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COGNITIVE SCIENCE & NEUROSCIENCE | RESEARCH ARTICLE

Theory of Mind in deaf adults

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Abstract: *Purpose:* The present study analyzed the social-cognitive and social-perceptual components of Theory of Mind (ToM) comparing three groups of deaf adults to three matched hearing groups. The influence of verbal IQ was also investigated. *Methods:* The participants were 15 native signers, 15 late signers, 17 oral deaf adults paired by gender, age and mental age to 47 hearing adults. All participants completed the assessment of the two components of ToM and of the verbal IQ. *Results:* Late signers and oral deaf adults showed lower scores than hearing peers both in the social-perceptual and social-cognitive components of ToM. Native signers showed lower scores than hearing peers in the social-perceptual component. Verbal IQ was the predictor of the social-cognitive component for late signers and oral deaf adults, while it was not significant for the social-perceptual component. *Conclusions:* The findings yielded support for the two components of TOM and contributed to the extent of the existing literature on ToM in deafness.

Subjects: Development Studies; Health & Development; Development Theory

Keywords: Theory of Mind; oral deaf adults; native signers; late signers; componential model of ToM

1. Introduction

1.1. The componential model of Theory of Mind

Theory of Mind (ToM) involves individuals' ability to infer cognitive and emotional states of others (i.e. intentions, desires, beliefs, knowledge, emotions), as well as understanding that those states guide their behaviors (Apperly, 2012; Hughes & Leekam, 2004; Marchetti et al., 2013; Wimmer & Perner, 1983).

ABOUT THE AUTHORS

The authors are involved in several research activities within typical and atypical developmental conditions, such as deafness, autism, and learning disabilities. Dr Flavia Lecciso and Dr Serena Petrocchi's research interests are focused on Theory of Mind in socio-cultural and affective-relational perspective in developmental ages and life-span approach. Dr Francesca Baruffaldi's research interests are focused on clinical psychology and specifically on linguistic and attention on deafness. She is also an expert in using Italian Sign Language. Annalisa Levante's research interests are mainly focused on Theory of Mind in Autism.

PUBLIC INTEREST STATEMENT

Our research studies two psychosocial abilities, which are very important for everyday interactions. The first is the ability to understand that mental states guide people's behaviors (Luke thinks his keys are on the table—actually they are not—and he looks for them on the table) and the second one is the ability to infer mental states through facial expressions, vocal, and body language (Luke's face shows frustration when he did not find his keys). We study those abilities on deaf adults because little is known on them. We found that deaf adults from hearing families showed fewer abilities than hearing adults, while deaf adults from deaf parents showed fewer ability than hearing adults only on the understanding of mental states through facial expressions. Our results can help professionals who work with deaf people to teach them these psychosocial abilities from the early years of life.

Tager-Flusberg and Sullivan (2000) developed a componential model of ToM which comprises a social-cognitive component and a social-perceptual component. The social-cognitive component refers to what authors have traditionally meant by ToM, that is the conceptual understanding of the mind as a representational system (Griffin, 1978; Tager-Flusberg, 2000). The social-cognitive component of ToM is closely related to both the general and specific aspects of language development (de Villiers & de Villiers, 2000). This component develops between the third and fourth year of life in the form of first-order false belief reasoning and during late childhood with the understanding of complex social situations (Tager-Flusberg, 2000). First-order false belief tasks (Wimmer & Perner, 1983) and Strange Stories (White, Hill, Happè, & Frith, 2009) are prototypical measures of the social-cognitive component of ToM.

The social-perceptual component refers to the ability to infer other's mental states through facial expressions, vocal and body language (Tager-Flusberg, 2000). This component involves perceptual information which is immediately available and observable and is less linked to other cognitive and linguistic abilities. It develops during the first years of life, earlier than the social-cognitive component, because one-year-old children already recognize and respond to their mother's emotional facial expressions (Baron-Cohen, Tager-Flusberg, & Cohen, 1993). Facial Expression Recognition (Gao & Maurer, 2009) and the Reading the Mind in the Eyes test (henceforth Eyes test) (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001) are prototypical measures of the social-perceptual component of ToM.

Although in everyday life the two components are interconnected, in some clinical conditions they may function in a dissociated way (Tager-Flusberg, 2000). For example, autistic individuals show a delay in the social-perceptual component, (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997) while the social-cognitive component may be preserved when the language ability is well developed. (Tager-Flusberg, 1997; Tager-Flusberg & Sullivan, 1994, 2000).

