The effects of age and education on pragmatic features of verbal communication: Evidence from the Italian version of the Right Hemisphere Language Battery (I-RHLB)

Sergio Zanini (1,2), Karen Bryan (3), Guido De Luca (4), and Antonio Bava (1)

(1) Department of Physiology and Pathology, University of Trieste, Trieste, Italy;

(2) Neurology Clinic, University of Udine, Udine, Italy;

(3) European Institute of Health and Medical Sciences, University of Surrey, UK;

(4) Regional Institute for Physical Medicine and Rehabilitation, Udine, Italy.

To be submitted to: *Aphasiology*

Key words: RHD; Pragmatics; Verbal communication; Language

Running title: *Age and education effects on verbal pragmatics*

Address for correspondence: Sergio Zanini, MD PhD, Neurology Clinic, University of Udine, Piazza Rodolone 2, 33013 Gemona del Friuli (Udine), Italy. Tel: +39 0432 989288; fax: +39 0432 989336; e-mail: zanini.sergio@spes.uniud.it

Abstract

Background: The field of pragmatic impairments of verbal communication in cerebrally damaged subjects dates back almost three decades. However, a systematic investigation of pragmatic competences has never been completed in a large sample of normal adults controlling for age and education factors.

Aims: We aimed to examine the effects of age and education on the main features of pragmatics of verbal communication in a large sample of normal healthy subjects.

Methods and Procedures: We developed an Italian version of the Right Hemisphere Language Battery devised by Bryan (1995) and administered it to four hundred and forty normal volunteers. Ages ranged from 20 to 79 years, and education corresponded to Italian levels of education.

Outcomes & Results: We found that ageing and low education influenced performance on almost all the subtests of the I-RHLB. In particular, performance dropped at 70-79 years, particularly in those with the lowest level of education.

Conclusions: These results suggest that processing of the pragmatic features of verbal communication parallels the decline of other cognitive functions associated with ageing and low education that previous studies have already established.

Introduction

Over the last thirty years, pragmatic aspects of verbal communication have gained increasing interest in both theoretical and clinical neurolinguistic fields (Joanette et al., 1990; Paradis, 1999). Historically, pragmatics has been defined as "the relation of signs to interpreters" (Morris, 1938, p.6). More recently, some authors have proposed alternative, although still inevitably vague, definitions, such as "meaning minus semantics" (Levison, 1983, p. 32), "language use in specific communicational contexts" (Joanette et al., 1990), or a sort of interface between language structure (phonology, grammar, and semantics) and language use (Crystal & Varley, 1998). In other words, pragmatics concerns the study of the meanings that single verbal propositions (i.e. words or sentences) can assume according to the communication contexts where they are used (e.g. an ironic joke) or to the intentions of the speaker (e.g. an indirect request), or to the general knowledge of the world.

Single verbal pragmatic features, that have been investigated both in patients with cerebral damage and in healthy subjects, concern connotative meanings of words and propositions, figurative speech, metaphors and idioms, sarcasm, irony, indirect speech acts, emotive meanings of words and emotions to be inferred from context, inference of implicit meanings of verbal propositions, vocal pitch processing in emotional and linguistic prosody, and humour (i.e. interpretation of the moral, punch-line, and theme of stories). Along with these linguistic features, discourse abilities are subsumed to the pragmatic dimensions of language. Discourse refers to multi-componential linguistic-cognitive operations. In van Dijk's terms (1997), three dimensions of discourse can be identified: discourse as a verbal structure ("language use" in the author's definition), as the communication of beliefs ("cognition" in van Dijk's definition), and as action and interaction in social situations.

Traditionally, it has been assumed that all these pragmatic features share common cognitive operations. Clinical evidence for this has been recently emphasised by Myers (2001) who, recalling that pragmatic impairments of verbal communication are frequently encountered in "syndrome"-

like fashion in right hemisphere damaged populations, suggested labelling these deficits as the Right Hemisphere Damage syndrome. This definition is in line with the traditional view that while implicit language competencies (phonology, morpho-syntax, and semantics) recruit operations of the left hemisphere, the right hemisphere is more committed to processing pragmatic aspects of verbal communication (see, for a review, Joanette et al, 1990; Beeman & Chiarello, 1998; Paradis, 1999; Bryan & Hale, 2001). However, verbal pragmatic impairments have also been reported in patients suffering from traumatic brain injury (TBI) (McDonald et al., 1999; McDonald, 2000; Marquardt et al., 2001; Coelho et al., 2003; Youse et al., 2005) who usually have bilateral frontal lesions, in patients with Alzheimer's (Caramelli et al., 1998; Hays et al., 2004) or Parkinson's disease (McNamara & Durso, 2003), as well as in developmental disorders such as autism (see Martin & McDonald, 2003, for a review). In addition, in recent years, the strong dichotomy of denotative vs. connotative language, processed by left vs. right hemisphere respectively, has been challenged (e.g. see, for lexical processing, Chiarello et al., 2001, Faust et al., 2002, Chiarello et al., 2003, Hutchinson et al., 2003; for discourse, Braun et al., 2001; for idiom comprehension Papagno et al, 2003 and Oliveri et al. 2004).

Despite the increasing interest in pragmatic impairments of verbal communication, clinical tools for diagnosing such communication impairments are still very few. To our knowledge, only two batteries of tests, the "Right Hemisphere Communication Battery" (Gardner & Brownell, 1986), and the "Right Hemisphere Language Battery" (Bryan, 1995), have been developed.

Limitations in clinical tools and the lack of robust theories of cognitive correlates of pragmatic deficits (a sort of neuro-pragmatics), has lead to a large number of experimental studies, largely performed with patients with right hemisphere lesions, which present critical differences in testing materials and in selection criteria of both patients and healthy subjects (e.g. see Blake et al., 2003, on differences in identification of verbal pragmatic impairments among different clinicians). Therefore, it is not surprising that we are still far from drawing any firm theoretical or clinical conclusions concerning the biological bases of the pragmatics of verbal communication (see

Tompkins et al., 2002, and Martin & McDonald, 2003, for a critical review of studies where frontal lobe functions underpinning verbal pragmatics are emphasised). In particular, Tompkins et al. (2002) explicitly suggest that a systematic study of normal healthy subjects should be a starting point.

There are many variables that could influence the performance of experimental subjects on linguistic pragmatic tests such as ageing, education, and socio-cultural status. Controlling for all three of these factors is quite difficult as many variables determine socio-cultural status, but a systematic investigation of healthy subjects with different ages and levels of education is possible.

In order to achieve this, we developed an Italian version of Bryan's (1995) Right Hemisphere Language Battery for purely clinical purposes (Zanini & Bryan, 2003, Zanini et al, 2005). The RHLB was selected as a clinically usable battery of tests devised to recognise the presence/absence of pragmatic impairments, and secondly, as a battery of tests that taps the majority of verbal pragmatic features (Bryan & Hale, 2001). In this study we aimed to investigate the influences of age and education on processing the key features of pragmatic aspects of verbal communication in a large sample of normal subjects

A large body of literature on the effects of education on linguistic and cognitive abilities shows that low education is associated with poor performance (see reviews in Ardila et al., 1989; Rosselli et al., 1990; Evans et al, 1993, and Lyketos et al., 1999; Ardila et al., 2000). Also many studies on ageing consistently show a decline with age in several cognitive functions such as working memory (Brebion et al., 1995; Yamadori et al., 1999; Palladino & De Beni, 1999; Grant & Dagenbach, 2000; Oberauer, 2001), speed of processing (Kemper et al., 1993; Salthouse, 1996), executive/attention functions (Daigneault & Braun, 1993; West, 1996; Robbins et al., 1998; Phillips, 1999), and linguistic functions such as sentence comprehension (Maxim, 1982; Just & Carpenter, 1992; Maxim, 1999), verbal discourse comprehension (North et al., 1986), and written language comprehension (Cohen, 1979; Light & Anderson, 1985; Light, 1990; Van der Linden et al., 1999). However, systematic studies examining both age and education effects on pragmatic

aspects of verbal communication have not yet been conducted. In addition, how the cognitive functions, that have been shown to influence language processing, are related to verbal pragmatics, is still largely obscure. Indeed, a clear-cut boundary between language and linguistic pragmatics is still a matter of theoretical speculation. In the verbal pragmatic literature there is a large body of investigations on verbal pragmatic impairments following right hemisphere lesions that will not be reviewed here as these patients are recognised to manifest such communication deficits. By contrast, only a few studies have explicitly addressed the issue of the changes in cognitive functions sub-serving processing of linguistic pragmatics associated with age in normal subjects.

