

## Research Article

# Emotional Lexicon in Autism Spectrum Disorders: Impact of Emotion Recognition Training with a Serious Game

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**Introduction:** Autism Spectrum Disorders (ASD) are characterized by emotion processing difficulties in several dimensions (emotion recognition, empathy and emotional lexicon). Emotional training programs might have a positive effect on the emotional lexicon which has been described in children with Asperger Syndrome.

JeStiMule is a serious game designed to teach emotional skills (emotion recognition and emotional lexicon) specifically for children and adolescents with ASD. The aim of the present study was to evaluate the impact of this serious game on the emotional lexicon of a heterogeneous ASD group. We expected that JeStiMule enriched and diversified the emotional lexicon of children and adolescents with heterogeneous profiles of ASD (wide age range, heterogeneous intellectual, verbal, functioning and academic level).

**Methods:** Twenty nine children and adolescents with ASD played JeStiMule on a computer, twice a week for four weeks. Participants were evaluated by means of 3 fluency tasks (emotions, animals, fruits) before and after training. Quantitative (repeated measures ANOVA, post-hoc LSD) and descriptive analyses were conducted on the number of emotional words pronounced by the participants.

**Results:** Quantitative analyses showed a significant improvement after training for emotional words ( $p < 0.05$ ). Descriptive analyses of after-training emotional words revealed 3 categories: 1) emotional words given before the training, 2) words presented during JeStiMule, and 3) new emotional words.

**Conclusion:** JeStiMule helped to guide the interest of individuals with ASD and different levels of functioning to emotional lexicon used in the serious game but also to new emotional words.

**Keywords:** Autism; Emotion; Computer-based intervention; Semantic fluency task; Cognition; JeStiMule

**Abbreviations**

ADI-R: Autism Diagnostic Interview-Revised; ADOS: Autism Diagnostic Observation Schedule; ANOVA: Analysis of variance; AS: Asperger Syndrome; ASD: Autism Spectrum Disorders; DSM-IV-R: Diagnostic and Statistical Manual of Mental Diseases, Fourth Edition; ECOSSE: Epreuve de COMpréhension Syntaxico-SEmantique; IQ: Intelligence Quotient; PDD-NOS: Pervasive Developmental Disorder-Not Otherwise Specified; WASI: Wechsler Abbreviated Scale of Intelligence

**Introduction**

Autism Spectrum Disorders (ASD) are characterized by qualitative impairments of social interactions and communication, as well as by repetitive, restricted or stereotyped activities and interests [1]. Social impairment is associated with atypical emotion processing. Individuals with ASD have difficulties to recognize facial emotions [2], whole-body emotional actions [3] and emotions in social scenes

[4]. In addition, impairment in ASD has been related to a deficit of empathy [5,6]. Furthermore, emotion recognition and empathy skills, compose with others skills the concept of emotional competence.

Emotional competence is a developmental concept which corresponds to the ability to understand, express and regulate emotions appropriately [7]. This concept comprises several skills, acquired progressively by a child with caregiver support. These skills refer to the ability of a child to recognize his own emotions, those of others and the use of his emotions to interact and adapt to the environment. In addition, emotion recognition and empathy are also related to the use of emotional lexicon skills [8]. The acquisition of each skill is essential for the development of adequate social experience as emotional and social experiences are reciprocally influenced [9,10]. Consequently, the altered acquisition of one capacity, such as the emotional lexicon is likely to have an impact on social development.

In ASD, impairment of the social dimension has consequences for language skills. Indeed, individuals with ASD seem to have difficulties

**Table 1:** Characteristics of participants.

N=29	Number	
Gender	28 males, 1 female	
ASD diagnosis	29	
Autism	19	
Asperger Syndrome	4	
PDD-NOS	6	
	Mean Score (Standard deviation)	Range
Age (months)	141.21 (40.09)	76-214
WASI	75.17 (26.15)	35-129
Age of semantic-syntactic language (years)	4.55 (4.77)	< 1-12
	Median	Range
Schooling (hours/week)	17	0-28
Special care (hours/week)	6	0-28

**ASD:** Autism Spectrum Disorders; **PDD-NOS:** Pervasive Developmental Disorder-Not Otherwise Specified; **WASI:** Wechsler Abbreviated Scale of Intelligence