1.2. The componential model of Theory of Mind in deafness

Although research on ToM in deafness has been the focus of an intensive investigation, most studies considered deaf children ToM development while few of them have analyzed deaf adults' understanding of their own and others' mind. Research on ToM on deafness focused especially on the social-cognitive component (i.e. first- and second-order false belief reasoning), while few studies have analyzed the social-perceptual component.

As regards research on the social-perceptual component, Wang, Su, Fang, and Zhou (2011) found that 2–3 year-old children with cochlear implants or hearing aids showed less ability to infer four basic emotional expressions (happiness, sadness, anger, fearfulness) than hearing peers. These authors found no significant correlation between Facial Expression Recognition and verbal ability which is a confirmation of Tager-Flusberg and Sullivan's (2000) hypothesis.

Further studies (Hopyan-Misakyan, Gordon, Dennis, & Papsin, 2009; Most & Aviner, 2009) supported the idea of a progressive improvement of the social-perceptual component of ToM in deafness. Hopyan-Misakian et al. (2009) analyzed children with cochlear implants or hearing aids and hearing children from 7 to 13 years of age; Most and Aviner (2009) studied the same two groups of children from 10 to 17 years. Both studies did not find significant differences between groups in the recognition of basic emotions (happiness, sadness, anger, fearfulness). It is worth pointing out that the task used in the two studies assesses a simple aspect of the social-perceptual component of ToM (i.e. four basic emotions) as administered for example to preschoolers (Wang et al., 2011). In this vein, a recent study, (Lecciso, Petrocchi, & Marchetti, 2013) measuring the social-perceptual component of ToM with an advanced task (i.e. eyes test), (Baron-Cohen et al., 2001) found that oral deaf children from 5 to 14 years of age performed worse than their hearing peers. This study also found a correlation between receptive language and the recognition of complex emotions through eye gaze. Considered overall, these few studies on the social-perceptual component of ToM showed a progressive improvement in oral deaf children in their recognition of basic emotions, while

underlined a delay in the recognition of complex mental states through eye gaze. No studies on the social-perceptual component of ToM were developed on deaf adults.

When research on the social-cognitive component of ToM is considered, three main topics need to be faced: (1) the consideration of three groups of deaf individuals (i.e. native signers, late signers, and oral deaf adults); (2) the progressive development of the social-cognitive component of ToM by age; and (3) the role of language in the development of the social-cognitive component of ToM.

Research on the social-cognitive component of ToM considered three groups of deaf people depending on the presence/absence of hearing loss in parents, the communicative mode mainly used in the family (sign vs. verbal mode), and the rehabilitation approach chosen by the family (verbal vs. sign training). According to these characteristics, it is possible to distinguish among: native signers, namely deaf individuals of deaf parents who learn to communicate by sign language from birth; late signers, that is, deaf individuals of hearing parents who learn to communicate by sign language through training; oral deaf people, that is, deaf individuals of hearing parents who learn to communicate by spoken language through training.

Research on deaf children (Courtin & Melot, 1998; Peterson & Siegal, 1997, 1999; Peterson, Wellman, & Liu, 2005; Woolfe, Want, & Siegal, 2002) showed that the performance of native signers in first-order false belief reasoning was better than late signers and similar to that of hearing children, while late signers, compared to hearing children and native signers, showed a delay in the same tasks (Peterson & Siegal, 1995, 1999). Most studies (Courtin, 2000; Courtin & Melot, 1998; de Villiers, 1997; de Villiers & de Villiers, 2000; Lecciso et al., 2013; Marchetti, Liverta-Sempio, & Lecciso, 2006) showed a delay also of oral deaf children when compared to hearing peers both in first- and second-order false belief reasoning (Courtin, 2000; Courtin & Melot, 1998; de Villiers, 1997; de Villiers & de Villiers, 2000; Lecciso et al., 2013; Marchetti et al., 2006) and in advanced ToM (Lecciso et al., 2013). Only one study (Peterson & Siegal, 1999) found similar performance comparing oral deaf children, native signers and hearing children in first-order false belief reasoning. According to these studies, the results found in late signers and oral deaf children are related to their communicative ability and, in particular, on language complementation, (de Villiers & de Villiers, 2000; de Villiers & Pyers, 2002; Villiers, 2005) general language ability including knowledge of vocabulary on mental states (i.e. thinking, knowing, believing), (Rommel & Peters, 2009) and the conversational deprivation in the family context (Peterson & Siegal, 1999).

