The Italian version of the Right Hemisphere Language Battery (Batteria del Linguaggio dell'Emisfero Destro – Ba.L.E.D.): the normative study

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Abstract

Clinical neurolinguistics still lacks consolidated and standardised tools for the assessment of impairments of pragmatics of verbal communication. In the present paper we present norms of the Italian version of the Right Hemisphere Language Battery (Batteria del Linguaggio dell'Emisfero Destro) [1] originally devised by Bryan [2]. The normative study has been conducted with recruitment of 440 healthy subjects. The battery of tests was not intended to be cognitively oriented, by providing evidence of the cognitive impairments underpinning verbal pragmatic deficits; on the contrary, it permits to detect the presence/absence of impairments in processing the main pragmatic features of verbal communication traditionally associated with right hemisphere lesions. Thus, apart from being a clinical tool for diagnosing pragmatic impairments of verbal communication, the Ba.L.E.D. represents a useful initial battery of tests for clinical assessment and for selecting specific populations of neurological patients suitable for investigation in further experimental studies.

Introduction

Adult acquired pragmatic disorders of verbal communication have gained increasing interest from clinicians and researchers over the last twenty years [3,4]. Historically, the pragmatics of verbal communication have been defined as "language use in specific communicational contexts" [5]. This is to say that pragmatics concerns the study of the meanings that single verbal propositions (i.e. words or sentences) can assume according to the communicational contexts where they are used (e.g. a ironic joke) and/or to the intentions of the speaker (e.g. an indirect request), and/or the general knowledge of the world.

Using a common aphorism, pragmatics of verbal communication are concerned more with what is *meant* than with what is *said* [5]. Typically, verbal pragmatic features that have been investigated in patients with cerebral damage 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 moral, punch-line, and theme of stories).

In the past, these pragmatic features have been reported to be frequently impaired in "syndrome" fashion following brain damage, thus suggesting the possibility of some common underlying cognitive operations. Literature on lesion studies suggested that the right hemisphere might be critical in processing these linguistic/communicative operation [4-6], and the dichotomy denotative vs. connotative language, processed by left vs. right hemisphere, respectively, has been frequently emphasised (see [3], for a review).

However, verbal pragmatic impairments have also been reported in patients suffering from traumatic brain injury (TBI) who generally have bilateral frontal lesions, as well as in developmental

disorders such as autism. In more recent years, the anatomo-clinical correlates of verbal pragmatic impairments have also been reconsidered and the traditional right hemisphere hypothesis has been challenged. The following are recent significant studies.

Concerning figurative language, Oliveri and collaborators [7] found significant interference in comprehending opaque and unambiguous idioms (traditionally considered as a right hemisphere competence) in normal subjects, when repetitive transcranial magnetic stimulation was applied to the left but not to the right temporal areas. In addition, Papagno and collaborators [8] emphasised the role of the central executive (a non-linguistic function) in idiom comprehension as it plays a critical role in inhibiting literal interpretations in favour of figurative ones. As far as the lexical-semantic linguistic level is concerned, recent studies confirmed that both hemispheres concur in processing word meanings [6] and that they reciprocally interact in elaborating narrow (left hemisphere) and coarse (right hemisphere) semantic features of words [9-11]. Finally, recent investigations [12,13] on humour processing aimed at better definition of its neural correlates, with respect to previous studies that only considered the laterality effect (right vs. left hemispheric lesions).

In addition an increasing body of experimental literature and theoretical frameworks of verbal pragmatics deficits have been recently discussed [14]. Three main perspectives have been put forward:
1) the weak central coherence (WCC) hypothesis suggests that verbal pragmatic deficits depend on a failure of a central system devoted to integrating different sources of information;
2) social inference theory (particularly, Theory of Mind - TOM) that interprets the inability to understand and predict linguistic utterances of co-conversant(s) as an inability to form adequate representations of other people's mental states; and
3) dysexecutive hypothesis that interprets all polysemic and non-literal meanings of linguistic utterances as a problem-solving situation that critically recruits executive functions. In addition, a sub-type of social cognition deficit, namely the impairment in processing empathy, that has been reported

in frontal lobe patients [15], might also be considered for its possible implications in pragmatic meta-literal interpretations of speech.

Despite the recent and increasing body of experimental and theoretical work, we are still far from precise definition of:

1) the neural bases of the different verbal pragmatic deficits,

2) suitable theoretical frameworks of linguistic pragmatics to set adequate approaches to verbal pragmatic impairments, and

3) working models of interactions between these pragmatic competences and other non-linguistic cognitive operations (e.g. social cognition, knowledge about co-conversant(s), knowledge of the specific communication context) that might be necessary to generate adequate meta-literal interpretations of speech acts.

In addition, very few clinical tools aimed at diagnosing such communication impairments have been proposed. To our knowledge, only two batteries of tests, the "Right Hemisphere Communication Battery" [16], and the "Right Hemisphere Language Battery" [2], are currently available, and no systematic investigation of normal subjects has been presented, controlling for age and education. Thus, no clear-cut norms on verbal pragmatic tests are available for clinicians.

We aimed to develop such norms from a very large group of normal adult people controlling for both age and education. The RHLB [2] was selected as a clinically usable battery of tests devised to recognise the presence/absence of any pragmatic impairment, and secondly, as a battery of tests that taps the majority of verbal pragmatic features [17].

Methods

Subjects

We tested four hundred and forty normal subjects. We split people 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 the Italian educational levels). Therefore, normal people were divided into twenty-two subgroups according to age (6 classes) and education (4 levels). In fact, two groups were missing as there were no people belonging to the first two age classes who had only a primary education (0-7 years of formal education) because secondary education has been compulsory in Italy from the mid nineteen sixties. We included in each subgroup twenty people achieving a total of four hundred and forty subjects (i.e. 20 people X 4 levels of education X 6 age classes, minus 40 people [20 subjects, 20-29 and 30-39 years old with 0-7 years of education] = 440 subjects).

