewin et al., 1939; McClintock et al., 2003; Oliver et al., 2003). It is common that such deficits are associated with the constraints of adaptive behavior skills caused by intellectual disability (Mortimer et al., 1982). There are also gender disparities where men are more prone to participate in SIBs and SSBs compared to women (Dekovic, 1999; McClintock et al., 2003). Moreover, severely or profoundly intellectually impaired individuals tend to have higher chances to exhibit these behaviors than people with mild or moderate ones (Pulkkinen and Pitkanen, 1993; Holden and Gitlesen, 2006; McClintock et al., 2003). People with ASD also have a higher chance to become aggressive, SIBs, SSBs and functioning

disruptively in the family and environments (Eron and Huesmann, 1984; McClintock et al., 2003).

The methods of treating the difficult behaviors are usually behavioral, training, physiologically, pharmaceutical and comprehensive educational programs (Heflin and Simpson, 1998; Kabot et al., 2003). Although there are numerous up-and-comers treatments that promise to work, some of them may not have the empirical backing necessary and hence the importance of testing their safety and effectiveness could be important before use (Rogers, 1998). Comprehensive treatment models have the objectives of managing a wide variety of ASD symptoms such as language, cognitive functioning, and social skills deficits with intensive, multidisciplinary treatment programs that may span years (such as 25 hours or more a week) (Romanczyk and Gillis, 2005; Rogers and Vismara, 2008). Such programs do not just aim at behavioral improvement but also lessening the disability severity in the long run. Operant theory and communication hypothesis make behavioral interventions especially applicable in the treatment of problematic behaviors in intellectually disabled individuals.

Visual communication strategies have become more and more popular in inclusive and multicultural education as a method of assisting multimodal language growth and communicative agency in students with diverse linguistic and cognitive patterns. Cross-linguistic communicative resources may be in the form of visual symbols, body languages, and graphic aids, especially in multilingual settings where there is a difference in the proficiency of speaking a language (Kress, 2010; Jewitt, 2014).

Although the study of the language acquisition of typical children has been wide, there are less studies done in the research on the development of socially appropriate communication as a substitute of SIBs and SSBs in individuals with ASD in the Pakistani setting. Functional Communication Training (FCT) is a potentially promising strategy, as it substitutes the maladaptive behaviours with functionally equivalent, socially acceptable forms of communication. The research is based on the existing evidence by studying the impact of auditory-adapted FCT on children with ASD and SIBs and SSBs caused by sensory hypersensitivity. Although it has been shown in the past studies that FCT can be used effectively to minimise challenging behaviours, little studies have been done to specifically explore whether it can be applied in sensory-related triggers, especially in low-resource environments. The growing awareness of the problem of visual communication in ASD has contributed to the significance of considering culturally and contextually relevant FCT interventions to enhance functional autonomy and quality of life.

Objectives of the Study

Following objectives were designed to address the research problem:

To evaluate the effectiveness of A-A FCT in reducing auditory hypersensitivity among children with autism spectrum disorder.

To determine the extent to which A-A FCT reduces SIBs and SSBs associated with auditory hypersensitivity.

To examine the relationship between reductions in auditory hypersensitivity and corresponding decreases in SIBs and SSBs.

To assess improvements in functional communication, as measured by the PECS "ear" card success rate, following A-A FCT.

Research Questions

Does A-A FCT significantly reduce auditory hypersensitivity in children with ASD compared to treatment-as-usual?

Does A-A FCT significantly reduce self-injurious behaviors and self-stimulating behaviors related to auditory hypersensitivity in children with ASD?

What is the relationship between the reduction in auditory hypersensitivity and the decrease in self-injurious/self-stimulating behaviors?

Does A-A FCT significantly improve PECS "ear" card communication success rates in children with ASD and auditory hypersensitivity?

Hypothesis of the Study

Null Hypothesis (H_{01}): A-A FCT does not significantly reduce auditory hypersensitivity in

children with ASD compared to treatment-as-usual.

Alternative Hypothesis (H_{11}): A-A FCT significantly reduces auditory hypersensitivity in children with ASD compared to treatment-as-usual.

Null Hypothesis (H_{02}): A-A FCT does not significantly reduce SIBs and SSBs associated with auditory hypersensitivity in children with ASD compared to treatment-as-usual.

Alternative Hypothesis (H_{12}): A-A FCT significantly reduces SIBs and SSBs associated with auditory hypersensitivity in children with ASD compared to treatment-as-usual.

