

Intermodal Sensory Transfer in Children with Autism Spectrum Disorder (ASD)

التحويل الحسي البيني لدى الأطفال المصابين باضطرابات طيف التوحد (ASD)

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Abstract

This research investigates the feasibility of intermodal transfer between touch and vision modalities in children with Autism Spectrum Disorder (ASD), and analyzes the impact of the severity of the disorder as well as the level of communication on this process. Conducted in an autism center, our quasi-experimental method relies on a sample of 20 children with ASD, using specific assessments to measure intermodal transfer capabilities and to examine communication variables. The findings indicate that the severity of the autistic disorder does not significantly alter the performances in Touch-Vision (T-V) and Vision-Touch (V-T) transfer tasks. However, receptive and expressive communication skills demonstrate a notable influence, but only in the TV task, suggesting that communication aspects play a crucial role in intermodal transfer among children with ASD.

Keywords: Intensity of ASD; Cross-modal transfer; Autistic children; Communication; Sensoriality.

ملخص:

تهدف الدراسة إلى الكشف عن دور التحليل الحسي البيني (اللمس-رؤية) والرؤية باللمس لدى الأطفال المصابين باضطراب طيف التوحد (ASD)، كذلك إلى دراسة تأثير شدة الاضطراب ومستوى التواصل على هذه العملية. من خلال المنهج شبه التجريبي، وباعتماد على عينة مكونة من 20 طفلاً مصاباً باضطراب طيف التوحد داخل مركز التوحد، وباستخدام اختبارات تقييمية محددة لقياس قدرات النقل متعدد الوسائط وفحص متغيرات التواصل. تشير النتائج إلى أن شدة اضطراب التوحد لا تعدل بشكل كبير الأداء في مهام نقل اللمس إلى الرؤية والرؤية إلى اللمس. ومع ذلك، تظهر مهارات التواصل الاستقبالية والتعبيرية تأثيراً ملحوظاً، ولكن فقط في المهمة التلفزيونية، مما يشير إلى أن جوانب التواصل تلعب دوراً مهماً في النقل عبر الوسائط لدى الأطفال المصابين باضطراب طيف التوحد.

كلمات مفتاحية: كثافة التوحد؛ التحويل الحسي؛ أطفال التوحد؛ تواصل؛ حسية.

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1. Introduction

Sensation is our primary interface with the world, involving the extraction of information from the environment through specialized sensors located in the sensory organs. The development of these systems starts early. Even in utero, foetuses are attributed with sensory abilities, allowing them to experience tactile functions by sucking their thumb or playing with their feet, as well as olfactory and gustatory functions through the amniotic fluid. Hence, sensory modalities are functional from an early stage.

Intermodal sensory transfer refers to delete the use of information gathered by one modality being utilized by another: an object felt in the dark can be recognized once the light returns.

Autism is an early neurodevelopmental disorder that appears before the age of 3 years and is characterized by alterations in two developmental domains: social interactions and communication, along with behavioral anomalies.

Children with autism often exhibit unique sensory characteristics that develop early on. These distinct traits are manifested as hypo/hypersensitivity, either uni- or multimodal, with variable perceptual thresholds (low or high) (Celine Laranjeira, Julien PERRIN, 2013). These sensory peculiarities prompted us to investigate intermodal sensory transfer in autistic children (touch-vision/vision-touch).

In our research, we focused on studying the sensory profile by assessing the levels of verbal and non-verbal communication, while also taking into consideration the intensity of Autism Spectrum Disorder (ASD) symptoms. Specifically, we examined how these factors influence intermodal sensory transfer performances in children with autism. The study seeks to determine whether children with ASD can successfully achieve intermodal sensory transfer between touch and vision, as well as from vision to touch.

Research Questions:

From the issue of our research, we have formulated the following two questions:

1. Is there a relationship between the intensity of autism and the performances of intermodal sensory transfer TV/VT?
2. Is there a relation between communication (receptive/expressive) and the performances of children with ASD in intermodal transfer TV/VT?

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- General Research Hypothesis:

Children with Autism Spectrum Disorder (ASD) can achieve intermodal sensory transfer between touch-vision and vision-touch.