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

Materials

We developed an Italian version of the Right Hemisphere Language Battery [1] devised by Bryan [2]. All pictorial material were newly produced for the Italian version of the RHLB (Batteria del Linguaggio dell'Emisfero Destro – BaLED) in order to adapt the testing materials to Italian culture. Adaptation criteria will be described at the end of this section.

The battery consists of six formal tests and one quali-quantitative scale for the evaluation of eleven features of pragmatic skills in a conversational setting such as a dialogue between the subject and the experimenter. For a detailed description of the RHLB, see Bryan [2]. A brief description of each test and of the conversational scale follows.

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 is aurally given 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. Three semantically related distractors 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) 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 constantly visible to the subject. The subject listens to this material presented verbally and is asked to point to the correct metaphorical interpretation of the sentence. The alternatives are the genuine metaphorical meaning, a primitive metaphorical meaning that only focuses on an incidental aspect of the metaphor, and a metonymic interpretation 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. This test represents a pictorial analogue of the Written Metaphor test (ten different metaphorical sentences are used). The subject is aurally given a sentence that includes a metaphor. The task is to indicate which among four pictures depicted on a single plate and available to the subject, represents the correct metaphorical interpretations of the sentence. The alternatives are the correct one, the literal meaning, and two control pictures 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 questions in turn. S/he can refer to the text to give his/her response (see Appendix 4). 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). 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, a straight ending of neutral content, a straight ending of emotional content, a surprise ending that does not relate to the body of the joke (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 use linguistic stress to distinguish "new" from "given" 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 with the line drawing of the second clause and s/he 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* – '*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 from a spontaneous conversation arising while testing is in progress. 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, and finally 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.

Ten undergraduate students, not included in standardisation, were used to select appropriate testing materials. For the Lexical-Semantic test, we asked them to classify, as common or uncommon, lexical-semantic elements from a pool of forty. Only common elements were included in the testing material. Clearly, all these lexical-semantic elements were different from those of the original English version. For the Written and the Picture Metaphor tests, we asked undergraduate students to classify metaphorical sentences as common or uncommon from a set of thirty sentences. Moreover, they had to classify each alternative answer, on the basis of theoretical definitions given for each alternative response: for the former test, correct metaphorical meaning, metonymic or "primitive" interpretation, and for the latter test, correct metaphorical meaning, literal interpretation, or visual distractor. For both tests, we selected ten common metaphorical sentences among those where the classification of alternative responses was totally correct. For the Inference test, we translated the English text, as no adaptation problems were present. For the Humour test, we asked undergraduate students to classify each alternative story-ending as correct punch-line, neutral, emotional, or incorrect response, on the basis of theoretical definitions given for each alternative response. We selected ten humorous stories, from a set of twenty, where the classification of alternative responses was totally correct. For the

Emphatic Accent test, we translated the original English material into Italian and made new drawings with the artistic style of all pictorial materials of the Ba.L.E.D. Finally, for as the Conversation Analysis , we used the eleven conversational pragmatic features of the original English battery and used the same scoring system.

We also carried out a pilot study on the whole battery before standardisation. Twenty normal volunteers, not included in standardisation, with ages and education ranging from 40 to 79, and from 5 to 18 years, respectively, were tested on the Ba.L.E.D. These subjects were all at ceiling on all the battery sub-tests.SERGIO- this sounds odd (eg older ones should not have been at ceiling? and contradict the claim re ceiling effects on p 16.

The whole battery was administered to normal volunteers in one testing session that lasted approximately twenty minutes.

Results

The results of the six tasks and of the Analysis of Conversational Ability are reported in Tables 1-7. Each table presents:

a) mean scores of the different age/education groups;

b) distribution of the different scores in terms of density and cumulative frequencies;

c) best simultaneous linear regression model (i.e. that which includes only the significant predictors), and the significance of each model variable;

d) percentile distribution of scores separated for age and education classes.

Table 8 reports correlation coefficients between performance of healthy subjects on all the Ba.L.E.D. tests.

Lexical-Semantic test

The overall mean score was 19.74 (SD = 0.56) (see Table 1a). All normative values were highly skewed towards the top score. In fact, the worse mean performance was equal to 97% correct. The left tail of the whole distribution of normative values approximated to a normal shape: only 5.2% of the distribution felt below two standard deviations of the overall mean value (see Table 1b). However, taking into account a cut-off of two SDs below normal mean (hereafter the 2SDs cut-off, a commonly used clinical cut-off to identify a pathologic performance) for each age class and each education class independently, we found that these values were above the 5th percentile score in many groups and even above the 10th percentile value in 39-39 and in 70-79 years people (see Table 1d). Finally, Age class significantly influenced the performance of healthy subjects ($t_{2,439} = -5.12$, $p < 0.0001$) – the older the people, the lower their performance, while Education did not ($t_{2,439} = -0.76$, $p > 0.44$) (see Table 1c).

Written Metaphor test

The overall mean score was 9.67 (SD = 0.76) (see Table 2a). All values were skewed towards the top score: the worse mean score was equal to 88.5% correct. Overall, the left tail of normative scores poorly approximated to a normal distribution: 92.5% of the distribution was above two standard deviations below normal mean (see Table 2b). However, when we considered the 2DSs cut-off for each age and education group, these values were above the 5th percentile performance only in some groups (see Table 2d). Both Age and Education factors significantly influenced the performance of healthy subjects: scores decreased as age increased ($t_{2,439} = -5.34$, $p < 0.0001$), and increase with education levels ($t_{2,439} = 5.60$, $p < 0.0001$) (see Table 2c).

