

A study about the Theory of Mind in primary and secondary aging

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Abstract

The present study investigates the differences in theory of mind tasks based on cognitive functioning and the influence of status variables: age, gender and education. The sample recruited is composed of 280 subjects aged between 65 and 94. Participants are administered one test to investigate the cognitive functioning and one theory of mind task. Results show that the presence of cognitive impairment appears to increase the difficulty in theory of mind tasks.

Also, the study explores how certain status variables affect the understanding of mental states in the sample with primary or physiological aging (206 subjects). In particular, success in the understanding of the theory of mind task undergoes a decline with increased aging. There is a significant correlation between performance and additional years of schooling. Theory of mind, however, is independent of the variable gender, men and women do not differ in their performance.

Keywords: Theory of mind, ToM, Aging

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1. Introduction

The Theory of Mind (ToM) is the ability to attribute mental states such as desires, intentions, thoughts and beliefs and to predict and explain each person's behavior based on these inferences (Maylor, Moulson, Muncher, & Taylor, 2002; Camaioni, 2006). This ability is also called *folk psychology* (Fodor, 1987), and describes and explains the naive understanding of others' behavior and creates a sense of the world around oneself.

Theory of mind has been widely studied in children, in order to study the exact period of onset, as well as in a clinical population with patients who had suffered head injury, schizophrenia or autism. Less has been done to know what changes there are over the life span in the ToM, and if age influences the rise, decline or stability of ToM. The Happè, Winner and Brownell study (1998) is considered the first work about theory of mind in the normal aging. In order to explore the effects of age on the theory of mind, the authors have given tasks of theory of mind through stories (*Strange Stories Test*) which ask participants to make inferences about the understanding that a protagonist of the story has about the mental state of another individual. Results show a better performance in the group of 19 elderly aged subjects (mean age 73 years) than the group of 52 young subjects (mean age 21 years). The authors suggest that the increase with aging of wisdom and social intelligence can lead to better performance in the theory of mind tasks. In another study, no differences were found regarding the age influence on the theory of mind (Winner, Brownell, Happè, Blum, & Pincus, 1998; MacPherson, Phillips, & Della Sala, 2002; Keightley, Winocur, Burianova, Hongwanishkul, & Grady, 2006; Slessor, Phillips, & Bull, 2007). In particular, Slessor *et al.* (2007) compare a group of 40 young (mean age 20 years) people and a group of 40 older people (mean age 67 years) in ToM tasks (*Strange Stories Test*) there are no difficulties for the elderly.

However, other recent research which used similar verbal tasks, found that the theory of mind declines with age (Saltzman, Strass, Hunter, & Archibald, 2000; Maylor *et al.*, 2002). Maylor *et al.* (2002) in two experiments, which require an understanding of ToM tasks (*Strange Stories Test*), with or without memory load, compare the performance of a group of 25 young people with one of two groups of elderly (25 young older-mean age 67 years and 25 older older-mean age 81 years). The authors show that the performance in ToM tasks with memory load, is worse for the two groups of the elderly, however when reducing the memory load, the impairment of ToM disappears for the group of young elders.

Charlton, Barrick, Markus and Morris (2009) have done a research on a sample of 106 subjects aged between 50 and 90 years, divided into four age groups: 50-59 years old ($n = 27$); 60-69 years old ($n = 27$); 70-79 years old ($n = 31$); and 80-89 years old ($n = 21$). The authors have used theory of mind

tasks and tasks designed to investigate the verbal intelligence and the performance intelligence, the executive functions, the speed of information processing, the cognitive impairment and depression. They found a measure of brain structure using magnetic resonance imaging. The results show that the performance of ToM tasks is adversely/negatively affected by the advance of age and that the intelligence performance, the executive functions and the speed of information processing, influence mental tasks. There are also significant correlations between the ToM and the measure of the integrity of white matter, but not the internal volume of the brain.

2. Research objective and hypotheses

There is very little literature on the theory of mind in aging and it is often in contradiction; this work aims to study ToM in normal aging, studying the influence of cognitive and status variables.