Null Hypothesis (H_{03}): There is no statistically significant relationship between the reduction in auditory hypersensitivity and the decrease in SIBs and SSBs in children with ASD.

Alternative Hypothesis (H_{13}): There is a statistically significant relationship between the reduction in auditory hypersensitivity and the decrease in SIBs and SSBs in children with ASD.

Null Hypothesis (H_{04}): A-A FCT does not significantly improve PECS "ear" card communication success rates in children with ASD and auditory hypersensitivity compared to treatment-as-usual.

Alternative Hypothesis (H_{14}): A-A FCT significantly improves PECS "ear" card communication success rates in children with ASD and auditory hypersensitivity compared to treatment-as-usual.

Research Methodology

Research Design

The present study aimed to assess the effectiveness of auditory-adapted Functional Communication Training (A-A FCT) on reducing auditory sensitivity, self-injurious behaviours (SIBs), and self-stimulatory behaviours (SSBs), and the improvement of functional communication of children with autism spectrum disorder (ASD) using a true experimental, parallel-group randomized controlled trial (RCT) with a pre-test, mid-test, post-test design. The participants were randomly assigned to the experimental group (structured A-A FCT) or the control group (TAU). Repeated measures were taken at baseline (Week 0), the middle of the intervention (Week 6), and at the end of the intervention (Week 12), which allowed for examination of behaviour changes over time, and enhanced the internal validity of the study. The randomized controlled design was chosen because it is the most robust design for establishing causal relationships between intervention and outcomes and reduces selection bias and confounding variables.

A priori estimation of the sample size was carried out using G*Power 3.1 software before the recruitment of participants. Based on a medium effect size (f = .25), a significance level of .05, a statistical power of .80, 2 parallel groups, and 3 repeated measurements, it was calculated that a minimum of 28 participants was needed. To offset for possible attrition throughout the intervention, 30 participants were recruited and then randomly assigned equally to the experimental and control groups.

Randomisation was done by a computer-generated random number sequence by an independent researcher. The sequentially numbered opaque, sealed envelopes were used to ensure the allocation concealment and were opened only after the participants were enrolled. For the current study, observer bias was minimized by having behavioural assessors, who were responsible for coding the video recorded sessions, be blinded to the group allocation, while the intervention providers were unblinded due to the nature of the behavioural intervention.

Participants

Participants were children diagnosed with ASD, aged 6–12 years, recruited from special education schools and therapy centres. Inclusion criteria: (i) confirmed ASD diagnosis by a qualified clinician, (ii) documented SIBs and/or SSBs associated with at least one of six identified auditory antecedents (atmospheric sounds, man-made noises, appliance sounds, transition from quiet to loud, door bells, mobile phone bells), (iii) parental consent, and (iv) regular attendance during the study period. Exclusion criteria: severe hearing impairment, uncontrolled medical conditions, or concurrent intensive behavioural interventions initiated within four weeks prior to baseline.

All participants had previously been diagnosed with ASD by a licensed child psychiatrist or clinical psychologist using the criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). Severity of autism was assessed from the existing clinical records obtained at the schools and therapy centres. Parents/legal guardians were told before enrolment about the purpose, procedures, potential benefits, and risks involved in participation in the study and written informed consent was obtained. Children who did not regularly attend intervention sessions or finish all three assessment points were excluded from the final analysis.

Sampling and Randomization

A purposive sampling method was used for initial participant recruitment based on inclusion criteria, followed by simple random allocation into experimental and control groups in a 1:1 ratio using a computer-generated random sequence. Allocation concealment was maintained through sealed opaque envelopes prepared by an independent researcher not involved in recruitment or assessment.

Setting

The intervention was conducted individually in designated therapy rooms located within participating special education schools and therapy centres. All intervention settings were arranged to minimize unnecessary environmental distractions and uncontrolled auditory stimulation. Each therapy room was equipped with standardized PECS materials, visual communication cards, preferred reinforcement items, observational recording sheets, and portable sound devices used to present standardized auditory stimuli. The physical environment remained consistent across sessions to ensure intervention fidelity and reduce environmental variability that could influence behavioural responses.

Intervention (Experimental Group)

The experimental group received a structured, manualized and non-aversive auditory-adapted version of Functional Communication Training (A-A FCT) specifically created for children with autism spectrum disorder who are auditory hypersensitive. Special education trained staff and experienced with behavioural intervention and PECS implementation implemented the intervention on a one-to-one basis. To ensure consistency in the treatment across the participants, all interventionists were given standardized training before beginning the intervention in regard to the treatment protocol.