While deaf children have been intensively studied, in literature there is a paucity of research on deaf adults. Hao, Su, and Chan (2010) compared four groups of deaf adults (pre-lingually deaf who are bilingual and came from hearing parents; post-lingually deaf who are bilingual and came from hearing families; pre-lingually deaf signers who came from hearing parents; pre-lingually deaf adults of deaf parents) administering both explicit (story recall task) (Rutherford, 2004) and implicit ToM tasks (story comprehension task) (Happé, Brownell, & Winner, 1999; Langdon & Coltheart, 2004). All four deaf groups showed worse performance compared to hearing peers when the explicit ToM was considered, while in the understanding of implicit ToM only the two groups of pre-lingually deaf adults who came from hearing families showed a delay. Sociolinguistic theory (Peterson & Siegal, 1995; Siegal, 1997) argues that early conversational deprivation in deaf children of hearing parents is the main reason accounting for their delay in ToM understanding.

The second topic considered in research on the social-cognitive component of ToM is the progressive development by age. Studies on ToM during early childhood (Courtin, 2000; Courtin & Melot, 1998; Woolfe et al., 2002) did not find significant difference by age up to 8 years. Other research (Gonzalez, Quintana, Barajas, & Linero, 2007; Russell et al., 1998) considers the period of late childhood and adolescence. Gonzalez et al. (2007), considering deaf individuals from 4 to 16 years of age, and Russell et al. (1998), studying deaf children aged 6 to 19, found significant improvement on first-order false belief reasoning after the age of 13–14. Both studies explain this development as depending on wider communicative experience within and outside the family.

The third topic considered in this field of research is the association between language and the social-cognitive component of ToM which is well established in typical developing children (Milligan, Astington, & Dack, 2007). Recent studies (Hao et al., 2010; Pyers & Senghas, 2009; Russell et al., 1998) analyzed the association between first-order false belief reasoning or advanced ToM and language ability in deaf adolescents and adults. Russell et al. (1998), assessing performance on first-order false belief tasks in deaf subjects aged between 6 and 19 years, underlined that it is the level of oral lexical competence that is associated with ToM performance. Specifically, children with a verbal/lexical age higher than four showed a better performance on ToM tasks independently of their chronological age. Hao et al. (2010) analyzed the associations between language ability and advanced ToM in deaf adults with a mean age of 21.5 years. They found a significant effect of language ability on advanced ToM although the quality of interpersonal experience in the first years of life also had an effect.

2. Materials and methods

2.1. Areas investigated and hypotheses of the research

The aim of this research was to analyze the social-perceptual and social-cognitive components of ToM as defined by Tager-Flusberg and Sullivan (2000) in deaf adults. The two components of the theoretical model have never been jointly tested in a single research study and never in deafness conditions. Other clinical conditions have been tested (i.e. Williams syndrome, Prader-Willi syndrome, Autism) (Baron-Cohen et al., 1997; Plesa Skwerer, Verbalis, Schofield, et al., 2006; Sullivan & Tager-Flusberg, 1999; Tager-Flusberg, 2000) revealing dissociations between the social-perceptual and social-cognitive component of ToM, which however were not jointly studied.

When the social-perceptual component is considered, research (Hopyan-Misakyan et al., 2009; Lecciso et al., 2013; Most & Aviner, 2009) has investigated only oral deaf children and adolescents. No studies involved either native or late signers or deaf adults. Furthermore, the social-perceptual component was mainly evaluated with tasks which analyze the understanding of basic emotions (FER) (Gao & Maurer, 2009). One study (Lecciso et al., 2013) measured the understanding of complex emotions and other mental states through eye gaze, but considered deaf adolescents. No studies analyzed the association between the social-perceptual component of ToM and language.

When the social-cognitive component is considered, research on deaf subjects is mainly based on childhood and adolescents (Gonzalez et al., 2007; Russell et al., 1998) and only one study analyzed deaf adults (Hao et al., 2010). The social-cognitive component of ToM was mainly studied through basic tasks analyzing first- and second-order false belief reasoning, (Gonzalez et al., 2007; Russell et al., 1998) while only two studies on deaf adults administered advanced ToM tasks (Hao et al., 2010; Lecciso et al., 2013). Results (Hao et al., 2010; Russell et al., 1998) showed that language ability seems to play a significant role on ToM performance together with other variables, such as age and type of group (i.e. native signers, late signers, oral deaf adults).

The current study was designed to redress the limitations underlined above. First, an essential aim of this study was to jointly analyze the two components of ToM, as proposed by Tager-Flusberg and Sullivan (2000) in three groups of deaf adults, as defined by the literature: native signers, late signers, and oral deaf. Each of the three groups of deaf adults was compared to a paired group of hearing adults. Second, the present study intended to administer both basic and advanced ToM tasks and to analyze the role played by verbal ability, measured as verbal IQ, on the two ToM components.