Picture Metaphor test

The overall mean score was 8.95 (SD = 1.46) (see Table 3a). The distribution of normative values was significantly large. Mean performance ranged from 70% to 99% correct and the left tail of the

distribution was far from being normal: in fact, 10.5% of values fell below two standard deviations below the mean score (see Table 3b). However, consistently with findings on the Written Metaphor test, the 2SDs cut-off value for each age and education group was above the 5th percentile values only in some groups (see Table 3d). Finally, we found that Age and Education factors influenced the performance of healthy subjects: negatively for age ($t_{2,439} = -8.70$, $p < 0.0001$), and positively for education ($t_{2,439} = 7.71$, $p < 0.0001$) (see Table 3c).

Inference test

The overall mean score was 9.99 (SD = 1.47) (see Table 4a). The normal mean scores ranged, in the different groups according to age and education from 71.7% to 91.2% correct. The left tail of the distribution of normative values approximated to a normal shape: only 5.2% of the distribution fell below two standard deviations of the overall mean value (see Table 4b). In addition, when we took into account the 2SDs cut-off for age class and education independently, we found that these values were above the 5th percentile score only in two groups, the first age class (20-29 years) and the fourth education group (≥17 years of education) (see Table 4d). Finally, we found that Age and Education factors significantly influenced the performance of healthy subjects, decreasing performance with age ($t_{2,439} = -5.12$, $p < 0.0001$), and increasing performance with education ($t_{2,439} = 4.71$, $p < 0.0001$) (see Table 4c).

Humour test

The overall mean score was 8.74 (SD = 1.43) (see Table 5a). The normal mean scores ranged widely, in the different groups according to age and education, from 68.5% to 99.5% correct. The left tail of the whole distribution of normative values approximated to a normal shape: only 3.9% of the distribution fell below two standard deviations of the overall mean value (see Table 5b). However, when we took

into account the 2SDs cut-off for age class and education independently, we found that these values were above the 5th percentile score in several groups (see Table 5d). Finally, we found that the performance of healthy subjects decreased with age ($t_{2,439}$ = -5.95, $p < 0.0001$), and increased with education ($t_{2,439}$ = 6.46, $p < 0.0001$) (see Table 5c).

Emphatic Accent test

The overall mean score was 9.23 (SD = 0.81) (see Table 6a). The normal mean scores ranged, in the different groups according to age and education from 85.5% to 97% correct. The left tail of the whole distribution of normative values approximated to a normal shape: only 3% of the distribution fell below two standard deviations of the overall mean value (see Table 6b). In addition, when we took into account the 2SDs cut-off for age class and education independently, we found that these values were above the 5th percentile score only in the groups of 50-59 years of age and in people with 13-16 years of education (see Table 6d). Finally, we found that Age class and Education factors significantly influenced the performance of healthy subjects, with age having a negative effect ($t_{2,439}$ = -2.09, $p < 0.05$), and education having a positive effect ($t_{2,439}$ = 4.24, $p < 0.0001$) (see Table 6c).

Conversational Analysis scale

The overall mean score was 43.8 (SD = 0.79) (see Table 7a). The normal mean scores were skewed towards the top score, with the lowest mean score equal to 97.9% correct. The left tail of the whole distribution of normative values approximated to a normal shape: only 6.6% of the distribution fell below two standard deviations of the overall mean value (see Table 7b). However, when we took into account the 2SDs cut-off for age class and education groups independently, we found that these values were above the 5th percentile score in all groups and even above the 10th percentile value in the group of people with age ranging from 60-69 years (see Table 7d). Finally, we found that Age class and

Education factors significantly influenced the performance of healthy subjects, with age having a negative effect ($t_{2,439} = -3.28$, $p < 0.001$), and education having a positive effect ($t_{2,439} = 3.09$, $p < 0.002$) (see Table 7c).

Correlation analysis

We ran a non-parametric correlation analysis between performance of healthy subjects on all the Ba.L.E.D. tests. We found that scores correlated across most tests with the exception of performance on the Lexical-Semantic test, the Emphatic Accent test and with the Analysis of Conversation Abilities (see Table 8).

Discussion

By themselves, normative data call for only a brief comment. However, several findings are worthy of discussion. Firstly, with very few exceptions, the performance on all subtests correlated among each other. We tested a large sample of normal subjects, but other cognitive measures for our sample were not available so it was not possible to suggest to what extent the different verbal linguistic competences recruited by the Ba.L.E.D. share common cognitive operations. Furthermore, the Right Hemisphere Language Battery has been proposed as an initial clinical tool to recognise the presence/absence of some verbal pragmatic impairments in brain-damaged patients and to identify areas for further investigation. In fact, the battery does not disentangle the cognitive operations underpinning the pragmatic features of verbal communication that are invariably better addressed by more analytical and more lengthy tests. However, clinical and experimental neurolinguistics still lacks consolidated clinical tools for the assessment of impairments of verbal pragmatics, and the Ba.L.E.D. could be widely used in standard neuropsychological examinations in several neurological populations, as its initial test

structure???function has been shown to be reliable [17]. In fact, apart from right hemisphere damaged patients, verbal pragmatic impairments have been reported in other clinical populations such as patients with traumatic brain injuries, frontal lobe lesions [18,19], Parkinson's disease[20] or Alzheimer's disease [21].

Clearly, clinical assessment of verbal pragmatic impairments might be influenced by any aphasic deficit (especially at the lexical-semantic level), or by other cognitive impairments such as visuo-spatial or neglect impairments. Therefore, one might cautiously interpret results on the Ba.L.E.D. before diagnosing a verbal pragmatic deficit. However, this holds for any neuropsychological test. In fact, no selective cognitive deficits can be diagnosed outside a complete clinical neuropsychological battery of tests.