The first objective is to investigate the theory of mind in relation to cognitive functioning, by comparing participants with normal or primary aging (Birren & Schroots, 1990) and participants with cognitive impairment (mild and moderate). The hypothesis that is to be studied retains that the ability to understanding other minds is influenced by cognitive functioning, and therefore it deteriorates in subjects with cognitive impairment. A second objective investigates the performance in theory of mind tasks using stories, and whether or not these performances are influenced by status variables as age, gender and education. It is known in the literature that these variables can influence cognitive performance in the aging, both verbal and non verbal measures (cfr. Kaufman & Kaufman, 1990). The first variable studied is the level of education. The research suggests that the level of adult education lessens according to age. These differences influence cognitive and neuropsychological test scores (Stratta, Rossi, Mancini, Cupillari, Mattei, & Casacchia, 1993; Uchiyama, Mitrushina, D'Elia, Satz, & Matthews, 1994). However, the conditioning of this variable on the performance of theory of mind tasks was not evaluated in the past, except by Maylor and other authors (2002) that show how they criticized the work of Happè *et al.* (1998). Hence in the research they recruited older people from universities for older people, therefore more educated than the average of the sample normal aged. In this study we will evaluate the effect on ToM tasks both of education and of the sampling. It is known that the level of education of older people is lower than that of the young older. This variable is very important when studying the effect of age that could be mediated by the effect of education. So, in this work the effect of education is statistically controlled by studying the effects of age.

With regard to the effect of the age on ToM tasks, data in the literature show conflicting results. In fact, sometimes the older subjects have a better of the best

performance (Happè *et al.*, 1998) and other times the younger subjects perform better (Maylor *et al.*, 2002). Age-related changes in neuronal functioning are particularly evident in the frontal and temporal lobes (West, 1996; Greenwood, 2000), the brain regions most often associated with ToM (Frith & Frith, 2003; Apperly, Samson, Chiavarino, & Humphreys, 2004), suggesting that the ToM may decline with age. On the contrary, it is argued that older people have more experience in social skills as, for example, representing the mental states of others (Happè *et al.*, 1998) and given priority to social and emotional information processing (Carstensen, Isaacowitz, & Charles, 1999). This work explores differences by comparing the results of three groups of elderly: young-older (65-74 years), older (75-84 years) and big-older (85-94 years). Finally, the effect of the gender variable will be taken consideration due to the fact that in previous works the possibility of an effect in solving ToM tasks was neglected.

3. Method

3.1 Participants

The sample of this study is composed of 280 participants (149 females and 131 males) aged between 65 and 94 years old, with an average age of 78 years old ($SD = 7.60$) from central Italy (Lazio and Umbria). The participants are divided into three age groups: from 65 to 74 years old ($n = 94$: 50 females and 44 males), from 75 to 84 years old ($n = 110$: 58 females and 52 males) and from 85 to 94 years old ($n = 76$: 41 females and 35 males). The sample is divided into three levels of education: 0-5 years of education (elementary school) ($n = 78$: 42 females and 36 males); 6-13 years of education (middle or high school) ($n = 54$: 26 females and 28 males); 14-18 years of education (degree) ($n = 44$: 21 females and 23 males). The participants have an average of 9 years of education, 46% have at most a primary school education level, 34% have finished middle or high school and 20% have graduated. There is a prevalence of participants with middle or high school level education in the age group from 65 to 74 years old. With the highest percentage of primary school level of education in the other two groups. This distribution is given by a higher level of education of the younger participants, due to social and economic changes, which have improved and widened the possibility and opportunity to further one's level of education.

To verify the presence of participants with cognitive impairment and identify participants with normal or primary aging, the sample was submitted to the *Mini Mental State Examination* (MMSE, Folstein, Folstein, & McHugh, 1975), which is one of the most community used tools in neuropsychological research for a brief screening of cognitive impairment. The MMSE is composed of 11 items that investigate the following: temporal orientation, spatial orientation, immediate memory, attention/concentration, delayed recall, naming, verbal