Specifically, the aims of the study were:

- To compare each group of deaf adults (native signers, late signers, oral deaf adults) to its hearing paired group on the two ToM components. In line with previous research on ToM in deaf children and adults, it was hypothesized that late signers and oral deaf participants would perform worse than hearing peers on the social-cognitive component of ToM. The lack of research on native

signers on the social-cognitive component did not allow a specific hypothesis to be made on their performance. Similarly the lack of studies in adulthood on the social-perceptual component in the three groups of deaf people did not allow specific hypotheses to be made on their performance.

- To assess the association between verbal IQ and the two ToM components in deaf and hearing participants.

2.2. Participants

Participants were 94 young adults with mean age 22 years 1 month (SD = 1 month) ranging from 15 years 9 months to 28 years 1 month. Forty-seven were profoundly deaf: 15 of them were native signers, 15 late signers, and 17 oral deaf. Forty-seven were hearing adults paired one-by-one by gender, chronological, and mental age with the 47 deaf participants. Each group of deaf adults (native signers, late signers, oral deaf) had a corresponding paired group to hearing adults to be compared with. Mental age was measured by the Standard Progressive Matrices (Raven, 2008).

T-tests were performed to control the matching procedure: no differences emerged between each group of deaf people (native signers, late signers, and oral deaf adults) and the corresponding group of hearing paired participants for both chronological, mental age, and years of education. No differences emerged between the three groups of hearing participants for chronological and mental age (Table 1).

Table 1. Characteristics of participants

	Native signers	Hearing paired adults	Late signers	Hearing paired adults	Oral deaf	Hearing paired adults
No. of adults	15	15	15	15	17	17
Mean age (SD), range	22.27 (4.03)	21.86 (4.08)	21.92 (3.4)	21.96 (3.26)	22.31 (2.7)	22.02 (2.62)
	16.7–28.1	16.2–28.2	16.4–26.9	15.9–26.5	17.5–25.4	17.9–25.5
Mean mental age (SD)	112.27 (4.91)	116.46 (8.35)	114.87 (7.81)	118.44 (10.14)	120.82 (7.4)	120.61 (8.02)
Ratio of males:females	4:11	4:11	10:5	10:5	6:11	6:11
Mean years of education (SD)	12.00 (2.07)	10.23 (3.26)	10.13 (2.87)	10.00 (2.82)	8.17 (2.62)	10.11 (3.47)
Communication mode	Italian sign language	Verbal language	Italian sign language and verbal language	Verbal language	Verbal language	Verbal language
Type of deafness						
Congenital deafness	15 (100%)		10 (66.7%)		10 (58.8%)	
Acquired deafness	–		5 (33.3%)		7 (41.2%)	
Deafness degree						
Mild	–		1 (6.7%)		1 (5.9%)	
Severe	1 (6.7%)		5 (33.3%)		3 (17.6%)	
Profound	14 (93.4%)		9 (60%)		13 (76.5%)	
Hearing aids						
External hearing aids	–		6 (40%)		13 (76.5%)	
Cochlear implant	–		–		4 (23.5%)	
None	15 (100%)		9 (60%)		–	
Mean years of speech therapy (SD)	3.00 (1.32)		3.36 (0.81)		3.83 (0.57)	

2.3. Measures

2.3.1. Verbal IQ

Five verbal subtests (information, vocabulary, comprehension, arithmetic, and similarities) of the Wechsler intelligence scale–WAIS-R (verbal IQ–vIQ) (Orsini & Laicardi, 1997) were administered. Because there are no existing standardized tests for LIS proficiency (Italian Sign Language), as done in previous studies on deaf people (Schick, de Villiers, de Villiers, & Hoffmeister, 2007) the five subtests and their instructions were translated into LIS and thus administered to native and late signers. Oral deaf and hearing participants received the original form of these subtests. Native and late signers replied to those tests using LIS, while oral and hearing participants replied using oral language. In the procedure section, the translation method followed is explained in greater detail.

For all participants, a final measure of the vIQ was obtained, following the standardized norms of the WAIS-R (Orsini & Laicardi, 1997). The final vIQ obtained could be considered an approximation of Italian verbal/spoken ability for oral deaf and hearing participants and an approximation of verbal/LIS ability for native and late signers. For an easy reading, the terms of verbal IQ or verbal ability were used in the following sections.

2.3.2. Social-cognitive component of ToM

The Look Prediction task (Astington, Pelletier, & Homer, 2002) and Strange Stories (White et al., 2009) were administered to evaluate the social-cognitive component of ToM. The Look Prediction task (Astington et al., 2002) involved the presentation of a story depicting one character having a false belief about the second character's belief (i.e. second-order false belief reasoning). Participants judge what the first story character would expect the second story character to do. The story was illustrated by four pictures.