The intervention was carried out for 12 weeks, 5 times a week. The length of each session was about 35-40 minutes, and the sessions were conducted in a standard manner. Sessions started with a short rapport building exercise that aimed to build engagement and decrease anxiety, followed by the presentation of a controlled one or more individualized auditory antecedent(s) identified during the functional behaviour assessment. If auditory discomfort was noted or expected, the participants were systematically prompted to verbally request their needs by using the PECS "ear" card which was exchanged independently rather than self-injury, self-stimulation or other maladaptive behaviours.

Functional reinforcement of communicative responses consisted of either the aversive auditory stimulus being removed or reduced immediately or the removal of access to a preferred calming activity that was identified during the baseline session. Initially, physical and gestural prompts given when needed to facilitate successful communication. Least-to-most prompting hierarchy was used to fade these prompts as participants became more independent. At the same time, extinction procedures were used to extinguish maladaptive behaviours, such as self-injury and self-stimulatory behaviours, by removing the maintaining consequence from the behaviours while maintaining the safety of the participant at all times. No aversive procedures, physical punishment or response cost was used throughout the intervention consistent with current ethical guidelines for behavioural intervention. Participants achieved mastery of each communication objective when they successfully exchanged the PECS 'ear' card

independently with at least 80% accuracy over three intervention sessions.

Control Group

The participants in the control group were given the educational and therapeutic care they were in the habit of receiving from their school and therapy center. Classroom instruction, speech and language therapy, occupational therapy and behavioural support (when available) were part of these services. None of the structured auditory-adapted Functional Communication Training, PECS "ear" card instruction and systematic behavioural communication programme was implemented during the study period, however. This treatment-as-usual provided the opportunity to compare routine services with the structured intervention, while providing ethical medical care.

Instruments and Measures

To ensure full coverage of intervention effectiveness, a number of complementary measures of behavioural outcomes were used. Prior to intervention, an FBA was completed for each participant using the procedures outlined by O'Neill et al. (2015) to determine the variables that maintain the self-injurious and self-stimulatory behaviors of each participant and the functions those behaviors serve. Information was collected via interviews with caregivers, teacher reports, direct observations of behaviour and Antecedent-Behaviour-Consequence (ABC) recording.

Partial Interval Recording (PIR) was used to record behaviour with fixed observation intervals of 15 seconds for each 20-minute observation session on set standardised sessions. For each participant, the percentage of intervals that contained a SIB or SSB was determined at baseline, Week 6 and Week 12. A researcher developed rating scale was used to assess auditory hypersensitivity with six common auditory antecedent categories such as 'Atmospheric sounds', 'Man made sounds', 'Appliance sounds', 'Transition sounds', 'Doorbells', and 'Mobile telephone rings'. The categories were each scored on a Likert scale of 5, with the higher the score, the greater the tolerance of the auditory stimulation. The reliability of the scale was assessed before application by Cronbach's alpha, and it was found to be satisfactory.

The percentage of successful independent exchanges on the PECS "ear" card (after the presentation of standardized auditory stimuli) was used as a measure of functional communication performance. The attempt to communicate was counted as successful if the exchange was initiated by the participant without being prompted by the person. Using a structured fidelity checklist, at least 20% of randomly selected intervention sessions were reviewed to ensure the structure of all treatment components were implemented consistently.

Data Collection Procedure

Data was measured at three points, namely, at the baseline (pre-test), mid-intervention (week 6), and post-intervention (week 12). Video-recordings of the sessions were made in which self-injury behavioural were coded so that this could be blinded rated by trained observers. PIR and hypersensitivity ratings were acquired with regard to the six auditory antecedents at every time point.

Data Analysis

Data were analyzed using IBM SPSS Statistics (Version 27) and the level of statistical significance was set at $p < .05$. Descriptive statistical information (mean, standard deviation, frequencies and percentages) were used to describe the characteristics of the study participants and to explore baseline comparability between groups. Assumptions of normality and homogeneity of variance were tested before inferential analyses with the Shapiro-Wilk and Levene's tests respectively. Linear Mixed-Effects Models (LMM) were used for the primary analyses, with the group (experimental versus control), time (baseline, Week 6, and Week 12) and group × time interaction as fixed effects, and participant as a random effect accounting for repeated observations within the individual. This modelling approach allows us to assess the changes in behavior over time, while accounting for the correlation between repeated measurements. Estimated marginal means with 95% confidence intervals were reported for all primary outcomes.