Some investigations have addressed the ability to make inferences on written text in the ageing population (Cohen, 1979; Cohen & Faulkner, 1983; Ulatowska et al., 1986; Hamm & Hasher, 1992; Wright & Newhoff, 2002). The majority of these studies were cognitively oriented as they aimed at determining the impaired cognitive operations underpinning the inability to make inferences. A reduced working memory capacity, reduced speed of processing, and impairment in inhibiting alternative interpretations of text were consistently suggested to determine the occurrence of inference deficits.

One study (Papagno et al., 1995) addressed the role of age and education in the comprehension of metaphors and idiomatic expressions without posing any theoretical interpretation of results. Papagno and colleagues recruited three hundred and twenty-two normal subjects with ages ranging from 19 to 94 years, and with years of education ranging from less than 5 to more than 13. Subjects were asked to verbally explain the true meaning of twenty metaphors and twenty idioms. Education but not age influenced performance on both metaphors and idiomatic expressions comprehension.

Duong and Ska (2001) investigated the production of narratives (a discourse dimension) in young and old subjects with high and low education. Both conceptual and organisational impairment was found among older subjects. Low education affected performance only in the older group. Similar results were reported also by Harris Wright et al. (2005) who showed that older

subjects produced less information on main events in a narrative production task based on pictures or picture sequences.

One recent study by Shammi and Stuss (2003) investigated processing operations concerning the appreciation of humour in a small sample of young (N = 17) and older (N = 20) normal volunteers. The main finding of the study was a decline in cognitive ability to appreciate humour although not in subjects' affective response to humorous materials (i.e. older subjects assigned humour ratings to stimulus items comparably to young people). In addition, a test-complexity factor was suggested to influence the performance of older subjects: the more cognitively demanding the task, the worse the performance. As well as having a small number of subjects, the Shammi & Stuss (2003) study had an education bias in that young subjects had more years of education than older ones.

In conclusion, research is still needed to analytically determine the cognitive bases of pragmatic processing phenomena and their relationship to age and education. The present study aims to systematically investigate the influence of age and education on the I-RHLB.

Methods

Subjects

We tested four hundred and forty normal subjects divided into subgroups according to age (i.e. one group per each decade: 20-29 years, 30-39 years, 40-49 years, 50-59 years, 60-69 years, 70-79 years), and years of education (i.e. 0-7 years, 8-12 years, 13-16 years, 17 or more years – these subgroups correspond to Italian education levels). Therefore, subjects were split into twenty-two subgroups according to age (6 classes) and education (4 levels). In fact, two groups were missing as there were no subjects belonging to the first two age classes who had only primary education (0-7 years of education) because the secondary level of education has been compulsory in Italy since the mid nineteen sixties. We included twenty people in each subgroup thus the total

number of healthy subjects was four hundred and forty (i.e. 20 people X 4 levels of education X 6 age groups minus 40 people = 440 people).

All subjects had no history of neurological or psychiatric diseases, and they were all free of drugs acting of the central nervous system.

Materials

We adapted to Italian the Right Hemisphere Language Battery (Zanini and Bryan, 2003, Zanini et al., 2005) originally devised by Bryan (Bryan, 1995). All pictorial materials were newly produced for the Italian version of the RHLB (I-RHLB).

The battery consists of six formal tests and of one quali-quantitative scale for the evaluation of eleven features of pragmatic skills in conversational setting (for extensive description of the battery, see Bryan 1995). The following is a short description of each test and of the conversational scale.

Lexical-Semantic test. This test taps the integrity of the lexical-semantic level. Six pictures are visually presented on a single plate. The position of pictures within the plate is randomly determined. The subject hears a word that refers to a target picture on the plate. The task is to indicate which, of the six pictures, represents the target word (correct response). Three semantically related distractors (semantic errors) are present (e.g. for the target word *fiume* – river, *riva* – bank, and *cascata* – falls, and one distractor which is semantically related to the target by means of functional attributes, *remare* – to row). In addition, a phonological distractor (e.g. in this example, *piume* – feathers), and a visual control (e.g. *ascensore* – elevator), phonologic and visual errors, respectively, are presented among the six pictures (see Appendix 1). The test includes twenty items and a familiarization trial. Each correct answer scores one. The maximum score is twenty.

Written Metaphor test. This test taps the ability to comprehend metaphors. One sentence and three interpretations are written on a single plate and are visible to the subject. The subject listens to the material presented verbally and is asked to point to the correct metaphorical interpretation of the sentence. The alternatives are the genuine metaphorical meaning (correct response), a primitive

metaphorical meaning (primitive error) that only focuses on an incidental aspect of the metaphor, and a metonymic interpretation (metonymic error) that merely replaces the sentence so that the two terms of the metaphor are interpreted literally without defying realism (see Appendix 2). Ten items and a familiarization trial are given. Each correct answer scores one. The maximum score is ten.

Picture Metaphor test. As for the Written Metaphor test, this test taps the ability to comprehend metaphors. The subject hears a sentence that includes a metaphor (selected metaphors were different to those in the Written Metaphor test). The task is to indicate which among four pictures depicted on a single plate and available to the subject, represents the correct metaphorical interpretation of the sentence. The alternatives are the correct one (correct response), the literal meaning (literal error), and two control pictures (visual errors) that depict one aspect of the sentence (see Appendix 3). Ten items and a familiarization trial are given. Each correct answer scores one. The maximum score is ten.

Inference test. This test taps the ability to comprehend inferential meanings in short paragraphs which describe a situation or event. Each paragraph (55-69 words long) has simple syntactic structures and it is printed on separate cards. The text is read by the examiner while the card is in front of the subject. Then, the subject is asked to answer four open questions in turn which require a simple inference from the information given in the text. The subject can refer to the text to give his/her response. Possible responses are the correct inference (correct response), incorrect inference (incorrect inference error), or a repetition of a part of the text without making any sort of inference (repetition-of-the-text error) (see Appendix 4). Three paragraphs and a familiarization trial are given. Each correct answer scores one. The maximum score is twelve.

Humour test. This test taps the ability to recognise the humorous punch-line of a short story. The story is written on a card and placed in front of the subject while the experimenter reads it. The subject is told to point to the humorous punch-line. Four choices are written on the same card: the correct punch-line (correct response), a straightforward ending of neutral content (neutral error), a straightforward ending of emotional content (emotional error) and a surprise ending that does not

relate to the body of the joke (incorrect error) (see Appendix 5). Ten items and a familiarization trial are given. The maximum score is ten.

Emphatic Accent test. This test taps the ability to recognise and subsequently use linguistic stress associated with "given" and "new" information. Ten sentences each having two clauses joined by a conjunction (*and* or *but*) are depicted in pairs of line drawings. The first clause is read by the examiner while pointing to the first picture. Then the subject is given the line drawing depicting the second clause and is expected to conclude the sentence by uttering the second clause stressing the element that corresponds to that stressed by the examiner in the first clause (e.g. *He sold the big car and* – being "*big"* stressed by the examiner, *bought a small one*, uttered by the subject who has to stress *"small"*) (see Appendix 6). Ten sentences and a familiarization trial are given. The maximum score is ten.

Analysis of Conversational Abilities. Eleven pragmatic features are evaluated in a conversational setting, namely during an introductory dialogue between the experimenter and the subject and during a spontaneous conversation arising whilst testing. The scale addresses: supportive routines (those concerned with politeness and affiliation), humour (appreciation of jokes and humour tone to conversation), questions (including indirect equivalents for gaining information), assertive routines (asserting rights and changing the behaviour of others by exerting initiatives such as making complaints, demands, criticism and giving advice), narrative (length of utterance as well as level of details), variety (of topic content and types of interaction such as giving information, expressing opinions and relating events), familiarity (level of formality between participants and the nature of the information disclosed), turn taking (the balance of interaction between the two participants), meshing (the timing of the interaction), discourse comprehension (coherence of utterances), and finally a prosodic rating for the first five pragmatic features. Each pragmatic feature can be scored from zero, if totally compromised, to four, if normal. The maximum score is forty-four.

Statistical analyses

Performance on each of the tests of the I-RHLB (i.e. accomplishment scores) were analysed by means of a multivariate ANOVA with raw data being transformed using the arc-sin procedure to avoid possible skewed distribution of results towards the top scores. Post-hoc analysis was conducted by means of Scheffe's test and *t*-test where necessary, with p values corrected following the Bonferroni's correction for multiple comparisons.

Error analysis was conducted by means of Chi-square tests. Where necessary, post-hoc Chi-square tests, with Bonferroni's correction for multiple comparisons, between expected and observed values were undertaken to determine which error type was prevalent. No error analysis was conducted on results from the Emphatic Accent test as no differentiation between errors types was possible (i.e. performance was either correct accentuation or incorrect) and on parameters considered in the Analysis of Conversational Abilities as no errors were present (i.e. pragmatic parameters included in the conversational scale were simply scored between 0 and 4).

Results

Descriptive statistical data namely mean performance and standard deviations for each age class and education on all the I-RHLB tests were previously published in Zanini et al. (2005).