repetition, verbal comprehension, writing, reading a sentence and constructional praxis. The MMSE has a scoring range from 0 to 30 points, with any score below 24 indicating cognitive impairment. The raw scores are corrected with the table of Magni, Binetti, Bianchetti, Rozzini and Trabucchi (1996) for age groups and level of education. The sample has a medium score corrected by table of Magni *et al.* (1996), equal to 25.32 ($SD = 2.63$). The analysis made by the MMSE divided the sample into three groups of participants: 1) a *group with normal or primary aging* (with scores on the MMSE higher than the cut-off 24), composed of 206 participants; 2) a *group with mild cognitive impairment* (with scores of 21 to 23), composed of 56 participants; 3) and last *group with moderate cognitive impairment* (with scores of 11 to 20), composed of 18 participants. Table 1 shows the frequency distribution of participants for cognitive assessment, age and gender. Relative to the group with primary aging ($n = 206$) equally distributed into three age groups and gender, this particular group is influenced by level of education ($F_{(2,203)} = 3.291, p < 0.05$). In particular, the first age group (65-74 years) had a mean level of education of 10.89 years ($SD = 5.06$), which is higher than the other two groups of older participants. In regard to participants aging from 75-84 years old the average level of education is equal to 8.96 years ($SD = 5.01$), and for the participants aging 85-94 years old the level of education is equal to 8.91 years ($SD = 5.78$). The study does not distinguish differences of level of education between the gender ($F_{(1,204)} = 0.292, p = 0.589$): the average level of education of the males is 9.45 years ($SD = 5.39$) and the average level of education of the females is 9.84 years ($SD = 5.22$). The average level of education of the group with mild cognitive impairment is to 7.12 years ($SD = 4.55$) while the average level of education of the group with moderate cognitive impairment is to 5.55 years ($SD = 3.50$).

Table 1 - Description of the groups according to cognitive evaluation, age and gender

	65-74 years	75-84 years	85-94 years	Total
Subjects with primary aging: 22 < MMSE < 30	n = 74 (F = 39, M = 35)	n = 78 (F = 42, M = 36)	n = 54 (F = 26, M = 28)	N = 206 (F = 107, M = 99)
Subjects with mild cognitive impairment: 21 < MMSE < 23	n = 17 (F = 9, M = 8)	n = 22 (F = 10, M = 12)	n = 17 (F = 12, M = 5)	n = 56 (F = 31, M = 25)
Subjects with moderate cognitive impairment: 11 < MMSE < 20	n = 3 (F = 2, M = 1)	n = 10 (F = 6, M = 4)	n = 5 (F = 3, M = 2)	n = 18 (F = 9, M = 9)
Total	n = 94 (F = 50, M = 44)	n = 110 (F = 58, M = 52)	n = 76 (F = 41, M = 35)	n = 280 (F = 149, M = 131)

3.2 Materials

Aside from using the MMSE for a cognitive screening and a questionnaire for biographical data of the participants, to measure the ToM the Stories for Images were used (Baron-Cohen, Leslie, & Frith, 1986). The test was composed of a series of three stories. Each story consisted of four illustrations put in order by the investigator in front of the participant and presented one at a time. The investigator then asked the participant to tell a story by looking at the illustrations. The three stories were correlated to three different situations: a mechanical story, where there is no human characters; a behavioral story, where there are the human characters but the status of their mental status is not asked; and a mentalistic story, where there are human characters and the participant must understand their mental state. In particular, the mechanical story is composed of a sequence of 4 images represented by 4 images: 1) a balloon that escapes the hand of a person; 2) the balloon floating away in the air; 3) the balloon being shown next to a tree; 4) the balloon colliding with on the branches of the tree and bursting. In the behavioral story the sequence of the 4 images is made by: 1) a child walking on the street; 2) the child entering a candy shop; 3) the child buying candies; 4) the child leaving the shop with a bag of candies. At last, the third mentalistic story is represented by the following 4 images: 1) a child hiding a candy in a box; 2) the child going outside to play with a ball; 3) the child's mother opening the box and eating the candy; 4) the child coming back home, opening the box and is surprised to not see the candy in the box.

For the assessment is there has been built *ad hoc* a grid of assessment based on the indications of Baron-Cohen *et al.* (1986) and identified the following three measure that will be considered in this research: the description of the cause and/or effect, the comprehension of causal connection and the psychological lexicon used in the stories.