Secondly, we found that both age and education influenced performance on all the tests tapping pragmatic competences. Apart from clinical purposes, these findings are interesting because they suggest that some other cognitive functions, that are known to be sensitive to age and education (e.g. pre-frontal functions), might, to a certain extent, come into play in processing some pragmatic features of verbal communication. In fact, more recent experimental findings [8,12,13,18-20] suggest that there is an important role exerted by pre-frontal cortices in processing verbal pragmatics (i.e. see TOM, WCC, and disexecutive hypotheses). Thus, it might be interesting to address these aspects in more cognitively-oriented experimental studies, where not only the anatomical bases of verbal pragmatic deficits is considered but also a thorough task-analysis of the different experimental materials is investigated.

Thirdly, except on the Lexical-Semantic test and on the Analysis of Conversational Abilities, performance of healthy subjects tended not to be too skewed towards the top score. This provides the clinicians with a diagnostic tool sufficiently reliable in avoiding floor and ceiling effects.

In conclusion, the rigorous standardisation of the Italian adaptation of the Right Hemisphere Language Battery devised by Bryan [2], might bea useful and reliable clinical tool to address verbal pragmatic impairments in several populations of neurological patients. It addresses a neurolinguistic field that has been neglected for a long time by clinical neuropsychologists. Ba.L.E.D administration lasted only twenty minutes in normal volunteers and, in our experience, between thirty and forty-five minutes in RHD patients; therefore, it is not time-consuming. Thus, we suggest that the insertion of the Ba.L.E.D. in standard clinical neuropsychological batteries will improve the information available to clinicians' experience concerning the pragmatic aspects of verbal communication. We understand that it covers linguistic functions that go beyond contributions of the right hemisphere to language processing, but we decided to maintain the original name to make the battery more recognisable. I suggest omit this last sentence.

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Riassunto

La neurolinguistica clinica tuttora è priva di test diagnostici standardizzati per i deficit di pragmatica della comunicazione verbale. In questo lavoro presentiamo i dati normativi della versione italiana della batteria "The Right Hemisphere Language Battery" (Batteria del Linguaggio dell'Emisfero Destro – Ba.L.E.D.) [1] elaborata originariamente da Bryan [2]. Lo studio normativo è stato realizzato mediante il reclutamento di un totale di 440 soggetti normali. La batteria di test non è stata concepita per operare una diagnosi cognitiva dei deficit pragmatici della comunicazione verbale; piuttosto la sua finalità consiste nella possibilità di riconoscere la presenza o meno di deficit nell'elaborazione degli aspetti principali della pragmatica della comunicazione verbale, tradizionalmente associati a lesioni dell'emisfero cerebrale destro. Pertanto, oltre ad essere uno strumento clinico per la diagnosi di tali deficit, essa funge da batteria di test di primo livello per la selezione di specifiche popolazioni di pazienti neurologici candidati ad essere studiati in ulteriori studi sperimentali.

Table 1. Lexical-Semantic test: a) values are expressed as mean and standard deviations (in parentheses) by Age (first column) and years of Education (top raw); b) density and cumulative frequencies of responses given by all normal subjects; c) best simultaneous linear regression model; significance levels of Age and Education factors are also reported; d) percentiles table of responses divided by Age and Education factors.

a)

LEXSEM	**0-7**	**8-12**	**13-16**	**>=17**	**Overall**
20-29	-	19.9 (0.31)	20 (0)	19.85 (0.37)	**19.92 (0.28)**
30-39	-	19.85 (0.37)	19.9 (0.31)	19.75 (0.55)	**19.83 (0.42)**
40-49	19.8 (0.62)	19.6 (0.75)	19.8 (0.41)	20 (0)	**19.8 (0.54)**
50-59	19.8 (0.52)	19.8 (0.52)	19.9 (0.31)	19.7 (0.57)	**19.8 (0.49)**
60-69	19.75 (0.55)	19.8 (0.41)	19.7 (0.66)	19.5 (0.89)	**19.69 (0.65)**
70-79	19.45 (0.76)	19.5 (0.61)	19.5 (0.76)	19.4 (0.75)	**19.46 (0.71)**
Overall	**19.7 (0.62)**	**19.74 (0.53)**	**19.8 (0.49)**	**19.7 (0.62)**	**19.74 (0.56)**

b)

LEX-SEM		**Density**	**Cumulative frequency**	**Percentage**	**Cumulative percentage**
Score	17	2	2	0.5	0.5
	18	21	23	4.8	5.2
	19	67	90	15.2	20.5
	20	350	440	79.5	100.0

c)

Best simultaneous linear regression model: 20.089 – 0.082 x Age class

Significance Age $t_{2,439} = -5.12$, $p < 0.0001$

Education $t_{2,439} = -0.76$, $p = ns$

d)

LEX-SEM	**Percentiles**						
Age classes	**5**	**10**	**25**	**50**	**75**	**90**	**95**
20-29 years	19	20	20	20	20	20	20
30-30 years	19	19	20	20	20	20	20
40-49 years	19	19	20	20	20	20	20
50-59 years	19	19	20	20	20	20	20
60-69 years	18	19	20	20	20	20	20
70-79 years	18	18	19	20	20	20	20
Education							
0-7 years	18	19	20	20	20	20	20
8-12 years	19	19	20	20	20	20	20
13-16 years	19	19	20	20	20	20	20
>= 17 years	18	19	20	20	20	20	20

Table 2. Written Metaphors test: a) values are expressed as mean and standard deviations (in parentheses) by Age (first column) and years of Education (top raw); b) density and cumulative frequencies of responses given by all normal subjects; c) best simultaneous linear regression model; significance levels of Age and Education factors are also reported; d) percentiles table of responses divided by Age and Education factors.

a)