We ran separate multivariate ANOVAs for accomplishment scores on each test of the I-RHLB with Age class (6 age groups) and Education (4 education levels) as main factors. Raw data were transformed following arc-sin procedure. The main factors Age class and Education were statistically significant in all subtests of the I-RHLB with the exception of Emphatic Accent and Lexical-Semantic tests, respectively. The interaction of Age group X Education reached statistical significance only in the Inference test (see Table 1) (Table 1 about here).

Then, we carried out post-hoc analysis of the main factors Age group and Education by means of Scheffe's tests (see Tables 2a and 2b) (Table 2a and 2b about here). As far as the Age factor was concerned, apart from performance on the Emphatic Accent test where performance were comparable across age groups, we found that the oldest people (70-79 years) had lower performance compared with: the youngest (20-29 years) on the Lexical-Semantic test, the three youngest groups (20-29, 30-39, 40-49 years) on the Written Metaphor and Humour tests, the four youngest groups (20-29, 30-39, 40-49, 50-59 years) on the Inference test, and the third youngest (40-49 years) on the analysis of Conversational Abilities. But on the Picture Metaphor test, a more linear decline of performance across age groups was found. The youngest group (20-29 years) had better performance compared with 50-79 year old people, 30-39 year old subjects had better performance compared with the eldest two groups (60-69, 70-79 years), and 70-79 year old people had lower scores compared with performance of 40-59 years subjects.

As far as the Education factor is concerned, apart from the Lexical-Semantic test where no difference was found in performance across groups, we found that subjects with the lowest education (0-7 years) had lower performance compared with those of all other education groups on Picture Metaphor, Humour, and Emphatic Accent tests and on the analysis of Conversation Abilities. Also performance of subjects with the two lowest education levels (0-7, 8-12 years) was lower than those of subjects with the two highest levels of education (13-16, 17-more years) on the Written Metaphor and on the Inference test (except from the comparison between performance of subjects with 8-12 *vs*. 13-16 years of education).

We further investigated the interaction of Age group X Education found on the Inference test by means of *t*-test on raw data transformed using the arc-sin procedure. We made comparisons between the performance of healthy subjects of different education levels within each age group. We made 30 comparisons (i.e. three, namely 8-12 *vs*. 13-16, 8-12 *vs*. 17-more, 13-16 *vs*. 17-more, in the 20-29 and 30-39 year groups, and six, namely 0-7 *vs*. 8-12, 0-7 *vs*. 13-16, 0-7 *vs*. 17-more, 8-12 *vs*. 13-16, 8-12 *vs*. 17-more, 13-16 *vs*. 17-more, in the other four groups). The threshold p value

was set at 0.0016 (i.e. 0.05 divided by 30 comparisons) using Bonferroni's correction for multiple comparisons. We found that performance of 40-49 year old subjects with 8-12 years of education was lower than those of people of same age with 17-more years of schooling ($t_{38} = -3.7$, $p < 0.001$), and that performance of 50-59 year old people with the lowest education level was lower compared with those of people of the same age with 8-12 years ($t_{38} = -3.56$, $p < 0.0001$), and with 17 or more years of schooling ($t_{38} = -4.36$, $p < 0.0001$). Interestingly, education did not influence performance on the Inference test in the youngest (20-29 and 30-39 years) and the oldest (60-69 and 70-79 year) groups.

We also investigated Age class and Education effects on each of the pragmatic parameters of the Conversational Analysis scale by means of separate multivariate ANOVAs. Raw data were transformed following the arc-sin procedure.

We found that the Age group main factor was statistically significant on the following pragmatic parameters: Narrative ($F_{5,418} = 3.19$, $p < 0.008$), Variety ($F_{5,418} = 3.47$, $p < 0.004$), Formalism ($F_{5,418} = 3.15$, $p < 0.008$), Discourse comprehension ($F_{5,418} = 3.85$, $p < 0.002$), and Prosody ($F_{5,418} = 3.61$, $p < 0.003$). The Education main factor was statistically significant on Narrative ($F_{5,418} = 4.27$, $p < 0.005$), Variety ($F_{5,418} = 4.76$, $p < 0.003$), and Discourse comprehension ($F_{5,418} = 5.68$, $p < 0.001$).

We ran post-hoc analysis of the main factors Age class and Education by means of Scheffe's tests with p values set at $p < 0.0033$ and $p < 0.0083$ using Bonferroni's correction for multiple comparison ($N = 15$ and $N = 6$) for Age group and Education factors, respectively. Two comparisons only on Prosody scores were influenced by the Age group factor: 20-29 ($p < 0.0033$) and 30-39 ($p < 0.0033$) year old people had better scores than 70-79 year old subjects. All other comparisons failed to reach statistical significance. On the other hand, Education proved to be more influential: people with 0-7 years of education having lower scores compared with highly educated subjects (17-more years) on Narrative ($p < 0.002$), Variety ($p < 0.004$), and Discourse comprehension parameters ($p < 0.001$). In addition, low educated subjects (0-7 years) also had

lower scores compared with people with 8-12 years of education on Variety ($p < 0.004$) and Discourse comprehension ($p < 0.003$) parameters.

Error analysis

Analytical data are reported in Tables 3a,b,c. (Table 3a,b,c about here)

Lexical-Semantic test. The distribution of errors was asymmetrical across error types, when both Age and Education factors were considered. There was a tendency to increase phonological errors after 40 years of age (except in 50-59 year old people). All education groups except people with 8-12 years of education, made more phonological errors than expected by chance. Visual errors turned out to be produced less than expected; however, this held only when data were collapsed across groups as the total amount of this error type was very small.

Written Metaphors test. More metonymic than primitive errors were made by 40-49 and 70-79 years subjects and by people with 0-7, 13-16, and 17-more years of education, than would be expected by chance.

Pictures Metaphor test. All groups with the exception of the youngest one (20-29 years of age) made more literal and less visual errors than expected by chance.

Humour test. All age and education groups (except both 40-49 year old people and subjects with 0-7 years of education, who produced statistically less incorrect errors than expected by chance) produced more emotional errors and less incorrect errors than expected by chance.

Inference test. All age and education groups produced more incorrect inferences than mere repetition of parts of the text as overt responses to specific test questions.

Summary of results

The main results of this study are as follows. Increasing age proved not to be influential until the age of 70-79 years, when mean scores tended to drop, especially when compared with the youngest subjects, for Lexical-Semantic, Written Metaphor, Inference and Humour tests and more

weakly when analysis of Conversational Abilities was considered. On the contrary, more linear decline of performance was found on the Picture Metaphor test as age increased, and no age effects were present on the Emphatic Accent test. In addition, more phonological errors on the Lexical-Semantic test and impoverishment of narrative, variety, formalism, discourse comprehension, and prosody parameters in conversational abilities were elicited as age increased. Low education (0-7 years, and in two tests – Written Metaphor test and, partially, the Inference test, 0-12 years of education) was associated with lower levels of performance on all tests except the Lexical-Semantic test. In particular, middle-age low-educated subjects (40-59 years), had worse performance on the Inference test compared with highly educated ones. No main effects of education on error profiles were found in all sub-tests of the I-RHLB. Only conversational parameters such as narrative, variety, and discourse comprehension were sensitive to lower education.

Discussion

We found a general decline in performance on almost all the I-RHLB both with age and with low education. These age and education effects are not surprising for any clinician given that old age and low education are almost always associated with poorer performance on any neuropsychological test (see, for a review, the recent large population study by Ardila et al., 2000). However, this empirical/clinical observation has never being investigated from the patho-physiological perspective, as far as verbal communication pragmatics is concerned

Neither are we able to set, on the basis of this study, any firm conclusion on causal roles of ageing and low education on verbal pragmatic abilities as we only administered the I-RHLB to normal volunteers. However, we will attempt to discuss our findings, separately for each subtest of the I-RHLB, with respect to previous studies that suggested the anatomo-clinical and/or the cognitive bases of these communication competencies.

Lexical-Semantic test

We found that increasing age affected performance on the Lexical-Semantic test. However, the post-hoc analysis showed that only the comparison between the oldest and the youngest groups was statistically significant. These findings are in partial agreement with previous studies on naming tasks that demonstrated a reduced performance in older people (Niels et al., 1995; Ardila et al., 2000; Tsang & Lee, 2003). However, the protocol used in these investigations was confrontation naming while we used a pointing-to-picture task on verbal presentation of the target.

Contrary to previous investigations (see Lecours et al., 1987; Neils et al., 1995; Ardila et al., 2000, and Manly et al., 1999 for illiterate people), we failed to show an education effect on the lexical-semantic test. However, again, in these studies, a confrontation naming task was used.