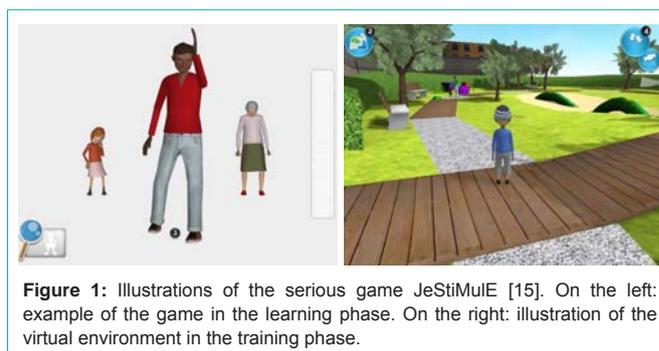
to process words with social components [11]. This is particularly important as affective variables influence word processing [12]. In addition, emotional lexicon has a key role in social development, promoting social interactions and permitting to be socially efficacious [8]. The lack of emotional lexicon can therefore contribute to social impairment. Enriching this lexicon might thus permit to improve the communication of individuals with ASD.

Research about social remediation in ASD focuses on emotion recognition since many years, with some training programs aiming to extend social skills. However, to our knowledge, only one of them has been interested in the emotional lexicon [13]. The Transporters designed by Golan and Baron Cohen's team is a program developed to teach emotion recognition skills using animated vehicles with real emotional faces. Studies have shown that this program improves emotion recognition [13,14]. Golan et al. [13] evaluated 20 preschooler's children with ASD before and after training. The training had an impact on their lexicon, showing an improvement after training. However, the children included in this study were diagnosed with Asperger Syndrome (AS) and they had to define predefined words, corresponding to emotional words used in the program. Therefore, the assessment was performed in participants with preserved verbal abilities and concerned only vocabulary of the program.

The originality of our study was to evaluate the improvement of the emotional lexicon after JeStiMulE training [15] in a heterogeneous ASD group. JeStiMulE is a game designed to teach emotional skills to individuals with ASD, independently of their age, intellectual, verbal, functional and academic level. We hypothesized that JeStiMulE would enrich the emotional lexicon of individuals with heterogeneous profiles of ASD. This improvement has been evaluated by means of tasks not related to JeStiMulE in order to extend our knowledge about its ability to increase emotional lexicon of individuals with ASD.

## Materials and Methods

The procedure of this study was approved by the local ethical committee ("Comité de Protection des Personnes Sud Méditerranée



**Figure 1:** Illustrations of the serious game JeStiMulE [15]. On the left: example of the game in the learning phase. On the right: illustration of the virtual environment in the training phase.

V", reference number 11.046). Participants and their parents signed informed consent prior to the study.

## Participants

Twenty-nine children and adolescents were recruited in four day-care units by the Autism Resource Center PACA, Nice, France. All participants received an ASD diagnosis based on DSM-IV-R criteria for ASD (Diagnostic and Statistical Manual of Mental Diseases, Fourth Edition) [1], as well as on the Autism Diagnostic Interview-Revised (ADI-R) [16] and/or the Autism Diagnostic Observation Schedule (ADOS) [17]. The characteristics of the participants are presented in Table 1. Cognitive abilities were assessed using: 1) Wechsler Abbreviated Scale of Intelligence (WASI) [18] to define IQ; and 2) ECOSSE (Epreuve de COMpréhension Syntaxico-SEmantique) [19] to evaluate the semantic-syntactic level (age). Information about schooling and special care (educative and/or therapeutic) was collected for all participants.

The primary inclusion criterion of the participants concerned their ability to name at least one animal and/or one fruit. Participants who are not able to name at least one example of each category were not included in this study.

## Power analysis

The present study was related to a larger protocol [15]. The sample size was determined by power analysis based on previous results (expected effect and variance), with 80% power and an  $\alpha$  value of 0.05. Some patients from the initial protocol population [15] have not been included in this study because of deficient or missing language and difficulties to name 'animals' and / or 'fruits', one of the inclusion criteria of the present study.

## Training program

JeStiMulE is a prototype of a multi-sensory serious game (with visual, auditory and tactile stimulations), and developed to teach emotional skills to ASD individuals regardless their age, intellectual, verbal, functioning and academic level: 1) emotion recognition (emotional facial expressions, gestures and social situations); 2) emotional lexicon (words/expressions). It combines the fun of playing with learning. The content and design of JeStiMulE are more detailed in Serret et al. [15].