Pearson correlation analysis was used to examine the correlation between reduction in auditory hypersensitivity and reduction in self-injurious and self-stimulatory behaviours. To aid in understanding the meaningfulness of intervention effects, effect sizes (Cohen's d, partial eta squared [η^2]) with corresponding 95% confidence intervals were reported.

Ethical Considerations

The appropriate institutional review board gave its approval to carry out this study ethically. Parents or legal guardians were informed of written consent. The research design avoided all unpleasant procedures, ensured the safety of participants was put in the first place and it adhered to international ethical principles on conducting research among children with disabilities.

Results

Table 1 *Baseline Characteristics of Participants by Group*

Variable	Experimental Group (n = 15)	Control Group (n = 15)	Total (N = 30)	*p* value
Age (years), M (SD)	9.1 (1.8)	9.3 (1.7)	9.2 (1.7)	.76
Gender, n (%) Male	11 (73%)	10 (67%)	21 (70%)	.71
ASD severity (moderate–severe), n (%)	13 (87%)	12 (80%)	25 (83%)	.63
PIR % SIBs, M (SD)	48.2 (8.9)	47.6 (9.2)	47.9 (8.9)	.84
PIR % SSBs, M (SD)	42.5 (9.5)	41.8 (10.2)	42.1 (9.8)	.82
Hypersensitivity score (5-point), M (SD)	2.1 (0.5)	2.0 (0.6)	2.0 (0.5)	.65
PECS success rate (%), M (SD)	18.4 (5.2)	17.9 (5.4)	18.1 (5.3)	.77

Note. Table 1 illustrates that the average age of the subject in experimentation was 9.1 years (SD = 1.8) and the control group was 9.3 years (SD = 1.7) as indicated in Table 1. The age difference was very small and p-value of 0.76 shows that there is no statistically significant age difference between the two groups. The proportion of males in the experimental and control groups was 73 and 67 percent respectively. On the whole, 70 percent of the total sample was male (N = 21). The p-value (.71) indicates that there was no significant difference in gender distribution, and so, the sex was evenly distributed among groups. Regarding the severity of autism, 87% (n = 13) of the experimental and 80% (n = 12) of the control sample on ASD were categorized as moderate to severe. This difference was not statistically significant and did not indicate that the severity profiles were different (p-value of.63). The average baseline percentage of SIBs was 48.2% (SD = 8.9) in the experimental and 47.6% (SD = 9.2) in the control group. The total mean was 47.9% (SD = 8.9) and the p-value was.84, which proved that there is no significant difference at baseline. The mean of the experimental group was 42.5% and SD was 9.5 and the mean of the control group was 41.8 and SD was 10.2 with the overall mean being 42.1 and SD is 9.8. The p-value of.82 shows that the difference between baseline SSBs in both groups is not significant. The mean score in experimental and control group was 2.1 (SD =.5) and 2.0 (SD =.6) respectively on a scale of 5 points. The overall mean was 2.0 (SD = 0.5). The p-value of.65 indicates that the baseline levels of hypersensitivity were similar between the two groups. The experimental group had a mean success rate of PECS of 18.4% (SD = 5.2) and the control group had 17.9% (SD = 5.4) success rate. The mean sample of the total was 18.1 (SD = 5.3), and the p-value (.77) showed no statistical significance of the difference in the baseline between the two groups in PECS performance.

Table 2 ***Linear Mixed-Effects Model Results for Primary Outcomes***

Outcome	Time	Experimental M (SE)	Control M (SE)	Mean Difference (95% CI)	p	Hedges' g
SIBs (%)	Baseline	48.2 (2.3)	47.6 (2.4)	—	—	—
	Week 6	31.4 (2.1)	43.9 (2.2)	−12.5 (−16.1, −8.9)	<.001	1.15
	Week 12	18.6 (1.9)	41.2 (2.3)	−22.6 (−26.1, −19.1)	<.001	2.05
SSBs (%)	Baseline	42.5 (2.5)	41.8 (2.6)	—	—	—
	Week 6	27.2 (2.0)	38.5 (2.2)	−11.3 (−14.9, −7.7)	<.001	1.02
	Week 12	15.9 (1.8)	36.7 (2.1)	−20.8 (−24.1, −17.5)	<.001	1.95

Note. Means represent estimated marginal means obtained from the Linear Mixed-Effects Model. Fixed effects included group, time, and the group × time interaction, while participant was specified as a random effect.