The impairments on naming tasks, such as confrontation naming, in older people have been suggested to be due to impaired access to the lexical network (Bowles & Poon, 1985; Nicholas et al., 1985), rather than a deficit of semantic memory. Given that we used a pointing-to-picture task on verbal presentation of the target rather that confrontation naming, we suggest that some evidence supporting this theoretical statement might come from our findings. In fact, we saw that the most frequently made error by our normal volunteers was the choice of phonological distractor (i.e. a semantically unrelated word that differed from the target one by a phoneme) and not the semantic one, both when age and education factors were considered. This however contrasts, at least partially, with results obtained by Albert et al. (1988), who showed that lexical errors (i.e. phonologically related real words and phonologically related nonwords) did not increase with age on the Boston Naming Test. A future possibility that has to be considered is that the older subjects might have experienced a deficit in phonological discrimination when word targets were presented aurally. Older people are known to have decreased hearing sensitivity (Ramage & Holland, 2001). However, this interpretation can not account for the prevalence of phonologic errors in all except

one education group. In conclusion, our findings appear not to provide evidence for any firm conclusion concerning age and education effects on lexical-semantic processing.

Written and Picture Metaphor test

We found that both age and education influenced performance on metaphor tests. On the written version, a reduction in performance occurred at the age of 70-79 years while a more linear decline was present on the pictorial version. In addition, low education (0-7 years) proved to influence performance with respect to all other levels of education on the latter test, while, on the written one, people with the two lowest education levels had worse performance than those of the other two groups.

Our findings are in partial disagreement with those reported by Papagno et al. (1995) who found an education but not an age effect on the processing of metaphors and idiomatic expressions. However, our study differed from Papagno et al's (1995) in several methodological aspects. Firstly, we had equally large groups for each age and education level, and we asked normal volunteers to select, from a given set, the correct response for both metaphor tests, while Papagno et al (1995) required subjects to give a verbally overt explanation of the true meanings of metaphors and idiomatic expressions. Secondly, we loaded our tests with distracting elements and, thus, inhibition operations (i.e. inhibiting the alternative interpretation of metaphors to select the correct one) were recruited in addition to the core metaphor processing. Support for this interpretation come from the analysis of the errors made by normal subjects, as literal and metonymic interpretations of metaphors were most commonly given on the Picture and Written Metaphor tests, respectively. In fact, it is well known that literal interpretations of metaphors might be frequently both semantically and visually plausible (e.g. "To have green fingers" with the man showing dirty fingers), and that metonymic interpretations of metaphors are still far more semantically acceptable than those we labelled as "primitive" interpretations. Thus, error analysis seems to suggest that an inhibition deficit could account for the errors that normal volunteers made on both metaphorical tests. This

statement agrees with Papagno et al's (2003) findings concerning the critical role exerted by the central executive system in idiom comprehension.

It is well documented that ageing (Daigneault & Braun, 1993; West, 1996; Robbins et al., 1998; Phillips, 1999) and low education (Ardila et al., 2000, and for a review, Coppens et al., 1998) determine a general decline of executive/attentive functions including ability to appropriately inhibit information in ordinary daily-living and neuropsychological testing conditions. This could be one source of interpretation. On the hand, we might bear in mind the large body of literature on right hemisphere damaged patients indicated that the right hemisphere plays a critical role in processing this kind of linguistic information (Joanette et al., 1990; Beeman & Chiarello, 1998) or in general, in resolving ambiguous linguistic materials (Tompkins et al., 2002).

In conclusion, our findings suggest that age and education influence metaphor processing. However, on the basis of this investigation we can not isolate the cognitive bases of impairments of metaphor processing due to ageing and low education.

Inference test

We found a drop in performance at the age of 70-79 with respect to all other age groups except for 60-69 years. Also education proved significant on the inference test: low educated subjects had lower performance than highly educated ones. In addition, in middle-aged subjects (40-59 years), low education was associated with lower scores than for subjects with higher education.

Our findings of an age effect on inferencing ability replicate previous studies (Cohen, 1979; Cohen & Faulkner, 1983; Ulatowska et al., 1986; Hamm & Hasher, 1992; Wright & Newhoff, 2002) but indicate that education effects may also be important. Considering in detail the two more cognitively oriented studies (Hamm & Hasher, 1992; Wright & Newhoff, 2002), Hamm & Hasher (1992) suggested that a reduced inhibitory efficiency could have lead older people to maintain active both correct and incorrect inference meanings, thus determining the communication

breakdown. These authors suggested that a purely working memory deficit was unlikely to account for the inference deficit, as their group of older people still stored initial incorrect inference on the task used, thus showing no relevant reduction of working memory storage capacity. Wright & Newhoff (2002) demonstrated that older people showed similar priming effects, compared to younger adults, in the activation of inferences and of inference revisions at long inter-stimulus intervals, thus suggesting that inference operations might rely on relatively automatic processing phenomena within the domain of linguistic comprehension of complex texts. However, when requested to overtly respond to questions, thus recruiting conscious and supervisory judgement operations, older people showed worse performance compared with younger ones.

Therefore, the main results from these two studies might suggest that making inferences on written texts recruits a large amount of executive/supervisory functions. These functions have been shown to decline with age (Daigneault & Braun, 1993; West, 1996; Robbins et al., 1998; Phillips, 1999) and to be less efficient in normal subjects with a lower education (Ardila et al., 2000). However, one might be cautious in drawing firm conclusions from these studies as inferences on texts might be of different types and might recruit different cognitive operations (see Lehman & Tompkins, 2000 for a review).

The analysis of the errors made by our normal volunteers showed that all age and education groups made more errors of incorrect inference than errors of mere repetition of the text. Even if the task was not devised to isolate the cognitive operations underpinning inferencing ability, these findings seem to weakly support the working memory deficit account of inference deficits: firstly, the task protocol allowed subjects to read the text as many times as they wished before giving the inference response; secondly, if reduced working memory efficiency was present, it should have lead to an incremental increase in repetition errors in older people. However, we saw that this was not the case: older normal volunteers made incorrect inferences (they inadequately processed inference generation and inference revision operations) thus showing that information from the text was available in their working memory system. With the above mentioned caution, these finding

might provide some evidence for the theoretical statements made by both Hamm & Hasher (1992) and Wright & Newhoff (2002).

Humour test

We found that both ageing, with a drop of performance at the age of 70-79 years, and low education influenced performance on the Humour test. Our findings concerning ageing replicated those reported by Shammi and Stuss (2003) and showed an additional education effect.

Shammi and Stuss (2003) emphasized that task complexity might have played some role in determining the main findings of their study. That is to say that when task complexity was low, older subjects had comparable performance to younger ones (see Appreciation of Humour Statements task). In addition, on all tests except the more cognitively demanding one, the Joke Completion Test, mirth responses were comparable between young and adult normal volunteers.

The humour test we adopted for the I-RHLB was very similar to the Joke Completion Test used by Shammi and Stuss (2003). We found that all subjects, when making an error, gave more emotional responses (all age groups but one, and all education groups except people with 0-7 years of education who gave more neutral responses). In addition, all groups gave less incorrect responses than expected.

From a semantic perspective, emotional and neutral responses corresponded, in our humour test, to the more straightforward response among alternatives (the other two were a semantically unrelated joke ending and the correct one). Shammi and Stuss (2003) reported that straightforward responses were the more frequently made error by their group of older subjects. Their straightforward response corresponded to what we labelled neutral response in our test (i.e. a semantically straightforward response without any emotional correlate). Therefore, our findings failed to replicate Shammi and Stuss's (2003) ones, as we found that the emotional response was the more frequently made error by all subjects with few exceptions. However, it is worth mentioning that Shammi and Stuss's (2003) tasks did not use distracting alternatives differentiated

between emotional and neutral responses as we did. Therefore, the prevalence of emotional responses upon neutral ones that we found in our normal volunteers might have been easily determined by the different protocol we used in comparison to Shammi and Stuss (2003).

In agreement with Shammi and Stuss (2003), we would emphasise that the humour task we used placed some cognitive demands in addition to the humour processing. When a subject is asked to judge which ending might represent, in a given social situation, the humorous one, one should also consider the social and cultural expectations for the specific situation given by the task. It is well known that humour often depends on socio-cultural factors. Bearing in mind these considerations, it is worth mentioning that the less educated group of our normal volunteers had significantly lower performance with respect to all other groups, and that these subjects, differently from the others, significantly selected more neutral joke endings than expected while other groups selected more emotional ending errors.

Emphatic Accent test

We found an education effect on the Emphatic Accent test but no age effect. People with low education (0-7 years) had lower scores compared with all other education groups. The main finding was a flattening of prosodic features when completing sentences.