WMET	**0-7**	**8-12**	**13-16**	**>=17**	**Overall**
20-29	-	9.8 (0.52)	10 (0)	10 (0)	**9.93 (0.31)**
30-39	-	9.8 (0.52)	10 (0)	9.95 (0.22)	**9.92 (0.33)**
40-49	9.9 (0.45)	9.65 (1.14)	9.95 (0.22)	9.95 (0.22)	**9.86 (0.63)**
50-59	9.2 (1.24)	9.55 (0.89)	9.65 (0.75)	9.95 (0.22)	**9.59 (0.88)**
60-69	9.2 (1.28)	9.4 (0.82)	9.85 (0.37)	9.75 (0.72)	**9.55 (0.88)**
70-79	8.85 (0.81)	9.05 (1.15)	9.65 (0.67)	9.75 (0.55)	**9.32 (0.9)**
Overall	**9.29 (1.06)**	**9.54 (0.9)**	**9.85 (0.46)**	**9.89 (0.41)**	**9.67 (0.76)**

b)

WMET		**Density**	**Cumulative frequency**	**Percentage**	**Cumulative percentage**
Score	5	1	1	0.2	0.2
	6	4	5	0.9	1.1
	7	8	13	1.8	3.0
	8	20	33	4.5	7.5
	9	58	91	13.2	20.7
	10	349	440	79.3	100.0

c)

Best simultaneous linear regression model: 9.607 – 0.11 x Age class + 0.179 x Education

Significance Age $t_{2,439} = -5.34$, $p < 0.0001$

Education $t_{2,439} = 5.60$, $p < 0.0001$

d)

WMET	**Percentiles**						
Age classes	**5**	**10**	**25**	**50**	**75**	**90**	**95**
20-29 years	9.05	10	10	10	10	10	10
30-30 years	9	10	10	10	10	10	10
40-49 years	9	10	10	10	10	10	10
50-59 years	7	8	10	10	10	10	10
60-69 years	7.05	9	9	10	10	10	10
70-79 years	8	8	9	10	10	10	10
Education							
0-7 years	7	8	9	10	10	10	10
8-12 years	8	9	9	10	10	10	10
13-16 years	9	9	10	10	10	10	10
>= 17 years	9	10	10	10	10	10	10

Table 3. Picture Metaphors test: a) values are expressed as mean and standard deviations (in parentheses) by Age (first column) and years of Education (top raw); b) density and cumulative frequencies of responses given by all normal subjects; c) best simultaneous linear regression model; significance levels of Age and Education factors are also reported; d) percentiles table of responses divided by Age and Education factors.

a)

PMET	**0-7**	**8-12**	**13-16**	**>=17**	**Overall**
20-29	-	9.6 (0.6)	9.9 (0.31)	9.85 (0.37)	**9.78 (0.45)**
30-39	-	9.5 (0.76)	9.85 (0.37)	9.6 (0.94)	**9.65 (0.73)**
40-49	8.65 (1.39)	9.25 (1.16)	9.45 (0.89)	9.75 (0.44)	**9.27 (1.09)**
50-59	7.95 (1.79)	8.75 (1.59)	9.35 (1.04)	9.5 (0.95)	**8.88 (1.49)**
60-69	7.2 (1.67)	8.2 (1.73)	9.15 (1.23)	9.15 (1.23)	**8.42 (1.67)**
70-79	7 (1.41)	8.45 (1.57)	7.95 (2.09)	8.9 (1.29)	**8.07 (1.74)**
Overall	**7.7 (1.68)**	**8.96 (1.39)**	**9.27 (1.3)**	**9.46 (0.98)**	**8.95 (1.46)**

b)

PMET		**Density**	**Cumulative frequency**	**Percentage**	**Cumulative percentage**
Score	4	3	3	0.7	0.7
	5	14	17	3.2	3.9
	6	29	46	6.6	10.5
	7	27	73	6.1	16.6
	8	39	112	8.9	25.5
	9	98	210	22.3	47.7
	10	230	440	52.3	100,0

c)

Best simultaneous linear regression model: 8.967 – 0.361 x Age class + 0.436 x Education

Significance Age $t_{2,439} = -8.70$, $p < 0.0001$

Education $t_{2,439} = 7.71$, $p < 0.0001$

d)

PMET	**Percentiles**						
Age classes	**5**	**10**	**25**	**50**	**75**	**90**	**95**
20-29 years	9	9	10	10	10	10	10
30-30 years	8	9	9.25	10	10	10	10
40-49 years	7	8	9	10	10	10	10
50-59 years	5	7	8	10	10	10	10
60-69 years	6	6	7	9	10	10	10
70-79 years	5	5	7	8.5	10	10	10
Education							
0-7 years	5	5	6	8	9	10	10
8-12 years	6	7	8	9.5	10	10	10
13-16 years	6	7	9	10	10	10	10
>= 17 years	7	8	9	10	10	10	10

Table 4. Inference test: a) values are expressed as mean and standard deviations (in parentheses) by Age (first column) and years of Education (top raw); b) density and cumulative frequencies of responses given by all normal subjects; c) best simultaneous linear regression model; significance levels of Age and Education factors are also reported; d) percentiles table of responses divided by Age and Education factors.

a)

INF	**0-7**	**8-12**	**13-16**	**>=17**	**Overall**
20-29	-	9.5 (1.79)	10.7 (1.17)	10.7 (1.22)	**10.3 (1.51)**
30-39	-	10 (1.41)	10.65 (1.14)	10.45 (1.1)	**10.37 (1.23)**
40-49	10.2 (1.2)	9.3 (1.42)	10.35 (1.31)	10.85 (0.86)	**10.17 (1.32)**
50-59	9.3 (1.13)	10.7 (1.13)	10.25 (1.07)	10.95 (1.19)	**10.3 (1.28)**
60-69	9.3 (1.49)	10.2 (1.1)	10.05 (1)	10.1 (1.17)	**9.91 (1.23)**
70-79	9 (1.69)	8.6 (2.16)	9.05 (1.36)	9.6 (1.67)	**9.06 (1.74)**
Overall	**9.45 (1.44)**	**9.72 (1.66)**	**10.17 (1.28)**	**10.44 (1.29)**	**9.99 (1.47)**

b)