- Operational Hypotheses:

1. There is a relationship between the intensity of autism and the performances of intermodal sensory transfer TV/VT.

2. There is a link between communication (receptive/expressive) and the performances of children with ASD in intermodal transfer TV/VT.

2. Autism Spectrum Disorder (ASD)

Autism is a developmental disorder that appears during the first two years of life. It is characterized by difficulties in establishing social interactions and relationships, in communicating through gestures and speech, and by stereotyped behaviors and restricted, ritualistic activities. (M.-P. GATTENGNO, L.REYNAUD, A.STRERI, C.BARTHELEMY, J.-L. ADRIEN, 2005).

2.1. Autism and Development

2.1.1. Autism, Verbal and Non-verbal Communication Disorders

Children with ASD experience difficulties in verbal and non-verbal communication, ranging from the absence of speech to the use of incomplete sentences that may seem odd. Autistic children display anomalies in verbal or non-verbal communication, whether in comprehension or expression. If they use oral language, semantic peculiarities, syntax, and echolalia are observed.

2.1.2. Autism and the Severity of the Disorder

Pry et al., 2005) conducted an assessment of the cognitive and adaptive functioning of children with autistic syndrome. Changes in contiguity involved 40 children, of which 10 regressed and 30 progressed, sometimes showing dramatic improvements. These results raise the question of a possible "transitory intellectual disability" in some children with autism.

In 2013, the DSM-5 (American Psychiatric Association, 2013) introduced a dimensional approach that takes into account the degree of severity of autistic disorders. The nosographic subgroups (Asperger, PDD-NOS, etc.) are replaced by the single group of ASD, introducing the notion of a continuum. This has sharpened the focus of many psychiatrists, some of whom are very critical, while for others, it legitimizes the notion of a "severity continuum" where each symptom can be rated on a severity scale (Frigaux et al., 2021).

2.2. Intermodal Sensory Transfer

Intermodal transfer is a complex process that requires several cognitive abilities such as: the processing of information by one modality, its memorization, and its recognition in another modality. This transfer of information from one modality to another requires the existence of bi- or multimodal neurons that respond, for example, to tactile and/or visual stimuli, as well as tactile/visual/auditory stimuli. (Emanuelle Lacaze, 2008).

2.2.1. Development of Intermodal Transfer in Typically Developing Children

The development of intermodal transfer between T-V is an adaptive necessity of the organism. Research on infant perception has shown that, from birth, babies are capable of discriminating different stimuli within the same modality (Emanuelle Lacaze, 2008). Tactile discrimination is important in several aspects of a child's development. It allows for thorough exploration of objects and the environment, as tactile cues broaden their understanding of their surroundings. It also contributes to enriching their body awareness and, thereby, influencing their motor planning skills. It has been shown that T-V transfer is possible from birth (Streri, A., Lhote, M., & Dutilleul, S., 2000) and (Streri, A., & Gentaz, E., 2003) (Streri, A., & Gentaz, E, 2004) but under certain conditions and that it is very fragile. Then it evolves with age and subsequently requires cognitive capacities that go beyond haptic and visual modalities (Rose, S. A., Feldman, J. F., Futterweit, L. R., & Jankowski, J. J., 1998).

A. Babies

(Streri, A., Lhote, M., & Dutilleul, S., 2000) showed, in an intermodal task, that newborns were capable of detecting differences in the contour of two small objects (a cylinder and a prism), from both the right and left hand, in a habituation and novelty reaction procedure. Subsequently, (Streri, A., & Gentaz, E., 2003) (Streri, A., & Gentaz, E, 2004) and more recently by (Sann, C., & Streri, A., 2007) observed that newborns can visually recognize the shape of an object they previously touched with their right hand (intermodal transfer through a habituation procedure). This transfer from the haptic modality to the visual modality has also been observed in 2-month-old babies (Streri, A., 1987) and 12-month-olds (Rose, S. A., & Orlian, E. K., 1991). However, V-T transfer in these studies is not observed at birth nor at 2 months, and it remains difficult at 12 months. Indeed, for a transfer to be established, the percepts (levels of representations) of the observed and manipulated objects must be analogous so that either system can effectively use it. However, the tactile and visual systems do not develop at the same pace during development. While somesthetic sensitivity is the most primitive ontogenetically and from the fetal stage, vision, on the other hand, functions later and only fully realizes its function at birth. (Streri, A., & Molina, M.,

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1993). (Streri, A., 1991) summarized research on intermodal transfer tasks between touch (oral or manual) and visual. This review reveals that the success of sensory integration depends on:

- properties of objects (shape, texture, substance...)/ type of task (perceptual conflict situation or intermodal transfer)/ duration of familiarization/ mode of familiarization (visual, oral or manual)/ age.