Methodological aspects of the task are important in interpreting these results. The task required subjects to complete a sentence in which the first half was aurally presented by the experimenter. Subjects had a visual cue: the first half of the sentence referred to a picture and subjects had to complete the sentence on the basis of a second picture. Even if there was such a visual basis for completing the sentence, it has been shown that sentence completion taps executive functioning (Burgess & Shallice, 1997), as almost all open-ended tasks do, in that subjects have to spontaneously generate ideas and, in this case, relate them to a context, suppressing all other alternative sentences that could have been activated by the first half of the sentence. Thus, it is possible that this might explain why poorly educated subjects failed more on this test, with respect

to all other education groups, as low education has been shown to impair executive functions (Ardila et al., 2000). However, if this was the case, we should also have found an ageing effect on performance on Emphatic Accent test but we did not. Therefore, the interpretation of performance on prosodic tests remains difficult, at least for healthy subjects, who show only mild, if any, prosodic impairments. In fact, it is worth emphasizing that such a test may not to be ideal to assess prosodic features of verbal communication that, in turn, are more suitable to be investigated in spontaneous speech production such as in the Conversation Abilities scale.

Analysis of Conversational Abilities

We found that age and education both significantly influenced overall conversational abilities scores. In particular, ageing affected narrative, variety, formalism, discourse comprehension, and prosody parameters, while low education affected narrative, variety, and discourse comprehension.

Duong and Ska (2001) studied ageing and younger subjects with low and high education, and found that both conceptual (lower percentage of expected main ideas) and organisational (lower number of transitional markers) levels were impaired in aged subjects. In addition, they failed to find clear-cut education factors in both younger and older normal volunteers. However, only older people with high education showed an advantage with a sequence of pictures instead a single picture, when producing discourse, compared with younger adults.

Our analysis of discourse production was not based on picture stimuli as in Doung and Ska's (2001) and Harris Wright et al.'s (2005) studies, but was centred on the spontaneous speech given by subjects in a naturally occurring dialogue with the experimenter. This difference makes these two previous studies and our investigation only partially comparable.

However, some findings from our investigation seem to replicate previous ones (Doung and Ska, 2001; Harris Wright et al., 2005). We found that narrative, variety, and discourse comprehension were affected by ageing and low education. These parameters considered richness and variety of conceptual ideas and cohesion between utterances that might easily be similar to

those investigated by Doung and Ska (2001) and Harris Wright et al. (2005). These findings are also in line with previous investigations that showed changes in the macrolinguistic aspects of discourse production such as quantity, precision, cohesion, and organisation of the language production occurring with increasing age (Critchley, 1984; Obler, 1989; see for a review Brownell & Joanette, 1993).

We also found that prosodic aspects were affected by ageing. To our knowledge, no previous investigations have specifically addressed this issue. Previous studies mainly address prosody in brain damaged patients with either right or left hemisphere lesions. Also patients with frontal lesions have been shown to manifest flattened prosody (Ghacibeh & Heilman, 2003; Heilman et al., 2004). Bearing in mind that normal ageing usually confers a mild reduction in frontal cortex functioning, it is possible that flattening of prosodic contours in our older normal volunteers might have been determined by a reduced efficiency of frontal cortices. However, other experimental studies are needed to clarify this issue.

Lastly, we found that older normal subjects more frequently violated the formalism of the conversational setting, namely they usually had more confidential tones. This conversational behaviour might have been influenced by socio-cultural norms (not strictly education-related) or may be due to mild disinhibition that has been suggested to characterise some older normal people (Ceccaldi et al., 1996).

Conclusions

We found that almost all the linguistic pragmatic features addressed by the I-RHLB were sensitive to both age and education effects. We found that performance was frequently low with the lowest education and the highest age class. No significant interactions between age and education

were found. Therefore, these two factors seem to have affected the performance of our normal volunteers independently.

A large body of literature has shown that ageing and low education determine a diffused decline of performance on almost all clinical neuropsychological tests (Salthouse, 2001). This is probably due to the common cognitive operations that are recruited by many clinical tests such as attention, executive, and memory functions, visuo-spatial processing, and language, if verbal material is given, even when the tasks used are devised to tap one specific cognitive operation. Our findings suggest that pragmatic competence declines with age and is less elaborated in people with lower education, in parallel with almost all other cognitive functions.

However, it is worth mentioning that all the recent theoretical frameworks (i.e. weak central coherence, theory of mind impairment, and dysexecutive hypothesis) (Martin & McDonald, 2003), suggest that frontal lobe operations might play a relevant role in sustaining several verbal pragmatic competencies. A reduction of frontal lobe functioning due to either increased age or low education, could be a possible explanation of our main findings as these normal volunteers were free from any neurological disease or focal/lateralised brain lesions. Indeed, the materials we used were clinical tests that were not devised to cognitively address and isolate operations underpinning processing of verbal pragmatics, as the aim of the present investigation was to posit some normative data in the field of pragmatics of verbal communication. In addition, we were not able to administer other cognitive tests to the normal subjects so it is not possible to outline possible correlations between performance on other cognitive tests and on the pragmatic ones from the I-RHLB. Therefore, further studies will be needed to determine the neural organisation of competences in the human brain.

References

Albert, M.S., Heller, H.S. & Milberg, W. (1988). Changes in naming ability with age. *Psychology of Aging, 3(2),* 173-178.

Ardila, A., Ostrosky-Solis, F., Rosselli, M. & Gomez, C. (2000). Age-related cognitive decline during normal aging: The complex effect of education. *Archives of Clinical Neuropsychology, 15(6),* 495-513.

Ardila, A., Rosselli, M. & Rosas, P. (1989). Neuropsychological assessment in illiterates: Visuospatial and memory abilities. *Brain and Cognition, 11,* 147-166.

Beeman, M. & Chiarello, C. (1998). *Right hemisphere language comprehension: perspective from cognitive neuroscience*. Mahwah, NJ: Lawrence Erlbaum.

Bowles, N.L. & Poon, L.W. (1985). Ageing and retrieval of words in semantic memory. Journal of Gerontolgy, 40(1), 71-77.

Braun, A.R., Guillemin, A., Hosey, L. & Varga, M. (2001). The neural organisation of discourse. An $H_2{}^{15}O$-PET study of narrative production in English and American sign language. *Brain, 124,* 2028-2044.

Brebion, G., Ehrlich, M.F. & Tardieu, H. (1995). Working memory in older subjects: Dealing with ongoing and stored information in language comprehension. *Psychological Research, 58,* 225-232.

Brownell, H.H. & Joanette, Y. (1993). *Narrative Discourse in Neurologically Impaired and Normal Ageing Adults*. San Diego: Singular Publishing Group.

Bryan, K. & Hale, J.B. (2001). Differential effects of left and right cerebral vascular accidents on language competency. *Journal of the International Neuropsychological Society, 7,* 655-664.

Bryan, K. (1995). *The Right Hemisphere Language Battery*. London: Whurr

Burgess, P.W. & Shallice, T. (1997). The Hayling and Brixton Tests. Bury St. Edmunds: Thames Valley Test Company.

Caramelli, P., Mansur, L.L. & Nitrini, R (1998). Language and communication disorders in dementia of Alzheimer type. In B. Stemmer & H.A. Whitaker (Eds.) *Handbook of neurolinguistics*. New York: Academic Press, pp 463-473.

Ceccaldi, M., Joanette, Y., Tikhomirof, F., Macia, M. & Poncet, M. (1996). The effects of age-induced changes in comunicative abilities on the type of aphasia. *Brain and Language, 54,* 75-85.

Chiarello, C., Liu, S. & Shears, C. (2001). Does global context modulate cerebral asymmetries? A review and new evidence on word imageability effects. *Brain and Language, 79,* 360-378.

Chiarello, C., Liu, S., Shears, C., Quan, N. Kacinik, N. (2003). Priming of strong semantic relation in the left and right visual fields: a time-course investigation. *Neuropsychologia, 41*, 721-732.

Coelho, C.A., Youse, K.M., Le, K.N & Feinn, R. (2003). Narrative and conversational discourse of adults with closed head injury and non-brain-injured adults: A discriminant analysis. *Aphasiology, 17(5),* 499-510.

Cohen, G. & Faulkner, D. (1983). Word recognition: age differences in contextual facilitation effects. *British Journal of Psychology, 74*, 239-251.

Cohen, G. (1979). Language comprehension in old age. *Cognitive Psychology, 11*, 412-429.

Coppens, P., Parente, M.A. & Lecours, A.R. (1998). Aphasia in illiterate individuals. In P. Coppens, Y. Lebrun, A. Basso (Eds.), Aphasia in Atypical Populations (pp.175-202). Mahwah, NJ: Lawrence Erlbaum Associates.

Critchley, M. (1984). And all the daughters of musick shall be brought low. *Archives of Neurology, 41*, 1135-1139.

Crystal, D. & Varley, R. (1998). Introduction to Language Pathology. London: Whurr Publishers Ltd.

Daigneault, S. & Braun, C.M.J. (1993). Working memory and the self-ordered pointing task: Further evidence of early prefrontal decline in normal aging. *Journal of Clinical and Experimental Neuropsychology, 15*, 881-895.