1) The degree of *description of the cause and/or the effect of the stories* is rated on a Likert scale 4 points, where "0" corresponds at a story that is not codified, "1" at a description of the story where it is not expressed neither the cause nor the effect, "2" corresponds to a description of the story where it is expressed the cause or the effect (partial description), and "3" at a description of the story where it is expressed both the cause and effect. For example, it attributes a capacity for full description of the cause and of the effect at the mechanical story when the participant says: "*the balloon goes near to a tree/branches*" and "*the balloon bursts*".

2) The capacity to *understand the causal connection* of the story, is defined when the participant inserts in the telling of the story a particular statement (provided by the Authors) that represents this capacity. In particular, the participant is given a positive score when they say: for the mechanical story "*the balloon crashed into branches and bursts*"; for the be-

havioral story “*the character goes out of the shop with a bag of candy*”; and for the mentalistic story “*the character is surprised*”.

3) To analyze the *psychological lexicon* used in the telling of the story the following categories of mental state are considered: perceptual (for example, to see, to feel, to look, to observe and to sight), positive emotional (for example, to love and to like), negative emotional (for example, to be sorry and to be afraid), volitional (for example, to want, to wish and to prefer), cognitive or epistemic (for example, to realize, to think, to know and to remember). That variable is given by the total of the terms to the different mental states (Longobardi, Piras, & Presaghi, 2008).

The answers given in the task stories for images are encoded by the person administering through an evaluation grid. The investigator then reviews all answers to be sure of its assessment. Two independent coders analyzed the answers given by participant to the task. The agreement index of evaluation between the two coders is equal to .95. After all, the investigators, through a big confront, have come to a unified coding.

3.3 Research design

The battery of tests were administered to participants recruited through random sampling to cascade. All participants were tested individually with a meeting for about an hour, with the same procedure and order of administration: the questionnaire, the MMSE and at last the task of Stories of images. The participants, to have more spontaneity, were interviewed in an environment familiar to them, such as their home, senior center at home of relatives or friends.

4. Results

4.1 Theory of mind and cognitive functioning

To verify the first hypothesis there were considered the scores of the tasks of the three stories (mechanical, behavioral and mentalistic) comparing participants with primary aging ($n = 206$) with those with mild cognitive impairment ($n = 56$) and moderate ($n = 18$). However, since there is a statistically significant difference in the educational level of these three groups, for the comparison of average performance on ToM measures, it was decided to conduct an Analysis of Variance with the education variable as a covariate (ANCOVA).

The results of the tasks of the three stories show that the participants with cognitive impairment (mild and moderate) describe fewer cause and / or the effects of the stories presented ($F_{(2,277)} = 10.59, p < .0001$) and show the worst performance in understanding of their causal connection ($F_{(2,277)}$

= 5.64, $p < .005$); on the contrary, they do not differ significantly in the use of psychological lexicon ($F_{(2,277)} = 0.66$, n.s.). Table 2 lists the means and standard deviations of the three groups on the three dependent ToM variables, with post-hoc comparisons that show significant results among the three groups.

Table 2 - *Understanding of the tasks of ToM stories in relation to cognitive functioning of subjects: mean (standard deviation), F values, p and significant post-hoc*

	(A) Older people with primary aging n = 206	(B) Older people with mild impairment n = 56	(C) Older people with moderate impairment n = 18	$F_{(2,277)}$	p	Post-hoc* (Fisher LSD)
	(MMSE: 24-30) Mean _{MMSE} =26,50 sd _{MMSE} =1,55	(MMSE: 21-23) Mean _{MMSE} =21,8 4 sd _{MMSE} =1,20	(MMSE: 11-18) Mean _{MMSE} =21,8 4 sd _{MMSE} =1,20			
Description of causes and/or effects in stories	6.26 (2.65)	4.89 (2.92)	2.67 (2.79)	10.59	.0001	A>B; A>C; B>C
Understanding causal connection in stories	0.94 (0.84)	0.53 (0.71)	0.17 (0.38)	5.64	.005	A>B; A>C
Psychological lexicon in stories	4.94 (5.63)	3.98 (4.17)	1.83 (3.05)	0.66	n.s.	

n.s. = not significant

* significant $p < 0.05$

4.2 Theory of mind and status variables

Since the focus was to be on normal physiological aging, the present study on the effect status variables such as age, gender and education has been carried out on old participants with primary aging ($n = 206$).