B. The Child

Manual exploration and tactile discrimination are thus possible in young infants. From the second semester of life until 3-4 years, studying tactile intermodal functioning becomes difficult because children hardly tolerate a screen preventing them from seeing what they are manipulating. (Bigelow, 1981) showed that 2.5-year-old children can name 5 to 7 familiar objects they held without being able to see them. The capabilities for intermodal transfer T-V and V-T increase with age in children (Stilwell, J.M., & Cermak, S.A., 1995). By 5 years old, intermodal recognition is almost perfect for familiar objects but less accurate for unfamiliar objects or abstract shapes (Bushnell, E.W., Baxt, C., 1999). All developmental studies of tactile exploration show that the younger the children, the more random and limited their exploration, in line with the poverty of their representational schemes. It was long believed that intermodal transfer capabilities improved with age due to the effect of bimodal experience and language development (Birch, H. G., & Lefford, A., 1963) (Hatwell, Y, 1994). Experimental works have indeed shown that the percentage of correct responses in intermodal T-V and V-T pairings increases with age.

2.2.2. Development of Intermodal Transfer in Children with Autism Spectrum Disorder

In individuals with ASD, sensory peculiarities are frequently and early noted by their surroundings in terms of particular or unusual behavioral manifestations; and when they have the opportunity, people with autism can also reveal the impact of these peculiarities in their daily lives and help us better understand the distress or fascination they evoke in them. These unique characteristics are manifested by hypo or hypersensitivities, uni- or multimodal, in the absence of any sensory organ damage, moreover, the cognitive processing of sensory information appears particular and hinders intermodal transfers (Visio-manual coordinations) that usually allow a better adjustment (precision or speed) to environmental changes. (Celine Laranjeira, Julien PERRIN, 2013).

3. Method and tools

To address the research problem and questions of this study, we employed an experimental method. This scientific approach aims to manipulate one or several dependent and independent variables, controlling and measuring any changes in other variables. Additionally, purposes sampling was used in the present research to ensure the inclusion of participants with specific clinical and contextual characteristics.

3.1. Sample and Research Location

Twenty children with Autism Spectrum Disorder (ASD) aged 4 to 13 years (average age: 100.9 months; Min: 47 months; Max: 163 months) with a developmental age ranging between 13 months and 5 years participated in the study. A group of 6 children was enrolled in a Specialized Integration Class for children with ASD (CLIS) under an adapted program, and the remaining 14 children were cared for in a psycho-educational center for children with ASD (Autism Association Tlemcen AAT). All 20 children were diagnosed under the criteria of ICD-10 and DSM-4.

Table (1): Sample Characteristics

Sex / Age in months	Boys	Girls	Age in months (minimum)	Age in months (maximum)
Children with ASD	14	6	47	163

Source: by the researchers

Table (2): Clinical Characteristics of Children with ASD

Characteristics	Average	Standard deviation
Intensity of ASD	31.05	5.98
Expressive communication	20.60	10.49
Receptive communication	32.10	13.67

Source: by the researchers

The tables above show that most children with ASD are boys. This indicates that our sample represents the general population, since ASD is more common in boys than in girls.

In the sample of children with autism, we have three groups of varying intensity: mild, moderate, and severe. It is noted that almost half of the children with ASD have mild ASD (45%), and a minority have severe ASD (15%).

It is observed that the percentages of children with ASD with low levels of receptive communication and with a medium level are almost equal (55% - 45%).

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It is noted that more than half of the children with ASD (60%) have a low level of expressive communication, and the rest of the children have a medium level (40%).