Duong, A. & Ska, B. (2001). Production of narratives: Picture sequence facilitates organisational but not conceptual processing in less educated subjects. *Brain and Cognition, 46(1-2),* 121-124.

Evans, D.A., Beckett, L.A., Albert, M.S., Hebert, L.E., Scherr, P.A., Funkenstein, H.H. & Taylor, J.O. (1993). Level of education and change in cognitive function in a community population of older persons. *Annals of Epidemiology, 3*, 71-77.

Faust, M., Kravetz, S. & Netzer, E. (2002). Effects of sentential context on the processing of unambiguous words by the two cerebral hemispheres. *Brain and Language, 80*, 438-448.

Gardner, H. & Brownell, H.H. (1986). *Right Hemisphere Communication Battery*. Boston: Psychology Service, VAMC.

Gracibeh, G.A. & Heilman, K.M. (2003). Progressive affective aprosodia and prosoplegia. *Neurology, 60(7),* 1192-1194.

Grant, D. & Dagenbach, D. (2000). Further considerations regarding inhibitory precesses, working memory, and cognitive aging. *American Journal of Psychology, 113*, 69-83.

Hamm, V.P. & Hasher, L. (1992). Age and the availability of inferences. *Psychology and Aging, 7*, 56-64.

Harris Wright, H., Capilouto, G.J., Wagovich, S.A., Cranfill, T.B. & Davis, J.E. (2005). Development and reliability of a quantitative measure of adults' narratives. Aphasiology, 19(3-5), 263-273.

Hays, S-J., Niven, B.E., Godfrey, H.P.D. & Linscott, R.J. (2004). Clinical assessment of pragmatic language impairment: A generalisability study of older people with Alzheimer's disease. *Aphasiology, 18(8),* 693-714.

Heilman, K.M., Leon, S.A. & Rosenbek, J.C. (2004). Affective aprosodia from a medial frontal stroke. *Brain and Language, 89*, 411-416.

Hutchinson, A., Douglas Whitman, R., Abeare, C. & Raiter, J. (2003) The unification of mind: integration of hemispheric semantic processing. *Brain and Language, 87,* 361-368

Joanette, Y., Goulet, P. & Hannequin, D. (1990). *Right hemisphere and verbal communication*. New York: Springer-Verlag.

Just, M.A. & Carpenter, P.A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 99(1),* 122-149.

Kemper, S., Jackson, J.D., Cheung, H. & Anagnopoulus, C.A. (1993). Enhancing older adults reading comprehension. *Discourse Processes, 16*, 405-428.

Lecours, A.R., Mehler, J., Parente, M.A., Caldeira, A., Cary, L., Castro, M.J., Dehaut, F., Delgado, R., Gurd, J., Karmann, D.F., Jakubovitz, R., Osorio, Z., Cabral, L.S. & Junqueira, A.M.S. (1987). Illiteracy and brain damage: 1. Aphasia testing in culturally contrasted populations (control subjects). *Neuropsychologia, 25*, 231-245.

Lehman Blake, M., Duffy, J.R., Tompkins, C.A. & Myers, P.S. (2003). Right hemisphere syndrome is in the eye of the beholder. *Aphasiology, 17(5),* 423-432.

Lehman, M.T. & Tompkins, C.A. (2000). Inferencing in adults with right hemisphere brain damage: An analysis of conflicting results. *Aphasiology, 14(5/6),* 485-499.

Levinson, S. C. (1983). *Pragmatics*. Cambridge: Cambridge University Press.

Light, L. & Anderson, P. (1985). Working-memory capacity, age, and memory for discourse. *Journal of Gerontology, 40*, 737-747.

Light, L. (1990). Interaction between memory and language in old age. In J.E. Birren & K.W. Schaie (Eds.), *Handbook of the psychology of ageing* (pp. 275-290). New York: Academic Press.

Lyketsos, C. G., Chen, L.S. & Anthony, J.C. (1999). Cognitive decline in adulthood: An 11.5 years follow-up of the Baltimore Epidemiological Catchment Area study. *American Journal of Psychiatry, 156*, 58-65.

Manly, J.J., Jacobs, D.M., Sano, M., Bell, K., Merchant, C.A., Small, S.A. & Stern, Y. (1999). Effect of literacy on neuropsychological test performance in nondemented, education-matched elders. *Journal of the International Neuropsychological Society, 5(3),* 191-202.

Marquardt, T.P., Rios-Brown, M., Richburg, T., Seibert, L.K. & Cannito, M.P. (2001). Comprehension and expression of affective sentences in traumatic brain injury. *Aphasiology, 15(10/11),* 1091-1101.

Martin, I., & McDonald, S. (2003). Weak coherence, no theory of mind, or executive dysfunction? Solving the puzzle of pragmatic language disorders. *Brain and Language, 85,* 451-466.

Maxim, J. (1982). Language changes with increasing age. In M. Edwards (Ed.), *Communication Changes in Elderly People, Monograph No.3*. London: College of Speech Therapists.

Maxim, J. (1999). Ageing and language. In F. Fabbro (Ed.), *Concise encyclopedia of language pathology* (pp.142-146). Amsterdam: Elsevier.

McDonald, S,. Togher, L & Code, C. (Eds.) (1999) *Communication disorders following traumatic brain injury*. Hove, UK: Psychology Press.

McDonald, S. (2000). Putting communication disorders in context after traumatic brain injury. *Aphasiology, 14(4),* 339-347.

McNamara, P. & Durso, R. (2003). Pragmatic communication skills in patients with Parkinson's disease. *Brain and Language, 84,* 414-423

Morris, C.H. (1938). Foundations of the theory of signs. In *International encyclopedia of unified science* (Vol. 2, No.1). Chicago: University of Chicago Press.

Myers, P.S. (2001). Toward a definition of RHD syndrome. *Aphasiology, 15*, 913-918.

Nicholas, M., Obler, L.K., Albert, M.L. & Goodglass, H. (1985). Lexical retrieval in healthy aging. *Cortex, 21*, 595-606.

Niels, J., Baris, J.M., Carter, C., Dell'Aira, A.L., Nordloh, S.J., Weiler, E. & Weisiger, B. (1995). Effects of age, education, and living environment on Boston Naming Test performance. *Journal of Speech and Hearing Research, 38(5),* 1143-1149.

North, A.J., Ulatowska, H.K., Macaluso-Haynes, S. & Bell, H. (1986). Discourse performance in older adults. *International Journal of Ageing and Human Development, 23,* 267-283.

Oberauer, K. (2001). Removing irrelevant information from working memory: a cognitive ageing study with the modified Sternberg task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27 (4),* 948-957.

Obler, L.K. (1989). Language beyond childhood. In J. BerKo Gleason (Ed.), *The development of language*. Columbus, OH: Merril Publishing.

Oliveri, M., Romero, L. & Papagno, C. (2004) Left but not right temporal involvement in opaque idiom comprehension: a repetitive transcranical magnetic stimulation study. *Journal of Cognitive Neuroscience, 16(5),* 848-855.

Palladino, P. & De Beni, R. (1999). Woking memory in aging: maintenance and suppression. *Aging, 11(5),* 301-306.

Papagno, C., Cappa, S.F., Forelli, A., Garavaglia, G., Laiacona, M., Capitani, E. & Vallar, G. (1995). Non-literal language comprehension: standardization of a metaphors and idiom comprehension test. *Archivio di Psicologia, Neurologia e Psichiatria, 56(4),* 402-420.

Papagno, C., Lucchelli, F., Muggia, S. & Rizzo, S. (2003) Idiom comprehension in Alzheimer's disease: the role of the central executive. *Brain, 126*: 2419-2430.

Paradis, M. (1999). The other side of language: Pragmatic competence. In M. Paradis (Ed.), *Pragmatics in neurogenic communication disorders* (pp. 1-10). Oxford, UK: Pergamon.

Phillips, L.H. (1999). Age and individual differences in letter fluency. *Developmental Neuropsychology, 15,* 249-267.

Ramage, A.E. & Holland, A.L. (2001). Language in normal ageing and age-related neurological disorders. In F. Boller & S.F. Cappa (Eds.), *Handbook of Neuropsychology, Vol. 6 – Ageing and Dementia*, (pp. 81-95). Amsterdam: Elsevier.

Robbins, T.W., James, M., Owen, A.M., Sahakian, B.J., Lawrence, A.D., McInnes, L. & Rabbit P.M.A. (1998). A study of performance on tests from the CANTAB battery sensitive to frontal lobe dysfunction in a large sample of normal volunteers: Implications for theories of executive functioning and cognitive aging. *Journal of the International Neuropsychological Society, 4,* 474-490.

Rosselli, M., Ardila, A & Rosas, P. (1990). Neuropsychological assessment in illiterates II: Language and praxic abilities. *Brain and Cognition, 12,* 282-296.