Table 3 Mixed-Effects Model Results for Hypersensitivity Ratings (5-Point Scale)

Antecedent Category	Time	Experimental Group M (SE)	Control Group M (SE)	Mean Difference (95% CI)	*p* value	Odds Ratio (95% CI)
Atmospheric sounds	Baseline	2.0 (0.1)	2.0 (0.1)			
	Week 12	4.1 (0.1)	2.3 (0.1)	1.8 (1.5 2.1)	<.001	6.25 (4.1 9.4)
Man-made noises	Baseline	1.9 (0.1)	2.0 (0.1)			
	Week 12	3.9 (0.1)	2.2 (0.1)	1.7 (1.4 2.0)	<.001	5.78 (3.8 8.8)
Appliance sounds	Baseline	2.0 (0.1)	2.1 (0.1)			
	Week 12	4.0 (0.1)	2.4 (0.1)	1.6 (1.3 1.9)	<.001	5.12 (3.4 7.7)
Transition sounds	Baseline	2.1 (0.1)	2.1 (0.1)			
	Week 12	4.2 (0.1)	2.5 (0.1)	1.7 (1.4 2.0)	<.001	5.90 (3.9 9.0)
Door bells	Baseline	1.8 (0.1)	1.9 (0.1)			
	Week 12	3.8 (0.1)	2.3 (0.1)	1.5 (1.2 1.8)	<.001	4.85 (3.1 7.5)
Mobile phone bells	Baseline	1.9 (0.1)	2.0 (0.1)			
	Week 12	3.9 (0.1)	2.4 (0.1)	1.5 (1.2 1.8)	<.001	4.92 (3.2 7.6)

Note. Table 3 indicates that mean scores of hypersensitivity at the baseline of all the antecedent sound categories were almost the same in both the experimental and control groups and no significant differences were found. At week 12, the experimental group had significantly higher tolerance scores in all the categories than the control group indicating a significant improvement after the intervention. In the case of atmospheric sounds, the experimental group

scored 4.1 (SE = 0.1) vs. 2.3 (SE = 0.1) on the control group, where the mean difference was 1.8 (95% CI = 1.5 to 2.1, p <.001) and odds ratio (OR) was 6.25 (95% CI = 4.1 to 9.4). On the same note, the mean of man made noises during week 12 in the experimental group is 3.9 (SE = 0.1) whereas in the control group is 2.2 and (SE = 0.1), a difference of 1.7 (95% CI = 1.4 to 2.0, p < .001) and an OR of 5.78 (95% CI = 3.8 to 8.8). On the appliance sounds category, the control group scored 2.4 (SE = 0.1) at week 12 which was lower than the experimental group which scored 4.0 (SE = 0.1), thus a difference of 1.6 (95% CI = 1.3 to 1.9) which had an OR of 5.12 (95% CI = 3.4 to 7.7). In the case of transition sounds, the experimental group obtained a mean of 4.2 (SE = 0.1) versus controls of 2.5 (SE = 0.1) with a mean difference of 1.7 (95% CI = 1.4 to 2.0) and an OR of 5.90 (95% CI =3.9 to 9.0). The same was observed in the case of door bells, with the experimental group recording 3.8 (SE = 0.1), and the control group recording 2.3 (SE = 0.1) with a mean difference of 1.5 (95% CI = 1.2 to 1.8, p <.001) and an OR of 4.85 (95% CI =3.1 to 7.5). Finally, using mobile phone bells, the experimental group had a mean of 3.9 (SE = 0.1) compared with the control group having 2.4 (SE = 0.1), a difference in means of 1.5 (95% CI = 1.2 to 1.8, p <.001) and an OR of 4.92(95% CI=3.2 to 7.6). All of these findings point to the fact that the intervention led to significant and statistically significant sound tolerance improvements in all categories of antecedents, and odds ratios remained high, which is a sign of a strong effect.

Table 4 ***Linear Mixed-Effects Model Results for PECS Communication Success Rate***

Time	Experimental Group M (SE)	Control Group M (SE)	Mean Difference (95% CI)	*p* value	Hedges' *g*
Baseline	18.4 (1.3)	17.9 (1.4)			
Week 6	58.7 (2.0)	23.1 (1.8)	35.6 (31.4, 39.8)	<.001	2.45
Week 12	82.5 (1.5)	28.7 (1.9)	53.8 (50.2, 57.4)	<.001	3.90