- Study of *education* effect. A one-way analysis variance showed how participants with more years of education have better results in both the description of the causes and / or effects inherent in the stories ($F_{(2,203)} = 15.43$, $p < .0001$), both in understanding of their causal connection ($F_{(2,203)} = 15.81$, $p < .0001$), and the use of psychological terms ($F_{(2,203)} = 19.66$, $p < .0001$). Table 3 gives the averages and standard deviations of the three education groups on the three dependent variables studied ToM, with post-hoc comparisons that has showed superior performance as well as those with an average level of education (6-13 years) compared to those who have a low level of education (0-5 years).

Table 3 - *Understanding of the ToM tasks in reference to the numbers of years of schooling of the subjects: mean (standard deviation), F value with their p and significant post-hoc*

	(A) 0-5 years n = 81	(B) 6-13 years n = 81	(C) 14-18 years n = 44	$F_{(2,203)}$	P	Post-hoc* (Fisher LSD)
Description of causes and/or effects in stories	5.20 (2.96)	6.54 (2.30)	7.70 (1.71)	15.43	.0001	C>A; C>B; B>A
Understanding causal connection in stories	0.65 (0.69)	0.94 (0.90)	1.48 (0.70)	15.81	.0001	C>A; C>B; B>A
Psychological lexicon in stories	3.00 (3.45)	4.64 (4.52)	9.04 (8.15)	19.66	.0001	C>A; C>B; B>A

significant $p < 0.05$

- *Study age effect* . Before studying the effect of age one must synthesize two important results of this research: 1) in the older population, the ToM tasks studied were effected by level of education; 2) in the sample of participants with normal aging the level of education is not balanced in the three age groups considered. Infact it was revealed that younger participants have higher educational levels than older participants. Therefore the study of the age effect should not be effected by the level of education of the sample. The ANCOVA was been implemented. The Ancova is the Analysis of Variance using the education variable as a covariate. The results showed that by controlling the education effect, it is evident that an age effect on the variable description of the causes and / or effects ($F_{(2,203)} = 8.59$, $p < .0001$), with the older group showing the worst performance. On the contrary, there are no differences in the age for the variables in causal connection stories ($F_{(2,203)} = 1.91$, n.s.) and psychological lexicon ($F_{(2,203)} = 0.92$, n.s.). Table 4 shows the average performance of the normal older group compared to three age groups with post-hoc.

Table 4 - Understanding of the ToM tasks with regard to age

	(A) 65-74 years n = 74	(B) 75-84 years n = 78	(C) 85-94 years n = 54	$F_{(2,203)}$	p	Post-hoc* (Fisher LSD)
Description of causes and/or effects in stories	7.04 (2.29)	6.40 (2.46)	5.00 (2.94)	8.59	.0001	A>C; B>C
Understanding causal connection in stories	1.13 (0.91)	0.90 (0.75)	0.74 (0.80)	1.91	n.s.	
Psychological lexicon in stories	4.88 (4.96)	4.83 (5.69)	5.17 (6.44)	0.92	n.s.	

n.s. = not significant

- Study *gender* effect. Investigates whether gender influences performance on the ToM story tasks. It was examined whether the two genders differ in educational level and it was found that there is no difference in level of education between females and males ($F_{(1,204)} = 0.292$, n.s.: women's average level of education = 9.44 ($SD = 5.39$), men's average level of education = 9.85 ($SD = 5.22$). Thus, there has been an ANOVA one-way with the gender variable as an independent variable and the three ToM variables as dependent variables. The results (see Table 5) emerged as both sexes got similar scores in the three stories. Men and women show a similar capacity for description of the causes and / or effects ($F_{(1,204)} = 1,73$, n.s.), understanding causal connection ($F_{(1,204)} = .63$, n.s.) and use the same psychological lexicon ($F_{(1,204)} = 2.67$, n.s.). Table 5 shows the average performance for the two sexes.