The Look Prediction was translated into LIS and then administered to native and late signers, while oral deaf and hearing participants received the original form of this test. Native and late signers replied to questions using LIS; oral and hearing participants replied using oral language. Participants were asked two control questions, one first-order false belief question, one second-order false belief question, and one justification question. The answers for each type of question were scored 1 (correct answer) or 0 (wrong or no answer). A total score was obtained by a scoring that ranged from 0 (2 wrong control questions) to 3 (all 5 correct answers) adjusted for chance answering (Naito & Seki, 2008), with higher scores denoting higher ability. Protocols were independently coded by two authors of this paper; inter-rater reliability was $r_s > 0.98$.

The Strange Stories (White et al., 2009) assess advanced ToM, that is the extent to which participant understands why a character says something that is not literally true. The task is composed of eight stories involving double-bluff, misunderstanding of intention, persuasion, and white lie (two stories for each). The Strange Stories was translated into LIS and then administered to native and late signers, while oral deaf and hearing participants received the original form of this test. Native and late signers replied to questions using LIS; oral and hearing participants replied using oral language. After each story, the participants were required to reply to a control question (different for each story) and to a test question (“Why did the character say that?”).

The answers to the Strange Stories were coded and scored as 0 (incorrect), 1 (answers containing implicit attribution of mental states), or 2 (answers with full/explicit attribution of mental states). Two raters independently scored the protocols. There were acceptable inter-rater correlations for all the eight stories ($r_s > 0.95$) and acceptable inter-item correlations ($r_s > 0.30$). The scores for the eight stories were summed to yield an advanced ToM measure ($\alpha = 0.74$, range = 0.50–2.88) with higher values denoting greater ability.

In the procedure section, the translation method followed is explained in greater detail.

2.3.3. Social-perceptual component of ToM

The reading the mind in the eyes test-adult version (Baron-Cohen et al., 1997, 2001; Serafin & Surian, 2004; Vellante et al., 2012) was administered to evaluate the perceptual cognitive component of ToM. The Eyes test has been used in samples of people expected to show impairment of social cognition, such as people with autism and schizophrenia (Baron-Cohen et al., 2001; Harrison, Tchanturia, & Treasure, 2010; Kettle, O'Brien-Simpson, & Allen, 2008). The Eyes test-adult version (Baron-Cohen et al., 1997, 2001; Serafin & Surian, 2004; Vellante et al., 2012) comprises 36 still pictures of the eye region with four possible answers each regarding the mental state expressed through the eyes. This task assesses the adult's ability to read complex epistemic and emotional mental states from the gazes. For example, an item shows a photo that presents the mental state "reflective" and the three distractors are "aghast", "irritated" and "impatient". All four words are written around the photo according to the Baron-Cohen et al. (2001) procedure. For native and late signers the four words were translated into LIS; oral deaf and hearing participants received the original form of this test. Participants had to choose one of the four labels by responding verbally (oral deaf and hearing participants), using LIS (native and late signers) or pointing a finger (all groups) to the correct answer on the paper.

Before testing, the glossary of all the mental state terms was used following the Baron-Cohen et al. (2001) procedure. The glossary was used to prevent comprehension problems with the words themselves from contributing to an individual's score. Before testing, subjects were asked to read through the glossary and indicate any word meanings of which they were unsure. Oral and hearing participants were then encouraged to read these particular meanings. Native and late signers also received the LIS translation of any word and any word meanings of which they were unsure. All participants were told that they could return to this glossary at any point during the testing. According to Baron-Cohen et al. (2001) procedure, preliminary analysis was conducted also on the number of words in the Eyes-test about which each subject in the six groups was unsure, and then checked in the glossary. The number of words checked never exceeded three.

According to the Baron-Cohen et al. (2001) procedure, one point was attributed for a correct reply and 0 point for a wrong reply. Because the test comprises 36 items with four response options, the chance to choose the right reply is $p = 0.25$, that means participants have to score 13 or above, out of 36, to be performing significantly above chance (Baron-Cohen et al., 2001). According to Baron-Cohen et al. (2001) adults who had 13 or more correct answers were included in the analyses. No subjects were excluded from the analyses. The correct replies were summed and averaged to yield an advanced ToM measure, with higher values denoting greater ability. In the procedure section, we explained the method followed to translate this ToM task (instruction, items, and glossary) for native and late signers.