Note. Table 4 At baseline represents the fact that the success rate of PECS communication was comparable between the groups with the experimental group showing an average of 18.4 (SE = 1.3) and the control group 17.9 (SE = 1.4) which proved to be not significant before the intervention. By week 6, the mean success rate of experimental group had increased by a significant margin to 58.7% (SE = 2.0) as compared to just 23.1% (SE = 1.8) in control group. The average difference was 35.6 percentage points (95% CI = 31.4 to 39.8, p <.001) which had a very large effect size (Hedges' g = 2.45) and represented a significant improvement in communication skills in the short-term in the experimental group. Gains continued to increase over the next 12 weeks with the experimental group recording an average success rate of 82.5 percent (SE = 1.5) as compared to the control group with 28.7 percent (SE = 1.9). The mean difference was 53.8 percentage points (95% CI = 50.2 to 57.4, p =.001), with an enormously large effect size (Hedges g = 3.90). These results show that PECS communication performance improved rapidly and remained improved throughout the duration of the intervention with statistically significant, as well as, practically large effects.

Table 5 ***Intervention Fidelity and Adherence***

Metric	Experimental Group M (SD)	Control Group M (SD)
% Sessions completed	94.7 (5.1)	91.2 (6.3)
Average session length (minutes)	36.5 (2.1)	35.8 (2.3)
Protocol adherence (%)	96.3 (3.2)	N/A
Inter-rater reliability (ICC)	.91	.89

Note. In Table 5, the measures of intervention fidelity and intervention adherence revealed that the two groups were very active in the study. The number of sessions attended by the experimental group according to a schedule was 94.7% (SD = 5.1), which is a little bit more than the controls with 91.2% (SD = 6.3), which indicates high overall engagement. The duration of the average sessions was similar in the experimental group and the control group, whereby the experimental group had an average duration of 36.5 minutes (SD = 2.1) and the control group had a duration of 35.8 minutes (SD = 2.3), which means that there is uniformity in the time to implement. The protocol adherence in the experimental group was very high being 96.3% (SD =3.2) which represented strict following of protocol intervention procedures; but protocol adherence could not apply to the control group. The inter-rater reliability of both groups was also outstanding with an intraclass correlation coefficient (ICC) of 0.91 in the experimental group and 0.89 in the control group as a testimony of consistency and accuracy in the observational coding and result measurement. On the whole, these findings confirm that the intervention was fidelity-based, the level of participant compliance was excellent, and data collection was reliable.

Table 6 ***Adverse Events and Withdrawals***

Event	Experimental Group n (%)	Control Group n (%)	Related to Intervention?
Behavioural escalation	1 (6.7%)	2 (13.3%)	No
Physical injury	0 (0%)	0 (0%)	
Participant withdrawal	1 (6.7%)	1 (6.7%)	No

Note. As it is presented in Table 6, the adverse event monitoring indicated that both groups tolerated the intervention with few negative outcomes being reported. There was one participant (6.7) in the experimental group who had a behavioural escalation episode and two participants (13.3) in the control group; none of these were considered related to the intervention. There were no physical injuries that were experienced by both groups within the study period. There was a low rate of participant withdrawals, and the same number of withdrawals occurred in both groups (6.7%), neither of which was related to intervention. These results indicated that the intervention was not particularly dangerous in terms of safety and that the dropout rates were low and not related to the treatment.

Table 7 ***Summary of Primary Hypothesis Testing***

Hypothesis	Outcome Variable	Statistical Analysis	Main Finding	Decision
H1	Auditory hypersensitivity	Linear Mixed-Effects Model	A significant Group × Time interaction ($p < .001$) indicated that participants receiving auditory-adapted Functional Communication Training demonstrated significantly greater reductions in auditory hypersensitivity than those receiving treatment-as-usual.	Reject H_{01}
H2	Self-injurious behaviours (SIBs) and self-stimulatory	Linear Mixed-Effects Model	Significant Group × Time interactions ($p < .001$) demonstrated that participants in the experimental group exhibited significantly greater reductions in self-injurious and self-stimulatory behaviours	Reject H_{02}

	behaviours (SSBs)		across the intervention period than those in the control group.	
H3	Association between reductions in auditory hypersensitivity and reductions in SIBs/SSBs	Pearson Correlation	A statistically significant positive correlation was observed between reductions in auditory hypersensitivity and reductions in maladaptive behaviours (r = .61, p < .001), indicating that behavioural improvement was associated with improved auditory tolerance.	Reject H_{03}
H4	Functional communication (PECS "ear" card communication success)	Linear Mixed-Effects Model	A significant Group × Time interaction (p < .001) indicated that participants receiving auditory-adapted Functional Communication Training achieved significantly greater improvements in independent PECS "ear" card communication than those receiving treatment-as-usual.	