Table 5 - Understanding of the ToM tasks with regard to age and gender (covariate: education)

	Males n = 99	Females n = 107	$F_{(1,204)}$	p
Description of causes and/or effects in stories	6.49 (2.50)	6.01 (2.79)	1,73	n.s.
Understanding causal connection in stories	0.90 (0.85)	0.99 (0.83)	0,63	n.s.
Psychological lexicon in stories	5.55 (5.82)	4.27 (5.36)	2,67	n.s.

n.s. = not significant

5. Discussion and conclusions

The primary focus of the present research was to understand if the ability to attribute mental states and predict behavior, on the basis of such inferences, changes in relation to cognitive functioning, and to the status variables as age, gender and level of education. It first became clear through a screening test (MMSE, Folstein *et al.*, 1975) how many subjects appeared to share a possibility of cognitive impairment. In order for them to then be compared with primary or physiological aging individuals. It was discovered that 26% of the total sample is shown to have a score below the MMSE cut-off. As suggested, comparing the performance obtained with the tasks of theory of mind by subjects with primary aging with that of subjects with cognitive impairment (mild to moderate both), it was concluded that the latter gets a lower performance in the stories tasks. Subjects with cognitive impairment in respect to those with primary aging, describe to a lesser extent the causes and / or effects derived from the stories. They also understand to a lower extent the causal connections of the stories. However, there are no differences with normal subjects who used the psychological lexicon. Therefore, the results show that the description and understanding of the causal connection of the stories require a higher level of cognitive processing of responses, compared with the ability to use verbal mentalistic labels. This data could indicate that to understand the causal relationships in stories, including mentalistic ones, in which one asks the subject to attribute mental states to the protagonists, requires certain skills. These skills can be deficit in patients with cognitive impairment. Given the results subjects with cognitive impairment were excluded from the subsequent analysis, and analysis was more focused on the theory of the normal aging mind. Inspired by the work of Happè *et al.* (1998) in which elderly people, recruited from senior universities, have a better performance in respect to the young, the study investigates if the level of education influences the performances and if it mediates the effect of age. In the understanding of the theory of mind in regards to the three stories, there is a significant difference between the three levels of schooling considered. There is a clear difference in performance to the task as a function of years of education. Better educated individuals are more successful in responding to the tasks of the stories than those who were less educated. Therefore, by statistically controlling the variable level of education, we tested the effect of age on the ToM performance. The results show that younger subjects have less difficulty in describing the causes and / or effects detectable in the stories than older subjects. However, there are no differences in age in the ability to identify causal connections and the use of psychological lexicon. These results seem to be partly in line with the study of Maylor *et al.* (2002), who noted a better performance of the group of young-elderly (mean age 67

years) compared to the old-elderly (mean age 81 years) in the tasks of *theory of mind* without load memory, while in the tasks of ToM with load memory they showed a decline with age. It should be stated, however, that the ToM tasks used in the present study differ from those used by Maylor *et al.* (2002). The first are visual narrative tasks while the second are a verbal processing of written material tasks (*Strange Stories Test*). The literature does not take into account variables such as gender and level of education. For example, the present study is part of a research area that is still unexplored. The results of this research show that the gender variable does not affect the performance in the three stories, and that there is no significant difference between males and females.

This work opens new development scenarios. It may be to better investigate the behavior of subjects with cognitive impairment and to identify which factors, together with level of education and cognitive decline, could be an obstacle or a strengthening factor in solving tasks of ToM; for example, the level of intelligence and integrity of executive functions may play an important role. Also, the social value of the theory of the mind and its implications in everyday life can lead to a deeper impact on the ability to a steady daily workout that can be implementation into daily life (Laicardi & Pezzuti, 2000).

It could eventually raise interest in the construction of ad hoc incentives for the daily operation of the capacity for mentalization by the elderly in rehabilitation, recovery or entertainment settings.

References

Apperly, I. A., Samson, D., Chiavarino, C., & Humphreys, G. W. (2004). Frontal and temporo-parietal lobe contributions to theory of mind: Neuropsychological evidence from a false-belief task with reduced language and executive demands. *Journal of Cognitive Neuroscience*, *16*, 1773-1784.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1986). Mechanical behavioural and Intentional understanding of picture stories in autistic children. *British Journal of Developmental Psychology*, *4* (2), 113-125.