2.4. Procedures

The participants were all Italian. All participants were recruited in three big cities located on the North (Verona, Padua) and South of Italy (Lecce). Deaf participants were recruited thanks the collaborations with several national deaf societies; hearing participants were recruited within High schools or Universities.

Inclusion criteria were: absence of diagnosis of physical illnesses/disabilities (other than deafness) or mental disabilities. To be included in one of the three groups of deaf participants (native signers, late signers, or oral deaf), deaf people had to show the intersection of the characteristics as defined by the literature: presence vs. absence of hearing loss in parents; sign vs. verbal communication mode mainly used in family; verbal vs. sign training approach vs. no training chosen by the family. Deaf participants were included in the native signers group if they have deaf parents, learn to communicate by sign language from birth without any training. Deaf participants were included in the late signers group if they have hearing parents and communicate by sign language through training. Deaf participants were included in the oral deaf group if they have hearing parents and communicate by spoken language through training. The three groups of hearing adults were paired to the

three groups of deaf participants. So, to be included in one of the three hearing groups, each hearing participant had to have the same gender, chronological, and mental age than the paired deaf participant.

All the participants were tested by one female hearing psychologist who is an author of this study and is a fluent Italian Sign Language user (5 years of experience issued by the ENS, which correspond to the Italian National Deaf Society). Prior to the administration, all the tasks and the corresponding instructions were translated into LIS for native and late signers. The following procedure was used. All the tasks and their instructions were translated into LIS by the psychologist who was responsible for the administration in collaboration with a LIS interpreter (registered with ANIOS - Italian Sign Language Interpreters Association which is member of the European Forum of Sign Language Interpreters). Independently, the same material was translated into LIS by a deaf native signing professor who is a linguistics expert. The two translations were then compared and a final common version was obtained. All the material was translated into sign through an approximation of the meaning following the usual method when material is translated into LIS (Fontana, 2013; Franchi & Maragna, 2013). Specifically, the translation was made following the LIS grammar characteristics, from left-to-right order for nouns (i.e. persons-objects) as in the written form, without introducing any kind of spatial change. As a back-translation method, the experimenter and the linguistics professor independently compared the final LIS version with the original spoken Italian version of the tasks concluding that the two versions were truly comparable.

Each participants received written information describing the aims of the research and provided informed consent. The participants received the tasks in two separate sessions in a quiet room. In the first session, the participants individually completed the five verbal subtests of the WAIS-R scale and the Standard Progressive Matrices. One week later in the second session, the participants individually completed the Look Prediction, the Strange stories and the Eyes test.

The study followed APA Ethical Principles of Psychologists and Code of Conduct and the principles of the Declaration of Helsinki.

3. Results

3.1. Social cognitive and perceptual component of ToM in deaf and hearing participants

All the data were subjected to *t*-test analysis to compare each group of deaf adults (native signers, late signers, oral deaf adults) and its hearing paired group on the social-cognitive and perceptual component of ToM. Means and standard deviations are shown in Table 2.

Table 2. Means and SD (between brackets) of the three groups of deaf participants and hearing paired participants

	Native signers	Hearing paired adults	Late signers	Hearing paired adults	Oral deaf	Hearing paired adults
Look prediction	2.33	2.54	1.40	2.38	2.35	2.72
	(SD = 0.61)	(SD = 0.52)	(SD = 1.1)	(SD = 0.62)	(SD = 0.60)	(SD = 0.57)
Strange stories	1.8	2.2	1.21	2.2	2.06	2.35
	(SD = 0.45)	(SD = 0.40)	(SD = 0.50)	(SD = 0.48)	(SD = 0.58)	(SD = 0.35)
Eyes test	0.60	0.69	0.51	0.66	0.62	0.74
	(SD = 0.11)	(SD = 0.11)	(SD = 0.07)	(SD = 0.07)	(SD = 0.12)	(SD = 0.07)

Late signers and oral deaf participants showed significant differences both in the social-cognitive and social-perceptual component of ToM, compared to hearing peers. Late signers showed lower scores in Look Prediction, $t(22.09) = -3.01, p = 0.006$, in Strange Stories, $t(28) = -5.54, p < 0.0001$, and in the Eyes-test, $t(27) = -6.26, p < 0.0001$, than hearing peers. Oral deaf participants showed lower scores in Look Prediction, $t(32) = -2.05, p = 0.048$, in Strange Stories, $t(23.87) = -2.13, p = 0.043$, and in the Eyes-test, $t(32) = -3.41, p = 0.002$, than hearing peers.

Native signers showed a significant difference in the social-perceptual component of ToM (Eyes-test) compared to hearing peers, $t(29) = -2.23, p = 0.049$.