Salthouse, T.A. (1996). The processing-speed theory of adult age difference in cognition. *Psychological Review, 103,* 403-428.

Salthouse, T.A. (2001). General and specific age-related influences on neuropsychological variables. In F. Boller & S.F. Cappa (Eds.), *Handbook of Neuropsychology, Vol. 6 – Ageing and Dementia* (pp. 39-49). Amsterdam: Elsevier.

Shammi, P. & Stuss, D.T. (2003). The effects of normal ageing on humour appreciation. *Journal of the International Neuropsychological Society, 9*, 855-863.

Tompkins, C.A., Fassbinder, W., Lehman-Blake, M.T. & Baumgaertner, A. (2002). The nature and implications of right hemisphere language disorders: Issues in search of answer. In A.E. Hillis

(Ed.), *The Handbook of Adult Language Disorders – integrating cognitive neuropsychology, neurology, and rehabilitation* (pp. 429-448). New York: Psychology Press.

Tompkins, C.A., Lehman Blake, M., Baumgaertner, A. & Fassbinder, W. (2002). Characterising comprehension difficulties after right brain damage: Attentional demands of suppression functions. *Aphasiology, 16(4-6),* 559-572.

Tsang, H-L. & Lee, T.M.C (2003). The effect of ageing on confrontation naming ability. *Archives of Clinical Neuropsychology, 18,* 81-89.

Ulatowska, H.K., Cannito, M.P., Hayashi, M.M. & Fleming, S.G. (1986). Language abilities in the elderly. In H.K. Ulatowska (Ed.), *The ageing brain: Communication in the elderly* (pp. 125-139). San Diego: College-Hill.

Van der Linden, M., Hupet, M., Feyereisen, P., Schelestraete; M.A., Bestgen, Y., Bruyer, Y., Lories, G., El Ahmadi, A. & Seron, X. (1999). Cognitive mediators of age-related differences in language comprehension and verbal memory performance. *Aging, Neuropsychology, and Cognition, 6,* 32-55.

Van Dijk, T.A. (1997). The study of discourse. In TA van Dijk (Ed.), *Discorse as structure and process: Discorse studies: A multidisciplinary introduction* (Vol.1, pp. 1-34). London: Sage.

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

Wright, H.H. & Newhoff, M. (2002). Age-related differences in inference revision processing. *Brain and Language, 80,* 226-239.

Yamadori, A., Ashina, Y., Fujii, T., Tsukiura, T., Okuda, J. & Osaka, M. (1999). The nature of age-related decline on the performance of the reading span task. *Brain and Cognition, 39,* 19-32.

Youse, K.M., Coelho, C.A., Mozeiko, J.L. & Feinn, R. (2005). Discourse characteristics of closed-head-injury and non-brain-injured adults misclassified by discriminant function analysis. *Aphasiology, 19(3-5),* 297-313.

Zanini, S. & Bryan, K. (2003). *La Batteria del Linguaggio dell'Emisfero Destro – Ba.L.E.D.*. Bologna, Italy: EMS.

Zanini, S., Bryan, K., De Luca, G. & Bava, A. (2005). The Italian version of the Right Hemisphere Language Battery (Batteria del Linguaggio dell'Emisfero Destro – Ba.L.E.D.): the normative study. *Neurological Sciences, 26(1),* 13-25.

Acknowledgements

We acknowledge Mr. Stefano Stern for his kind collaboration in preparing the pictorial material for the Italian version of the Right Hemisphere Language Battery (I-RHLB). We are also grateful to all the volunteers who agreed to be tested and all the people who helped in collecting the normative data: Mrs. Sandra Barbalarga, Mrs. Monica Cavazzon, Mr. Dario Filiputti, Mrs. Stefania Marson, Mrs. Katia Paljavec, Mrs. Mara Quintiliano, Dr. Alessandro Tavano, Mrs. Cristina Tofful, Dr. Barbara Tomasino, Mrs. Lorenza Vorano. The work was supported by grants from the Ministero dell'Università e della Ricerca Scientifica e Tecnologica, Roma, and from the Università degli Studi di Trieste, Italy.

Table 1. Age class and Education effects on each test of the I-RHLB.

	Age class		**Education**		**Age X Education**	
	$F_{5,418}$	p value	$F_{5,418}$	p value	$F_{13,418}$	p value
Tests						
Lexical-semantic	6.59	<0.0001	0.77	>0.51	0.72	>0.73
Written Metaphors	10.16	<0.0001	13.71	<0.0001	1.43	>0.13
Picture Metaphors	14.22	<0.0001	26.52	<0.0001	0.66	>0.79
Inference	7.9	<0.0001	9.32	<0.0001	2.31	<0.01
Humour test	8.51	<0.0001	13.46	<0.0001	0.74	>0.72
Emphatic Accent	1.08	>0.36	15.7	<0.0001	0.88	>0.56
Conversational Abilities	4.07	<0.001	5.8	<0.001	1.2	>0.27

Table 2a. Post-hoc analyses of the Age factor across all the I-RHLB tests.

LEXSEM	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**
20-29	**-**	n.s.	n.s.	n.s.	n.s.	<0.0001
30-39		-	n.s.	n.s.	n.s.	n.s.
40-49			-	n.s.	n.s.	n.s.
50-59				-	n.s.	n.s.
60-69					-	n.s.
70-79						-

WMET	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	***70-79***
20-29	**-**	n.s.	n.s.	n.s.	n.s.	*<0.0001*
30-39		-	n.s.	n.s.	n.s.	*<0.0001*
40-49			-	n.s.	n.s.	*<0.0001*
50-59				-	n.s.	*n.s.*
60-69					-	*n.s.*
70-79						-

PMET	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**
20-29	**-**	n.s.	n.s.	<0.002	<0.0001	<0.0001
30-39		-	n.s.	n.s.	<0.0001	<0.0001
40-49			-	n.s.	n.s.	<0.0001
50-59				-	n.s.	<0.003
60-69					-	n.s.
70-79						-

INF	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	***70-79***
20-29	**-**	n.s.	n.s.	n.s.	n.s.	*<0.0001*
30-39		-	n.s.	n.s.	n.s.	*<0.0001*
40-49			-	n.s.	n.s.	*<0.002*
50-59				-	n.s.	*<0.0001*
60-69					-	*n.s.*
70-79						-

HUM	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**
20-29	**-**	n.s.	n.s.	n.s.	n.s.	<0.0001
30-39		-	n.s.	n.s.	n.s.	<0.0001
40-49			-	n.s.	n.s.	<0.002
50-59				-	n.s.	n.s.
60-69					-	n.s.
70-79						-

ACC	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	***70-79***
20-29	**-**	n.s.	n.s.	n.s.	n.s.	*n.s.*
30-39		-	n.s.	n.s.	n.s.	*n.s.*
40-49			-	n.s.	n.s.	*n.s.*
50-59				-	n.s.	*n.s.*
60-69					-	*n.s.*
70-79						-

CA	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	***70-79***
20-29	**-**	n.s.	n.s.	n.s.	n.s.	*n.s.*
30-39		-	n.s.	n.s.	n.s.	*n.s.*
40-49			-	n.s.	n.s.	*<0.002*
50-59				-	n.s.	*n.s.*
60-69					-	*n.s.*
70-79						-

Note. Threshold p value was set at p < 0.0033 following Bonferroni's correction for multiple comparisons (N = 15); LEXSEM: Lexical-Semantic test, WMET: Written Metaphor test, PMET: Picture Metaphor test, INF: Inference test, HUM: Humour test, ACC: Emphatic Accent test, CA: Conversation Ability scale; n.s.: not statistically significant.

Table 2b. Post-hoc analyses of the Education factor across all the I-RHLB tests.

LEXSEM	**0-7**	**8-12**	**13-16**	**17-more**
0-7	**-**	n.s.	n.s.	n.s.
8-12		-	n.s.	n.s.
13-16			-	n.s.
17-more				-

WMET	**0-7**	**8-12**	**13-16**	***17-more***
0-7	**-**	n.s.	<0.0001	*<0.0001*
8-12		-	<0.003	*<0.0001*
13-16			-	*n.s.*
17-more				-

PMET	**0-7**	**8-12**	**13-16**	**17-more**
0-7	**-**	<0.0001	<0.0001	<0.0001
8-12		-	n.s.	n.s.
13-16			-	n.s.
17-more				-

INF	**0-7**	**8-12**	**13-16**	***17-more***
0-7	**-**	n.s.	<0.003	*<0.0001*
8-12		-	n.s.	*<0.001*
13-16			-	*n.s.*
17-more				-

HUM	**0-7**	**8-12**	**13-16**	**17-more**
0-7	**-**	<0.0001	<0.0001	<0.0001
8-12		-	n.s.	n.s.
13-16			-	n.s.
17-more				-

ACC	**0-7**	**8-12**	**13-16**	***17-more***
0-7	**-**	<0.0001	<0.0001	*<0.0001*
8-12		-	n.s.	*n.s.*
13-16			-	*n.s.*
17-more				-

CA	**0-7**	**8-12**	**13-16**	***17-more***
0-7	**-**	<0.007	<0.001	*<0.001*
8-12		-	n.s.	n.s.
13-16			-	n.s.
17-more				-

Note. Threshold p value was set at p < 0.0083 following Bonferroni's correction for multiple comparisons (N = 6); LEXSEM: Lexical-Semantic test, WMET: Written Metaphor test, PMET: Picture Metaphor test, INF: Inference test, HUM: Humour test, ACC: Emphatic Accent test, CA: Conversation Ability scale; n.s.: not statistically significant.