Birren, J. E., & Schroots, J. J. F. (1990). Concept of time and aging in science. In Birren J.E., Schiaie K.W. (editors), *Handbook of psychology of aging* (terza edizione) (pp. 44-64). New York: Academic Press.

Camaioni, L. (2006). *La teoria della mente. Origini, sviluppo e patologia*. Bari: Laterza.

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist*, *54*, 165-181.

Charlton, R. A., Barrick, T. R., Markus, H. S., & Morris, R. G. (2009). Theory of mind associations with other cognitive functions and brain imaging in normal aging. *Psychology and Aging, 24* (2), 338-362.

Fodor, J. A. (1987). *Psychosemantics: The problem of meaning in the philosophy of mind*. Cambridge, MA: Bradford Books/MIT Press (trad. It. Psicosemantica. Il problema del significato nella filosofia della mente, Bologna, Il Mulino, 1990).

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-Mental State" – A practical method for grading the cognitive state of patients for the clinicians. *Journal of Psychiatric Research, 12*, 189-198.

Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society of London B, 358*, 459-473.

Greenwood, P. M. (2000). The frontal aging hypothesis evaluated. *Journal of the International Neuropsychological Society, 6*, 705-726.

Happè, F., Winner, E., & Brownell, H. (1998). The getting of wisdom: theory of mind in old age. *Developmental Psychology, 34* (2), 358-362.

Kaufman, A. S., & Kaufman, N. L. (1990) *Kaufman Brief Intelligence Test*. Circle Pines, MN: American Guidance Service.

Keightley, M. L., Winocur, G., Burianova, H., Hongwanishkul, D., & Grady, C. L. (2006). Age effects on social cognition: faces tell a different story. *Psychology and Aging, 21*, 211-220.

Laicardi, C., & Pezzuti, L. (2000). *La psicologia dell'invecchiamento e della longevità*. Bologna: Il Mulino.

Longobardi, E., Piras, R., & Presaghi, F. (2008). Lessico psicologico nelle narrazioni dei bambini della scuola primaria. *Rivista di Psicolinguistica Applicata, VIII*, 1-2, 55-72.

MacPherson, S. E., Phillips, L. H., & Della Sala, S. (2002). Age, executive function, and social decision making: A dorsolateral prefrontal theory of cognitive aging. *Psychology and Aging, 17*, 598-609.

Magni E., Binetti G., Bianchetti A., Rozzini R., & Trabucchi M. (1996). Mini-Mental State Examination: a normative study in Italian elderly population. *European Journal of Neurology, 3*, 198-202.

Maylor, E. A., Moulson, J. M., Muncer, A., & Taylor, L. A. (2002). Does performances on theory of mind tasks decline in old age? *British Journal of Psychology, 93*, 465-485.

Saltzman, J., Strass, E., Hunter, M., & Archibald, S. (2000). Theory of mind and executive functions in normal human aging and Parkinson's disease. *Journal of the International Neuropsychological Society, 6*, 781-788.

Slessor, G., Phillips, L. H., & Bull, R. (2007). Exploring the specificity of age-related differences in theory of mind tasks. *Psychology and Aging, 22* (3), 639-643.

Stratta, P., Rossi, A., Mancini, F., Cupillari, M., Mattei, P., & Casacchia, M. (1993). Wisconsin Card Sorting Test performance and educational level in schizophrenic and controls samples. *Neuropsychiatry, Neuropsychology, and Behavioural Neurology, 6*, 149-153.

Uchiyama, C. L., Mitrushina, M. N., D'Elia, L. F., Satz, P., & Matthews, A. (1994). Frontal lobe functioning in geriatric and non-geriatric samples; An argument for multimodal analyses. *Archives of Clinical Neuropsychology, 9*, 215-227.

West, R. L. (1996). An application of prefrontal cortex function theory to cognitive aging. *Psychological Bulletin, 120*, 272-292.

Winner, E., Brownell, H., Happe, F., Blum, A., & Pincus, D., (1998). Distinguishing lies from jokes: Theory of mind deficits and discourse interpretation in right hemisphere brain-damaged patients. *Brain and Language, 62*, 89-106.