JeStiMulE allows training of emotional skills about seven expressions: six basic emotions (happiness, surprise, anger, fear, disgust, sadness) [20,21] and one complex emotion (pain).

JeStiMulE consists of three phases: 1) the calibration phase: adjusting the tactile stimulations of the joystick according to the

sensitivity of participants; 2) the learning phase (Figure 1, on the left): training with three games to recognize different emotional faces and gestures associated with emotional words/expressions in avatars; 3) the training phase: applying the knowledge acquired during the learning phase in a virtual environment (city) with five areas (square, garden, restaurant, theatre and shop) (Figure 1, on the right).

In JeStiMulE, each emotion is associated with one color (Plutchick's emotional wheel [21]), three emotional words (e.g. joy, happy, angry, fear) and three idiomatic emotional expressions (e.g. 'to walk on air' to express joy). Idiomatic expressions are short sentences with a figurative meaning conventionally understood by native speakers and essential for human emotional communication [22].

### Assessments of lexicon

Three tasks were used to evaluate the lexicon.

For the emotional lexicon, the participants were assessed by an emotional semantic fluency task inspired by the tasks of semantic fluency created by Cardebat [23]. Participants were asked to give the maximum of emotional words or expressions within two minutes. Each emotional word or idiomatic expression used in the game was scored 1 point. Each other word considered to be an emotional term [24] was also scored 1 point. Repeated words or words with the same root (e.g. joy, joyful) was eliminated from the total score.

For the non-emotional lexicon, non-emotional semantic fluency tasks [23] were used. Participants were asked to give a maximum of animal names (and fruit names in the second task) within two minutes. As in the emotional lexicon task, each correct word was scored 1 point, with no point for repeated or similar names.

### Procedure

Each participant was assessed individually and the order of the execution of tasks was counterbalanced.

The first evaluation of the lexicon (emotional and non-emotional) was performed 2 weeks before the start of the training with JeStiMulE. Each participant then performed a maximum of four weeks training, with two one-hour sessions a week, always accompanied by a caregiver with the role to support and to help the participant. The second evaluation of the lexicon was performed 2 weeks after the end of training.

### Data analysis

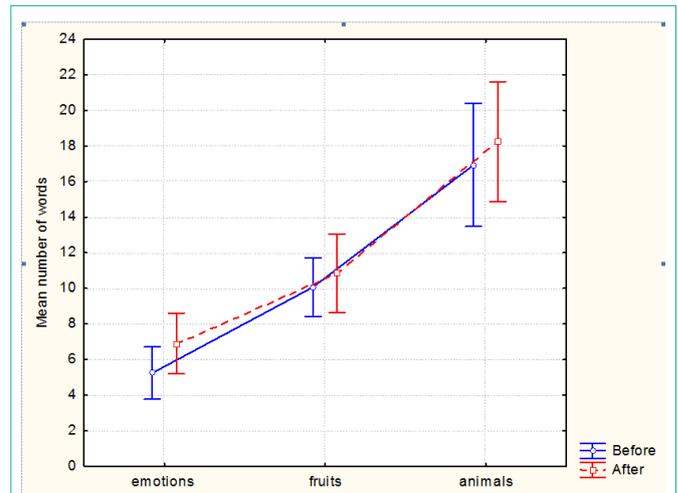
To evaluate the improvement of the emotional lexicon, we performed quantitative and descriptive analysis of results.

#### Quantitative analysis

The mean number of emotional words/expressions given before training was compared to those given after training. Statistical analyzes considered time (before vs after) and the type of semantic fluency task (emotional vs animals vs fruits), and was performed using the Repeated Measures ANOVA and post-hoc analyses (Fisher's LSD) on the Statistical device (Statsoft, <http://www.statsoft.com>) with a alpha critical value of 0.05.

#### Descriptive analysis

A descriptive analysis of emotional words/expressions given after training compared to those given before training has been performed.



**Figure 2:** Mean number of words pronounced in each fluency task before (blue) and after (red) training. Results revealed a significant improvement only of the emotional fluency task ( $p < 0.05$ ).

Emotional words/expressions after training were classified into three categories: 1) words already given before training ("repetition category"), 2) words used in JeStiMulE ("game category"), and 3) new emotional words not derived from JeStiMulE ("non-game category").