Table 3a. Error distribution of normal subjects on two tests of the I-RHLB that had different chance levels for incorrect responses.

	LEXICAL-SEMANTIC TEST				***PICTURE METAPHOR TEST***		
	Semantic	**Phonologic**	**Visual**	χ_2^2	**Literal**	**Visual**	χ_1^2
Age							
20-29	4/5 [3/5]	1/5 [1/5]	0/5 [1/5]	1.33 n.s.	7/13 [4.3/13]	6/13 [8.7/13]	*2.52* *n.s.*
30-39	6/10 [6/10]	4/10 [2/10]	0/10 [2/10]	4 n.s.	13/21 [7/21]	8/21 [14/21]	*7.71* *p<0.01*
40-49	9/20 [12/20]	10/20 [4/20]*	1/20 [4/20]	12 p<0.01	49/72 [24/72]	23/72 [48/72]	*39.06* *p<0.0001*
50-59	9/16 [9.6/16]	7/16 [3.2/20]	0/16 [3.2/20]	7.74 p<0.05	77/93 [31/93]	16/93 [62/93]	*102.37* *p<0.0001*
60-69	9/25 [15/25]	13/25 [5/25]*	3/25 [5/25]	16 p<0.001	82/122 [40.7/122]	40/122 [81.3/122]	*62.88* *p<0.0001*
70-79	19/44 [26.4/44]	23/44 [8.8/44]*	2/44 [8.8/44]	30.22 p<0.0001	128/166 [55.3/166]	38/166 [110.7/166]	*143.31* *p<0.0001*
Total	56/120 [72/120]	58/120 [24/120]*	6/120 [24/120]*	65.31 p<0.0001	356/487 [162.3/487]	131/487 [324.7/487]	*121.62* *p<0.0001*
Education							
0-7	14/28 [16.8/28]	14/28 [5.6/28]*	0/28 [5.6/28]	18.66 p<0.0001	145/205 [68.3/205]	60/205 [136.7/205]	*129.16* *p<0.0001*
8-12	21/33 [19.8/33]	10/33 [6.6/33]	2/33 [6.6/33]	5.02 n.s.	85/121 [40.3/121]	36/121 [80.7/121]	*74.33* *p<0.0001*
13-16	8/23 [13.8/23]	13/23 [4.6/23]*	2/23 [4.6/23]	19.22 p<0.0001	83/96 [32/96]	13/96 [64/96]	*121.92* *p<0.0001*
17-more	13/36 [21.6/36]	21/36 [7.2/36]*	2/36 [7.2/36]	33.62 p<0.0001	43/65 [21.7/65]	22/65 [43.3/65]	*31.27* *p<0.0001*
Total	*56/120* *[72/120]*	*58/120* *[24/120]**	*6/120* *[24/120]**	*65.31* *p<0.0001*	*356/487* *[162.3/487]*	*131/487* *[324.7/487]*	*121.62* *p<0.0001*

Note. Values within square brackets represent expected values by chance; Lexical-Semantic test: star refers to statistically significant Chi-square post-hoc analysis between observed and expected values for each type of error – semantic, phonological, and visual (for post-hoc analysis, statistically significant p value was set at 0.016 following Bonferroni's correction for multiple comparisons [N = 3]); n.s.: Picture Metaphor test did not need post-hoc analysis within each age class and education group; not statistically significant.

Table 3b. Error distribution of normal subjects across two tests of the I-RHLB that had equal chance levels for incorrect responses.

	WRITTEN METAPHOR TEST			***HUMOUR TEST***			
	Metonimic	**Primitive**	χ_1^2	**Neutral**	**Emotional**	**Incorrect**	χ_2^2
Age							
20-29	1/4 [2/4]	3/4 [2/4]	1 n.s.	15/43 [14.3/43]	25/43 [14.3/43]*	3/43 [14.3/43]*	*15.54* *p<0.001*
30-39	4/5 [2.5/5]	1/5 [2.5/5]	1.8 n.s.	12/43 [14.3/43]	30/43 [14.3/43]*	1/43 [14.3/43]*	*29.95* *p<0.0001*
40-49	12/15 [7.5/15]	3/15 [7.5/15]	5.4 p<0.05	45/93 [31/93]	42/93 [31/93]	6/93 [31/93]*	*30.38* *p<0.0001*
50-59	18/33 [16.5/33]	15/33 [16.5/33]	3 n.s.	33/102 [34/102]	55/102 [34/102]*	14/102 [34/102]*	*24.75* *p<0.0001*
60-69	22/36 [18/36]	14/36 [18/36]	1.77 n.s.	38/113 [37.7/113]	62/113 [37.7/113]*	13/113 [37.7/113]*	*31.84* *p<0.0001*
70-79	43/54 [27/54]	11/54 [27/54]	18.96 p<0.0001	59/157 [52.3/157]	72/157 [52.3/157]*	26/157 [52.3/157]*	*21.49* *p<0.0001*
Total	100/147 [73.5/147]	47/147 [73.5/147]	19.1 p<0.0001	202/551 [183.6/551]	286/551 [183.6/551]*	63/551 [183.6/551]*	*138.16* *p<0.0001*
Education							
0-7	44/61 [30.5/61]	17/61 [30.5/61]	11.95 p<0.001	87/187 [62.3/187]*	67/187 [62.3/187]	33/187 [62.3/187]*	*23.91* *p<0.0001*
8-12	31/54 [27/54]	23/54 [27/54]	1.18 n.s.	59/155 [51.7/155]	80/155 [51.7/155]*	16/155 [51.7/155]*	*41.17* *p<0.0001*
13-16	14/19 [9.5/19]	5/19 [9.5/19]	6.36 p<0.05	36/106 [35.3/106]	63/106 [35.3/106]*	7/106 [35.3/106]*	*44.42* *p<0.0001*
17-more	11/13 [6.5/13]	2/13 [6.5/13]	6.23 p<0.05	20/103 [34.3/103]	76/103 [34.3/103]*	7/103 [34.3/103]*	*78.37* *p<0.0001*
Total	*100/147* *[73.5/147]*	*47/147* *[73.5/147]*	*19.1* *p<0.0001*	*202/551* *[183.6/551]*	*286/551* *[183.6/551]**	*63/551* *[183.6/551]**	*138.16* *p<0.0001*

Note. Values within square brackets represent expected values by chance; Humour test: star refers to statistically significant Chi-square post-hoc analysis between observed and expected values for each type of error – neutral, emotional, and incorrect (for post-hoc analysis, statistically significant p value was set at 0.016 following Bonferroni's correction for multiple comparisons [N = 3]); Written Metaphor test did not needed post-hoc analysis within each class and education group; n.s.: not statistically significant.

Table 3c. Error distribution of normal subjects across the Inference test of the I-RHLB.

	INFERENCE TEST		
	Incorrect inference	**Repetition of the text**	χ_1^2
Age			
20-29	68 [50.5/101]	33 [50.5/101]	*12.12* *p<0.001*
30-39	66 [49/98]	32 [49/98]	*11.79* *p<0.001*
40-49	134 [82.5/165]	31 [82.5/165]	*64.29* *p<0.0001*
50-59	108 [68/136]	28 [68/136]	*47.05* *p<0.0001*
60-69	129 [81.5/163]	34 [81.5/163]	*55.36* *p<0.0001*
70-79	183 [108.5/217]	34 [108.5/217]	*102.3* *p<0.0001*
Total	688 [440/880]	192 [440/880]	*279.56* *p<0.0001*
Education			
0-7	190 [112/224]	34 [112/224]	*108.64* *p<0.0001*
8-12	198 [129.5/259]	61 [129/259]	*72.46* *p<0.0001*
13-16	163 [105.5/211]	48 [105.5/211]	*62.67* *p<0.0001*
17-more	137 [93/186]	49 [93/186]	*41.63* *p<0.0001*
Total	*688* *[440/880]*	*192* *[440/880]*	*279.56* *p<0.0001*

Note. Values within square brackets represent expected values by chance.