INF		**Density**	**Cumulative frequency**	**Percentage**	**Cumulative percentage**
Score	4	2	2	0.5	0.5
	5	1	3	0.2	0.7
	6	5	8	1.1	1.8
	7	15	23	3.4	5.2
	8	48	71	10.9	16.1
	9	76	147	17.3	33.4
	10	101	248	23.0	56.4
	11	134	382	30.5	86.8
	12	58	440	13.2	100.0

c)

Best simultaneous linear regression model: 9.911 – 0.19 x Age class + 0.296 x Education

Significance Age $t_{2,439} = -4.71$, $p < 0.0001$

Education $t_{2,439} = 4.71$, $p < 0.0001$

d)

INF	**Percentiles**						
Age classes	**5**	**10**	**25**	**50**	**75**	**90**	**95**
20-29 years	7.05	8	9	11	11	12	12
30-30 years	8	9	10	11	11	12	12
40-49 years	8	8	9	11	11	11.9	12
50-59 years	8	8	10	10	11	12	12
60-69 years	8	8	9	10	11	11	12
70-79 years	6	7	8	9	11	11	11
Education							
0-7 years	7	8	8	9.5	11	11	11
8-12 years	7	8	9	10	11	12	12
13-16 years	8	8	9	10	11	12	12
>= 17 years	8	9	10	11	11	12	12

Table 5. Humour Appreciation test: a) values are expressed as mean and standard deviations (in parentheses) by Age (first column) and years of Education (top raw); b) density and cumulative frequencies of responses given by all normal subjects; c) best simultaneous linear regression model; significance levels of Age and Education factors are also reported; d) percentiles table of responses divided by Age and Education factors.

a)

HUM	**0-7**	**8-12**	**13-16**	**>=17**	**Overall**
20-29	-	8.85 (1.27)	9.75 (0.44)	9.3 (0.86)	**9.3 (0.98)**
30-39	-	8.85 (1.87)	9.55 (0.76)	9.45 (0.89)	**9.28 (1.29)**
40-49	8.8 (0.83)	8.6 (1.63)	9.15 (0.81)	9.2 (1.1)	**8.94 (1.15)**
50-59	7.75 (1.97)	8.7 (1.49)	9.05 (1.05)	9.25 (0.85)	**8.69 (1.5)**
60-69	7.5 (1.99)	8.7 (1.03)	9.95 (0.83)	9.1 (1.12)	**8.56 (1.44)**
70-79	6.85 (2.06)	8.2 (1.4)	8.15 (1.35)	8.55 (1.05)	**7.94 (1.62)**
Overall	**7.72 (1.89)**	**8.65 (1.46)**	**9.1 (1.03)**	**9.14 (1.01)**	**8.74 (1.43)**

b)

HUM		**Density**	**Cumulative frequency**	**Percentage**	**Cumulative percentage**
Score	1	1	1	0.2	0.2
	2	1	2	0.2	0.5
	3	1	3	0.2	0.7
	4	3	6	0.7	1.4
	5	11	17	2.5	3.9
	6	15	32	3.4	7.3
	7	42	74	9.5	16.8
	8	67	141	15.2	32.0
	9	138	279	31.4	63.4
	10	161	440	36.6	100.0

c)

Best simultaneous linear regression model: 8.564 – 0.226 x Age class + 0.382 x Education

Significance Age $t_{2,439} = -5.95$, $p < 0.0001$

Education $t_{2,439} = 6.46$, $p < 0.0001$

d)

HUM	**Percentiles**						
Age classes	**5**	**10**	**25**	**50**	**75**	**90**	**95**
20-29 years	7.05	8	9	10	10	10	10
30-30 years	7	8	9	10	10	10	10
40-49 years	6.05	7.1	9	9	10	10	10
50-59 years	5.05	7	8	9	10	10	10
60-69 years	5	7	8	9	10	10	10
70-79 years	5.05	6	7	8	9	10	10
Education							
0-7 years	5	5	7	8	9	10	10
8-12 years	6	7	8	9	10	10	10
13-16 years	7	8	9	9	10	10	10
>= 17 years	7	8	9	9	10	10	10

Table 6. Emphatic Accent test: a) values are expressed as mean and standard deviations (in parentheses) by Age (first column) and years of Education (top raw); b) density and cumulative frequencies of responses given by all normal subjects; c) best simultaneous linear regression model; significance levels of Age and Education factors are also reported; d) percentiles table of responses divided by Age and Education factors.

a)

ACC	**0-7**	**8-12**	**13-16**	**>=17**	**Overall**
20-29	-	9.2 (0.89)	9.7 (0.57)	9.1 (0.79)	**9.33 (0.8)**
30-39	-	9.4 (0.6)	9.5 (0.76)	9.3 (0.8)	**9.4 (0.72)**
40-49	8.95 (0.39)	9.5 (0.83)	9.45 (0.6)	9.25 (0.85)	**9.29 (0.71)**
50-59	8.55 (1.23)	9.35 (0.88)	9.55 (0.51)	9.5 (0.83)	**9.24 (0.97)**
60-69	8.65 (0.82)	9.35 (0.59)	9.4 (0.75)	9.3 (0.8)	**9.17 (0.79)**
70-79	8.6 (0.82)	9.2 (0.7)	9.05 (0.83)	9.3 (0.73)	**9.04 (0.8)**
Overall	**8.69 (0.87)**	**9.33 (0.75)**	**9.44 (0.7)**	**9.29 (0.79)**	**9.23 (0.81)**

b)

ACC		**Density**	**Cumulative ferquency**	**Percentage**	**Cumulative percentage**
Score	5	1	1	0.2	0.2
	7	12	13	2.7	3.0
	8	59	72	13.4	16.4
	9	178	250	40.5	56.8
	10	190	440	43.2	100.0

c)