The normality and the sphericity of assumptions have been confirmed respectively by Kolmogorov Smirnov test and Mauchly test with multivariate statistics.

## Results

### Quantitative analysis

Results analyzed by Repeated Measures ANOVA showed a significant main effect of time ( $F(1,28) = 10.33, p = 0.001$ ), indicating that the mean number of words was significantly higher after training ( $M = 11.99, SD = 1.06$ ) than before ( $M = 10.75, SD = 0.93$ ). There was also a significant main effect of type of lexicon ( $F(2,56) = 63.89, p < 0.001$ ), indicating that the mean number of emotional words (E) ( $M = 6.07, SD = 0.74$ ) was significantly lower than the mean number of fruit (F) ( $M = 10.45, SD = 0.91$ ) and animal words (A) ( $M = 17.59, SD = 1.60$ ) ( $E$  vs  $F$ :  $< 0.001$ ,  $E$  vs  $A$ :  $< 0.001$ ,  $F$  vs  $A$ :  $< 0.001$ ). The interaction effect time x type of lexicon was not significant ( $F(2,56) = 0.42, p = 0.66$ ) (Figure 2). Results were further analyzed by the post-hoc Fisher comparisons. Concerning the emotional lexicon task (E), the mean number of words was significantly higher after training ( $M = 6.90, SD = 0.83$ ) than before ( $M = 5.24, SD = 0.72$ ) ( $p < 0.05$ ). However, the mean number of words did not differ for the fruit (before ( $M = 10.07, SD = 0.80$ ) vs after ( $M = 10.83, SD = 1.08$ )  $p = 0.28$ ) as well as animal words (before ( $M = 16.93, SD = 1.69$ ) vs after ( $M = 18.24, SD = 1.65$ )  $p = 0.67$ ).

### Descriptive analysis

Results showed that, among emotional words/expressions spontaneously given after training, 45.94% were repetitions (repetition category), 52.03% were used in JeStiMulE (game category) and 2.03% were new words (non-game category, e.g. nervous).

## Discussion

The purpose of this study was the evaluation of the improvement of the emotional lexicon of ASD individuals after JeStiMulE training.

We hypothesized that training will improve and enrich the emotional lexicon. Indeed, after training, participants gave significantly more emotional words. Moreover, descriptive analysis of results clarified the type of the lexical learning. An analysis of after-training emotional words revealed that approximately half of the words have been used in JeStiMulE. Hence, individuals with ASD had memorized emotional words seen in the serious game. Moreover, some words given spontaneously after training were novel and not used in the program. These words may have been used by the caregivers during moments of interaction with the participant while using JeStiMulE. Therefore, participants might have memorized what they have seen, but also what they have heard during the training.

The current findings are consistent with previous research reporting an increase of emotional words in Asperger Syndrome after training with The Transporters [13]. Our study extends former results by showing that individuals with ASD can process words with social components [11] and are also able to process them implicitly. Therefore, learning social elements is possible on the condition to use adapted learning tools such as JeStiMulE [15]. Results also highlight the importance of the caregiver during training, especially the content of caregiver's oral speech.

In conclusion, the present study provides evidence that JeStiMulE training improved and diversified the emotional lexicon of individuals with ASD and heterogeneous intellectual, verbal, functioning and academic levels.

Increasing the emotional lexicon of children and adolescents with ASD can directly improve their communication capacities in everyday life, particularly about the emotional state which is essential as we know the difficulties of individuals with ASD to communicate their feelings.

## Limitations

The first limitation concerns the characteristics and the number of participants. JeStiMulE has been designed to teach emotions to individuals with heterogeneous profiles of ASD. Although all participants were able to understand the set of tasks, the heterogeneity of the group requests cautiousness in interpreting the results. Therefore, a study on a larger sample would be interesting to conduct.

The second limitation concerns the origin of new emotional words. We made the hypothesis that new emotional words given during the assessment after training were from the caregiver's speech. In a future study, caregiver's speech should be standardized using a precise list of emotional words, thus allowing to define more precisely the origin of new emotional words.

The third limitation concerns the quite short duration of training (four weeks). Future research might be warranted studying the effects of a longer training period.

## Conclusion

This study provides additional evidence for social learning opportunities for individuals with ASD by using a support and tool adapted to ASD specificities. Results further allow extending our knowledge about ASD children and adolescents and their capacity to learn information with social and emotional components.

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