3.2. Research Tools

To conduct our research, we used the following tools;

CARS-T: The Childhood Autistic Rating Scale (CARS) is a scale developed by Eric Schopler and his colleagues in the 1980s to assess autism spectrum disorders. (Bernadette Rogé, 2008)

The psychometric properties of the childhood Autism assessment scale in the Algerian environment was investigated by the researchers) Ehouari,C &Belmihoub,K(2020) ‘. The results analysis was accepted ; the test retest reliability (ICC= 0.79) and the evidence based on construct validity(factor analysis) shows the presence of a single factor that explains 15 developmental domains for measuring autism accounting for 69% of the variance.

Vineland: Verbal and non-verbal communication was assessed using the Vineland Adaptive Behavior Scale or VABS (Sparrow, S. S., Balla, D. A., & Cicchetti, D. V., 1984). This scale evaluates the adaptation level of children in functional domains of communication, socialization, and motor skills in daily life. It also allows for the calculation of a composite total score, modifying character.

An adaptation for the Algerian population was carried out by the doctoral (Dib,Z, 2017) which shows that the scale had good psychometric properties based on internal consistency to measure validity (*Cronbach α = 0.71*) and the split half method to measure reliability of the tool (Guttman = 0.65)

3.2.1. Procedure:

Children were tested individually in a room, sitting in front of a setup similar to that of (Rose, 1977), which I personally constructed. It includes a cardboard placed on a table between the child and the experimenter. The back of the cardboard was open to allow the experimenter to present objects to the child and observe their finger movements. To manipulate the stimulus (the object), the child introduces their hands through two circular openings cut out on the front of the cardboard to manipulate and explore the objects tactilely without seeing them.

- Tactile Stimuli: The tactile objects consist of dinette games that the children with ASD were already familiar with, and 3 image cards, one of which contains the photo of the target object.

- Visual Stimuli: Three visual stimuli were used, along with an image card of the target object.

3.2.2. Experimental Procedure:

The procedure consists of two intermodal transfer tasks (touch-vision) / (vision-touch). Between the first and second experiments, the child was allowed to rest for about 10 minutes. Each of the tasks is described below.

- The intermodal transfer task (touch-vision): The experimenter introduces the child to the procedure and shows how to explore objects with his manual guidance. The experimenter invites the participant to replicate the same action. In the T-V procedure, the child introduces their hands into the cut-out circles, and the experimenter gives them the objects. The child manipulates and explores the objects with their hands; then, the experimenter removes the cardboard and places three image cards on the table. He asks the child to give him the object they had manipulated in the cardboard.

- The intermodal transfer task (vision-touch): For the second procedure, the experimenter shows the child the target image for a few seconds and then places the cardboard and introduces the child's hands into the cardboard; after that, he places the objects among which one object was visualized earlier by the child in the image card. The experimenter asks the child to give him the object shown in the card.

Figure (1): Tools for the Touch-Vision (T-V) task



Source: Photo taken by the researchers

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Figure (2): Tools for the Vision - Touch (V-T) task



Source: Photo taken by the researchers

4. Results

All statistical analyses were performed using SPSS version 21. We conducted a chi-square analysis to examine the relationship between clinical characteristics (communication, intensity) and performance levels. The results are presented in the following tables:

Table (3): Intensity and Intermodal Transfer

	chi-square	Ddl	P
Intensity and T-V	1.70	2	0.42
Intensity and V-T	0.64	2	0.72

Source: by the researchers

Result of the first hypothesis: The degree of intensity of autistic disorder impacts the performances of sensory intermodal transfer (T-V & V-T).

The results showed no significant relationship between the degree of intensity of the disorder and the performances of sensory intermodal transfer between touch and vision with a value of ($P=0.42$), which confirms that it is greater than $P=0.05$, and for the vision-touch performance ($P=0.72 > 0.05$).

Table (4): Expressive Communication and Intermodal Transfer

	chi-square	Ddl	P
Expre Comm and T-V	4.44	1	0.03
Expre Comm and V-T	3.33	1	0.06

Source: by the researchers

Result of the second hypothesis: Receptive and expressive communication plays a very important role in the performances of sensory intermodal transfer (TV & V-T)

The result of expressive communication in the touch-vision performance, with a value of ($P=0.03 < 0.05$), was significant, indicating that communication plays an important role in the success of performances. For the vision-touch performance, it was slightly significant with a value of ($P=0.06$), which explains the nature of their disorder, the presence of communication disorder in children with ASD.