Note. Intervention hypotheses were evaluated using Linear Mixed-Effects Models with group, time, and group × time interaction specified as fixed effects and participant as a random effect. Pearson correlation analysis was conducted to examine the association between reductions in auditory hypersensitivity and behavioural improvement.

Findings of the Study

The results of the analyses of the Linear Mixed-Effects Model showed that all primary outcome variables showed significant group × time interaction effects, with children who received auditory-adapted Functional Communication Training (A-A FCT) showing significant improvement over the 12 weeks of intervention compared to children who received treatment-as-usual. Prior to treatment, both groups were similar in their levels of auditory hypersensitivity, self-injurious behaviors (SIBs), self-stimulatory behaviors (SSBs) and functional communication. The experimental group showed progressive improvement in Week 6 and by Week 12, this had significantly outpaced the improvement seen in the control group.

The main outcome measures showed a significant Group × Time interaction in analyses of the Linear Mixed-Effects Model, such that children receiving auditory-adapted Functional Communication Training showed significant improvements over time compared to children receiving treatment-as-usual. Specifically, auditory hypersensitivity, self-injurious behaviours, self-stimulatory behaviours, and PECS "ear" card communication success (all p < .001) showed a significant Group × Time interaction effect. The results show that the intervention was more effective over the 12 weeks than treatment as usual.

The experimental group had significantly fewer reductions in the number of self-injurious and self-stimulatory behaviours than the control group (group × time interaction effects, p < .001). Likewise, scores for auditory hypersensitivity significantly increased over time for children who were treated, suggesting a decrease in sensitivity to individualized auditory stimuli post-treatment with systematic Functional Communication Training.

In addition, there was a significant improvement in functional communication outcomes for participants in the experimental group. A-A FCT was associated with increases in functioning at each assessment point, with children making increasingly higher numbers of independent exchange of the PECS "ear" card, reflecting the successful replacement of maladaptive behavioural responses with socially appropriate

communicative behaviours. The improvements were both clinically and educationally significant, with large practical effects, and were statistically significant.

Additionally, reductions in auditory hypersensitivity were found to be statistically significantly correlated with reductions of self-injurious and self-stimulatory behaviours ($r = .61$, $p < .001$), indicating that meaningful behavioural change was found to be correlated with reduction of auditory hypersensitivity.

Discussion

The results of the current study are also consistent with the findings of previous studies that have established the effectiveness of FCT in the elimination of maladaptive behaviours, as well as the improvement of communication skills in children with ASD. In keeping with the FCT as a successful way to replace problem behaviour by means of teaching communicative responses that are functionally equivalent, as the pioneering study by Carr and Durand (1985) initially held FCT to be an effective approach, both SIBs and SSBs showed significant negative changes due to the structured intervention. Tiger, Hanley, and Bruzek (2008) and Mancil (2006) also reported similar positive results, noting the flexibility of FCT in different contexts and behavioural functions and its efficiency in children with different sensory sensitivities, respectively. Moreover, this significant enhancement of PECS-based communication is also reflective of the results of Flippin, Reszka, and Watson (2010), who stressed PECS as the means of efficient communication in children with ASD of a non-verbal and minimally verbal nature.

The positive results found in the present study are also in line with the current evidence with children diagnosed with autism spectrum disorder (ASD) (Baranek et al., 2018; Schaaf et al., 2014; Tomchek & Dunn, 2007). Based on the current results, auditory-adapted Functional Communication Training could be a promising intervention for decreasing auditory hypersensitivity while also improving functional communication. The study took place in Pakistan but the intervention framework may have applicability in other countries with inclusive educational settings with considerations made for cultural, linguistic, and educational adaptations before implementing. The present results add to the international emerging data on the efficacy of individualized, nonaversive behavioural interventions for children with ASD.

Nevertheless, the current research provides a novel contribution to the literature by the specific application of FCT to auditory hypersensibility triggers, which is not a common area of study covered by prior studies. Although the previous research has mostly dealt with either the tactile or social stimulus, our findings broaden the applicability of FCT to auditory stimulus. This observation is partly in contrast to Lequia et al. (2012) that showed a variable responsiveness to FCT in relation to the sensory modality used indicating that the effects of interventions can vary depending on the nature and extent of sensory stimulation. In that sense, the high effect sizes in the current study show that auditory-related maladaptive behaviours can be quite responsive to the structured and functionally-grounded communication training but only when the intervention is well-individualised and not aversive.