Best simultaneous linear regression model: 9.011 – 0.048 x Age class + 0.152 x Education

Significance Age $t_{2,439} = -2.09$, $p < 0.05$
Education $t_{2,439} = 4.24$, $p < 0.0001$

d)

ACC	**Percentiles**						
Age classes	**5**	**10**	**25**	**50**	**75**	**90**	**95**
20-29 years	8	8	9	9.5	10	10	10
30-30 years	8	8	9	10	10	10	10
40-49 years	8	8.1	9	9	10	10	10
50-59 years	7	8	9	9	10	10	10
60-69 years	8	8	9	9	10	10	10
70-79 years	8	8	8	9	10	10	10
Education							
0-7 years	7	8	8	9	9	10	10
8-12 years	8	8	9	9	10	10	10
13-16 years	8	8	9	10	10	10	10
>= 17 years	8	8	9	9	10	10	10

Table 7. Conversation Analysis scale: a) values are expressed as mean and standard deviations (in parentheses) by Age (first column) and years of Education (top raw); b) density and cumulative frequencies of responses given by all normal subjects; c) best simultaneous linear regression model; significance levels of Age and Education factors are also reported; d) percentiles table of responses divided by Age and Education factors.

a)

CA	**0-7**	**8-12**	**13-16**	**>=17**	**Overall**
20-29	-	43.75 (0.91)	44 (0)	44 (0)	**43.92 (0.53)**
30-39	-	43.9 (0.45)	44 (0)	43.9 (0)	**43.93 (0.36)**
40-49	44 (0)	44 (0)	44 (0)	44 (0)	**44 (0)**
50-59	43.25 (1.62)	43.75 (0.79)	44 (0)	43.9 (0.45)	**43.72 (0.95)**
60-69	43.4 (1.35)	43.9 (0.45)	44 (0)	43.8 (0.89)	**43.77 (0.86)**
70-79	43.1 (1.48)	43.8 (0.62)	43.3 (1.34)	43.8 (0.89)	**43.5 (1.16)**
Overall	**43.44 (1.31)**	**43.85 (0.6)**	**43.88 (0.6)**	**43.9 (0.57)**	**43.8 (0.79)**

b)

CA		**Density**	**Cumulative frequency**	**Percentage**	**Cumulative percentage**
Score	39	1	1	0.2	0.2
	40	11	12	2.5	2.7
	41	4	16	0.9	3.6
	42	13	29	3.0	6.6
	43	2	31	0.5	7.0
	44	409	440	93.0	100.0

c)

Best simultaneous linear regression model: 43.784 – 0.073 x Age class + 0.108 x Education

Significance Age $t_{2,439} = -3.28$, $p < 0.001$

Education $t_{2,439} = 3.09$, $p < 0.002$

d)

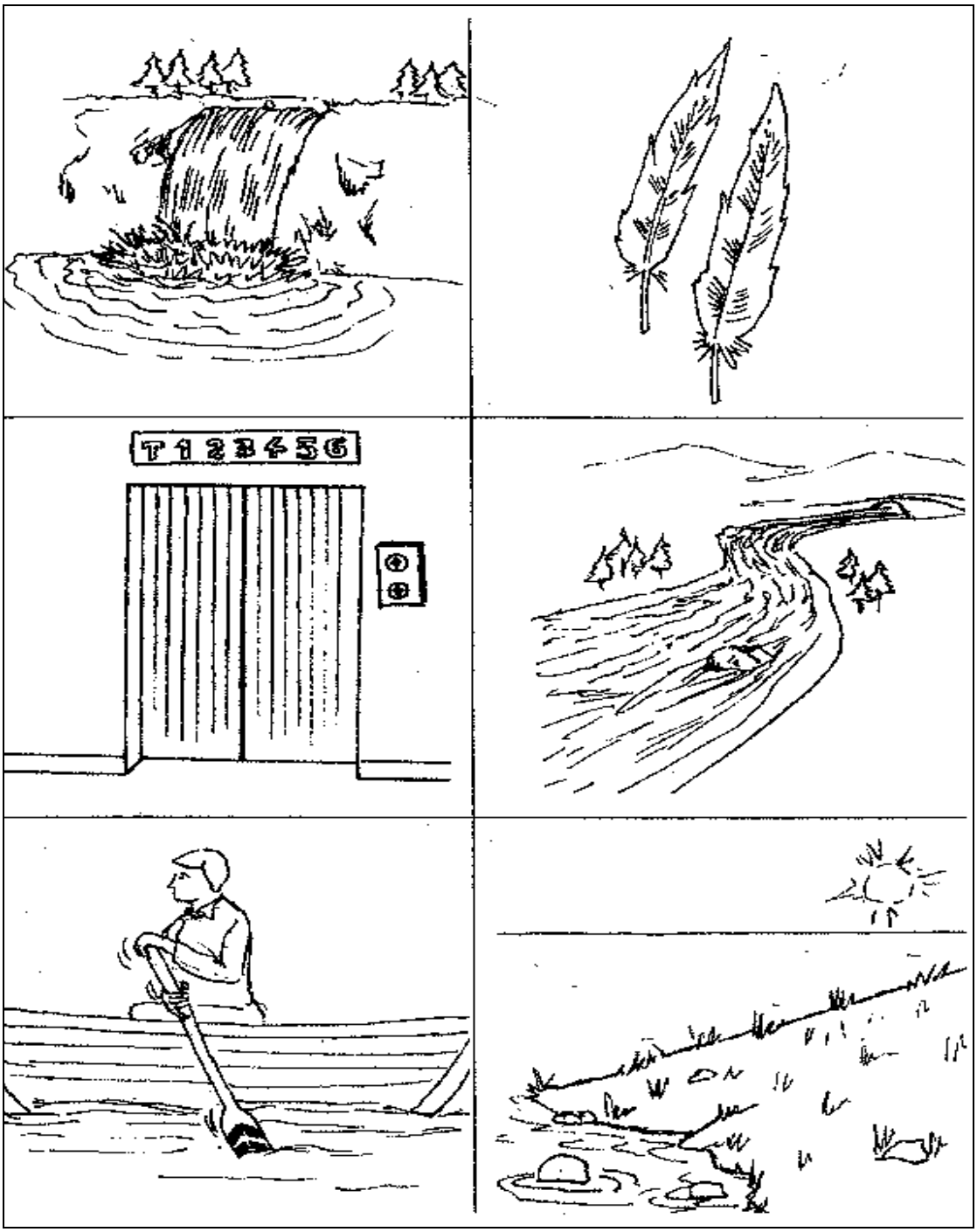
CA	**Percentiles**						
Age classes	**5**	**10**	**25**	**50**	**75**	**90**	**95**
20-29 years	44	44	44	44	44	44	44
30-30 years	44	44	44	44	44	44	44
40-49 years	41.05	44	44	44	44	44	44
50-59 years	41.05	44	44	44	44	44	44
60-69 years	40	42	44	44	44	44	44
70-79 years	44	44	44	44	44	44	44
Education							
0-7 years	40	41	44	44	44	44	44
8-12 years	42	44	44	44	44	44	44
13-16 years	44	44	44	44	44	44	44
>= 17 years	44	44	44	44	44	44	44