3.2. Verbal IQ and ToM

Hierarchical regression analyses (HRAs) were carried out to examine whether the significant differences found between deaf and hearing participants in ToM depended on vIQ. ToM measures served as dependent variables, vIQ (which was centered) and hearing status (which was dummy coded) served as independent variables. In a given HRA, the predictors were: (Step 1) vIQ, (Step 2) hearing status.

The role of vIQ was considered for the comparison between native signers and hearing peers for both components of ToM. The results indicated that the models were not significant.

When late signers and hearing peers were compared, the results indicated that vIQ was the only significant predictor for the social-cognitive component of ToM, while hearing status was the only significant predictor for the social-perceptual component of ToM. The results from the model are reported in Table 3.

Table 3. Hierarchical regression analyses for late signers and hearing peers

	Look prediction		Strange stories		Eyes test	
	ΔR^2	<i>B</i>	ΔR^2	<i>B</i>	ΔR^2	<i>B</i>
Step 1	0.18*		0.68***		0.51***	
vIQ		0.43*		0.85***		0.71***
Step 2	0.06		0.00		0.09*	
vIQ		-0.01		0.80**		0.70
Group		0.51		0.03		0.62*
Total R^2	0.18*		0.68***		0.60***	
<i>n</i>	29		29		28	

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 4. Hierarchical regression analyses for oral deaf and hearing peers

	Look prediction		Strange stories		Eyes test	
	ΔR^2	<i>B</i>	ΔR^2	<i>B</i>	ΔR^2	<i>B</i>
Step 1	0.35***		0.39***		0.31**	
vIQ		0.59***		0.62***		0.56**
Step 2	0.03		0.03		0.13*	
vIQ		0.54**		0.57***		0.40
Group		0.17		0.17		0.39*
Total R^2	0.35***		0.39***		0.34**	
<i>n</i>	33		33		33	

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

When oral deaf adults and hearing peers were compared, the results indicated that *vIQ* was the only significant predictor for the social-cognitive component of ToM, while hearing status was the only significant predictor for the social-perceptual component of ToM. Results from the model are shown in Table 4.

4. Discussion

As regards the first aim, when each deaf group and its hearing group were compared, the results underlined some specificities both among the three deaf groups and the two ToM components (social-cognitive and social-perceptual components). (Tager-Flusberg, 2000) When the social-cognitive component was considered, the results underlined that late signers and oral deaf participants had lower scores in Look Prediction and Strange Stories than the hearing peers. Native signers' performance did not significantly differ from that of hearing peers.

These results expanded the evidence available on deaf children (Courtin, 2000; Courtin & Melot, 1998; de Villiers, 1997; de Villiers & de Villiers, 2000; Lecciso et al., 2013; Marchetti et al., 2006) and confirmed results from the single study on deaf adults (Hao et al., 2010). Mainly, our results showed that the difficulties of oral deaf adults and late signers in the social-cognitive component of ToM persist also during adulthood and pertain both standard/basic and advanced ToM level. By contrast, native signers showed a performance similar to hearing peers to this component of ToM both in childhood (Courtin & Melot, 1998; Peterson & Siegal, 1997, 1999; Peterson et al., 2005; Woolfe et al., 2002) and adulthood (Hao et al., 2010).

When the social-perceptual component was analyzed, present results showed lower performance in all of the three groups of deaf adults compared to their hearing peers in recognition of mental states through the eyes (Eyes Test-adult version). Although research on the social-perceptual component in deaf children and adolescents showed a progressive improvement in the recognition of basic emotions through the eyes, (Hopyan-Misakyan et al., 2009; Most & Aviner, 2009) our results confirmed the study (Lecciso et al., 2013) which found that difficulties remained stable during adulthood in the recognition of complex emotion through the eyes.

A complex picture seems to emerge from our results. While late signers and oral deaf participants performed worse than hearing peers in both components of ToM, native signers showed similar ToM abilities to hearing peers in the social-cognitive component, but they scored lower than hearing peers in the social-perceptual component. It seems that for native signers the two ToM components are dissociated as previously found in autistic children (Baron-Cohen et al., 1997) who preserved the social-cognitive component but not the social-perceptual component. These specific difficulties of native signers in the social-perceptual component could depend on the fact that they needed to focus on the whole face and body gestures when interacting with other people. As demonstrated by Vinson, Cormier, Denmark, Schembri, and Vigliocco (2008) for deaf signers emotional information must be conveyed through visual cues like movement and position of the hands, face, eyes, torso, and shoulders. Also Morgan and Wool (2007) and Roberts and Hindley (1999) stated that the hands and whole face are the most important cues for emotional understanding for deaf signers. It follows that, compared to hearing peers, they show a delay in that mentalistic comprehension based only on the visual channel (i.e. social-perception component). The native signers' performance in the social-cognitive component of ToM may be due to the fact that it may require different ways of accessing reality, rather than the visual-body channel. Further studies should analyze this hypothesis in greater depth.