While this study was carried out in Pakistani context of educational environment, the implications of the findings may be extrapolated to the global context of inclusive education. The intervention highlights the use of individualized visual communication supports in combination with evidence-based behavioral supports to address auditory hypersensitivity in children with autism spectrum disorder. The effectiveness of this intervention needs to be explored in a variety of educational systems, cultural contexts and resource settings prior to broad international implementation.

Conclusions

This randomized controlled trial demonstrates that a structured, nonaversive auditory-adapted Functional Communication Training programme using the PECS 'ear' card is an effective intervention for reducing auditory hypersensitivity, self-injurious behaviours and self-

stimulatory behaviours and increasing functional communication for children with autism spectrum disorder.

The effect sizes noted in the behavioural reduction, as well as, the effect size in communication gains are substantial and thus indicate the practical importance of the results. Additionally to statistical validation, the results highlight the future of FCT as a valid practitioner, educator, and family-focused method of helping children with ASD who show signs of sensory hypersensitivity.

Considering these results, the research contributes to the existing literature by showing that FCT could be successfully modified to be used with auditory sensitivity triggers without using aversive stimulations. It has a direct impact on the intervention planning, the need to promote the development of self-advocacy skills in children with ASD, and the need to reconcile the therapeutic practice with the principles of inclusive, human rights, and person-centred care. The results also indicate the more general educational significance of visual communication supports as inclusive aids that encourage communicative agency and agency among neurodiverse learners in culturally and linguistically diverse learning settings.

Further studies are needed to examine the long term persistence of behavioural and communication improvements, whether the skills can be generalised to naturalistic contexts and whether the strategy can be generalised to other senses. However, the current study presents a strong argument of the need to incorporate FCT in holistic intervention programmes among ASD and auditory hypersensitive children.

Recommendations

1. Structured FCTs as modified to sensory triggers should be implemented in the regular intervention plan in educational institutions and therapy centres that deal with children with ASD and auditory hypersensitivity. This kind of integration can be used to minimise maladaptive behaviours and encourage socially appropriate communication.
2. Special educators, speech-language pathologists and behavioural therapists will need to be trained with the inclusion of professional development programmes to teach them on PECS "ear" card techniques and other non-aversive FCT strategies. The emphasis of the training should be placed on cultural flexibility, ethical aspects, and principles of reinforcement.
3. The caregivers and parents are supposed to be trained on how to use simplified forms of the FCT at home so that they can be able to generalise and sustain the skills acquired during therapy when they are not in the therapy setting. This will help create a continuity and support the communication strategies in the natural context.
4. The implementation of evidence-based, non-aversive interventions including FCT should be encouraged by the policymakers through funding of training, resources, and research. This can guarantee fair access to effective behavioural interventions among children with ASD even those in inadequately resourced communities.

Limitations and Future Directions

1. Even though the current research indicates a solid evidence that supports the effectiveness of A-A FCT in the prevention of maladaptive behaviors and the enhancement of functional communication in children with ASD, there are a number of limitations that should be mentioned. To start with, the sample (n = 30) was small and, although it was adequate to identify the presence of large effects, it might not be applicable to the general ASD population. These results should be replicated in other studies using larger and more diverse cohorts to validate them in various cultural, linguistic, and socioeconomic settings.
2. Second, the duration of intervention was not long, and the long-term sustainability of the behavioral and communication improvements was not considered. Longitudinal follow-ups would assist in concluding whether the improvements would last and be generalized to untrained conditions and new auditory stimuli.
3. Third, while random assignments minimized preexisting differences between groups, other factors that were not measured like parent

involvement, concurrent therapeutic services, individual sensory processing profiles, and home-based intervention practices could have influenced participant outcomes. These contextual variables could be better understood in the future with larger multi-site samples and more sophisticated multilevel modelling approaches.

4. Finally, in the current research, auditory hypersensitivity was studied in isolation. Although this sensory modality is very pertinent in most children with ASD, the ability of FCT to other sensory inducers (e.g., tactile, visual, olfactory) is also worth studying. The protocol can be expanded in the future to cover multi-sensory sensitivities to make it more applicable and effective.

5. To overcome these limitations, future studies should focus on large, multi-site studies, cross-cultural samples, and technology-aided delivery (e.g., telehealth coaching) to achieve greater access to the target population of self-injury behaviorists. This will help reinforce the evidence base of FCT as a holistic, sensory responsive intervention to people with ASD.

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