Table (5): Receptive Communication and Intermodal Transfer

	chi-square	Ddl	P
Recep Comm and T-V	5.45	1	0.02
Recep Comm and V-T	4.09	1	0.04

Source: by the researchers

Result of the third hypothesis: Receptive or expressive communication plays a very important role in the performances of sensory intermodal transfer (TV & V-T)

The result of receptive communication in the touch-vision performance ($P=0.02 < 0.05$) and vision-touch ($P=0.04$) was also significant with a value of ($P \leq 0.05$), indicating that the level of receptive communication plays a very important role in the success of sensory intermodal transfer tasks.

5. Discussion

In this section, we will discuss the main results of our study.

It was noted that most children with ASD succeeded in the touch-vision intermodal transfer task despite their disorder's intensity level (in our sample, 9 children with mild ASD, 7 succeeded and 2 failed the task; 8 children with moderate ASD, 5 succeeded and 3 failed; significantly, all children with severe ASD succeeded in the task).

The analysis showed that most children succeeded in the vision-touch intermodal transfer task regardless of the intensity degree of the autistic spectrum disorder (7 successes and 2 failures in mild ASD; 7 successes and 1 failure in moderate ASD; 2 successes and 1 failure in severe ASD).

This is particularly noteworthy giving prior research indicating that individuals with ASD often experience sensory integration difficulties (Laranjiera et perrin,2013).

To lend more credibility to our statistical analysis results, we divided the autistic children in our sample into two groups by communication level (low level / medium level) for easier interpretation of results.

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The analysis indicated that all children with ASD with a medium level of communication succeeded in the T-V intermodal transfer. Regarding children with a low level of communication, the number of children who failed (5) was almost equal to those who succeeded (6).

The analysis revealed that all children with a medium level of communication succeeded in the task, and most children with a low level of communication succeeded in the task (7 successes and 4 failures).

The analysis showed that the majority of children with ASD with a low level of communication succeeded in the touch-vision intermodal transfer task, whereas those with a medium level of communication delete all succeeded.

The above diagram shows that most children with ASD succeed in the task regardless of their communication levels (Low level: 8 successes and 4 failures; medium level: 8 successes and 0 failures).

The success of children with low levels of communication suggests that intermodal transfer is not strictly dependant on advanced language or communication skills. This aligns partially with studies showing that early tactile-visual transfer is possible in infants (Strei and gentaz,2003,2004), although fragile and influenced by object complexity, familiarity and age.

Interestingly, all children with a medium communication level succeeded in both tasks, supporting the hypothesis that some level of communication development may facilitate sensory integration. These findings highlights the role of language in enhancing multimodal processing as suggested by birch and Lefford (1963) and hatwell(1994).

Moreover, the full success of children with severe ASD in the T-V task could indicate the presence of adaptive or compensatory sensory mechanisms in structured environments. This finding emphasizes the plasticity of sensory processing in children with ASD and challenges the assumption that intermodal transfer is systematically impaired in this population.

6. Conclusion

In our study, we were interested in examining intermodal sensory transfer in children with autism between the touch and vision modalities. Our findings suggest that the well documented challenges in multisensory integration commonly observed in children with Autism Spectrum Disorder (ASD), many of these children have the ability of retaining or even developing effective intermodal transfer abilities particularly when provided with structured, supportive and sensory-adaptive environments. The observed success in both touch to vision and vision to touch tasks across varying level of communication and ASD severity underscores the presence of underlying cognitive and perceptual abilities that may not always apparent in everyday

settings. These results reinforce the notion that sensory and cognitive functioning in autism is not uniformly deficient, but rather heterogeneous and influenced by contextual and environmental factors. This emphasizes the need to move away from generalized assumptions of dysfunction and toward more nuanced and individualized understanding of each child's unique sensory profile.

Importantly our study highlights the critical value of tailored of educational and therapeutic interventions that account for sensory sensitivities and strengths by incorporating multisensory learning opportunities and respecting each child's mode of processing information. Educators and clinicians can better support cognitive development and adaptive behavior in children with ASD.

Furthermore, these findings open new perspectives for future research on neuroplasticity and compensatory mechanisms in ASD suggesting that intermodal integration skills can be nurtured, rather than presumed absent.

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