The second aim of this research was to assess the association between verbal ability, measured as Verbal IQ, and the two components of ToM in deaf and hearing participants. When the social-cognitive component was analyzed, the regressions showed a significant effect of verbal ability on both second-order false belief reasoning and understanding of implicit mental states (i.e. Strange Stories) for late signers and for oral deaf adults. On the one hand, this finding confirmed the association between verbal ability and ToM found in the literature on deaf children and adults (Hao et al., 2010; Russell et al., 1998). On the other hand, this result confirmed on deaf adults Tager-Flusberg and Sullivan's hypothesis (2000)

of the association between language and the social-cognitive component. When the social-perceptual component was analyzed, the regressions did not find significant effect of verbal ability on ToM for all of the three groups of deaf. Specifically, for late signers and the oral deaf adults the analyses pointed out that the only significant predictor was hearing status. Our results confirmed Wang et al's findings (2011) who found an association between the facial recognition of basic emotions and verbal ability in oral deaf children. However, they did not confirm Lecciso, Petrocchi and Marchetti's results (2013) who found that verbal ability had an effect on Eyes Test performance of deaf children and adolescents.

It is possible that in deaf subjects there is a developmental continuum in the association between the social-perceptual component and language in advanced ToM performance (Eyes-test adult version). While verbal ability in childhood seems to be involved in the recognition of mental states through the eyes, it is no more necessary in young deaf adults. These results confirm Tager-Flusberg and Sullivan's (2000) speculative hypothesis which states that the social-perceptual component is not linked to verbal ability. Our findings highlighted also that deafness is the most important variable in determining the performance of late signers and oral deaf participants and showed that the presence/absence of deafness plays a causal role for this component of ToM.

5. Conclusions

The comparisons between deaf and hearing adults underlined mentalistic difficulties in both components of ToM for late signers and oral deaf and in social-perceptual component of ToM also for native signers. The difficulties of late signers and oral deaf adults in the social-cognitive component were not linked to their deafness status, but to their verbal IQ. It is well known that language development is the most problematic aspect linked to deafness (Marcelli, 1989) and that it is associated with ToM understanding (Milligan et al., 2007). Our results confirmed the evidence and showed that the delay in this ToM component depends on language difficulties and not on deafness per se.

Our results are in line with the socio-conversational hypothesis by Peterson and Siegal (1995, 1999) stating that the main factor explaining the deaf adults' delay in mentalistic ability is the conversational deprivation in daily interactions with hearing caregivers from the first years of childhood. The good performance of native signers in ToM tasks is a confirmation of this trend. Because they share a conversational channel to communicate with parents (i.e. signs) they develop the social-cognitive component of ToM as their hearing peers do. In that vein, an early intervention to develop verbal ability or to reduce conversational deprivation could enhance social-cognitive ToM abilities in late signers and oral deaf adults.

The difficulties in the understanding the social-perceptual component in all three deaf groups of deaf adults underlined that this component is the most challenging for them because it is not linked to their verbal ability, but to deafness per se. The visual channel, the most important one for the social-perceptual component, may be used by deaf adults in a different manner than hearing adults. While for hearing people it is a preferential channel for ToM understanding, for deaf adults, especially for signers, emotional information must be conveyed through the hands and whole face (Morgan & Woll, 2007; Roberts & Hindley, 1999).

The present study has several limitations. First, the narrowness of the three groups of deaf participants (native, signers, late signers, oral deaf) which reflects the difficulty to reach large community of deaf people as found also in other research with deaf adults (Rommel & Peters, 2009; Siegal, 1997). This is an important limitation to the generalization of the data that could be overcome with repeated research on the same topic. Second, our study considered the vIQ as a concurrent variable in determining the ToM performance of deaf and hearing participants. Further research are needed on this field to analyze other variables that emerged in literature as associated with ToM, such as interpersonal trust (Lecciso, Petrocchi, Sempio, & Marchetti, 2011; Rotenberg, Petrocchi, Lecciso, & Marchetti, 2015) and attachment (Lecciso et al., 2013). Third, our research administered three tasks to measure ToM: future research should analyze this ability with a wider range of instruments, for example, to better understand the role played by the visual channel on ToM understanding.

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