Table 8. Correlation coefficients between performance on the I-RHLB (Ba.L.E.D.) tests across all subgroups of healthy controls.

Spearman's rho		**LEX-SEM**	**WMET**	**PMET**	**INF**	**HUM**	**ACC**	**CA**
LEX-SEM	Corr. Coeffic.	----	**.163**	**.221**	**.192**	**.173**	.035	.036
	Sig. (2-tailed)	----	<0.001	<0.0001	<0.0001	<0.0001	>0.460	>0.448
WMET	Corr. Coeffic.		----	**.415**	**.206**	**.345**	**.132**	**.234**
	Sig. (2-tailed)		----	<0.0001	<0.0001	<0.0001	<0.006	<0.0001
PMET	Corr. Coeffic.			----	**.290**	**.412**	**.230**	**.166**
	Sig. (2-tailed)			----	<0.0001	<0.0001	<0.0001	<0.0001
INF	Corr. Coeffic.				----	**.283**	**.266**	**.189**
	Sig. (2-tailed)				----	<0.0001	<0.0001	<0.0001
HUM	Corr. Coeffic.					----	**.253**	**.245**
	Sig. (2-tailed)					----	<0.0001	<0.0001
ACC	Corr. Coeffic.						----	**.212**
	Sig. (2-tailed)						----	<0.0001
CA	Corr. Coeffic.							----
	Sig. (2-tailed)							----

Appendices

Appendix 1. Example from the Lexical-Semantic test



Target: *fiume* (river); Semantic coordinators: *riva* (bank), *cascata* (falls); Functional coordinator: *remare* (to row); Phonological distractor: *piume* (feathers); Visual distractor: *ascensore* (elevator)

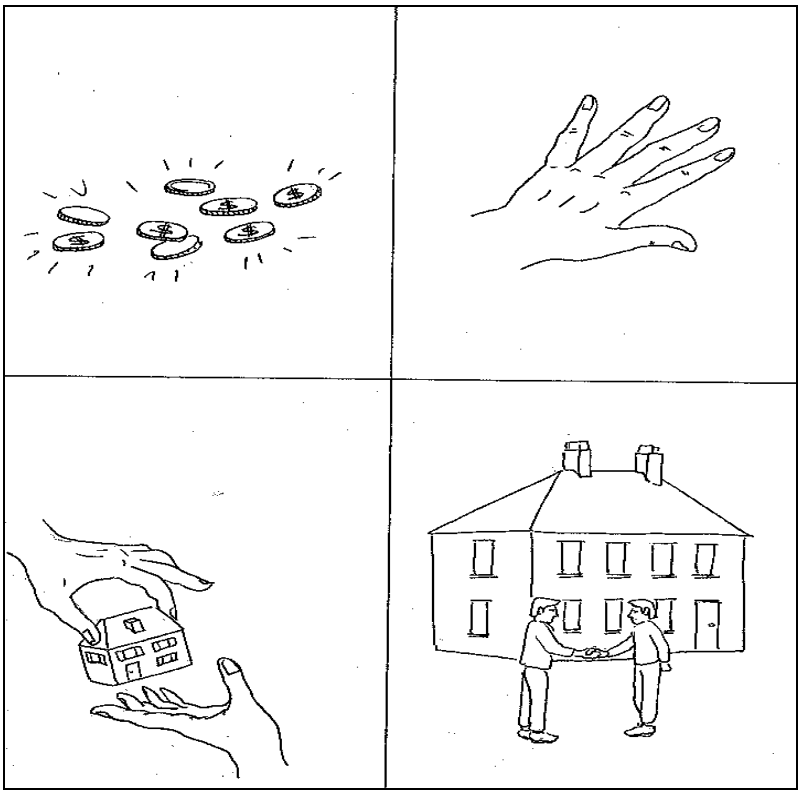
Appendix 2. Example from the Written Metaphor test

Metaphorical given sentence: *Carlo ha sempre vissuto con il sudore della propria fronte* (Carlo has always earned by the sweat of his brow)

Sentence with metaphorical meaning explained: *Carlo ha sempre lavorato molto per procurarsi di che vivere* (Carlo has always worked a lot to earn his living)
Sentence with metonimic meaning: *Carlo per vivere ha sempre venduto il suo sudore* (Carlo has always sold his sweat to earn his living)
Sentence with primitive meaning: *Carlo, in tutta la sua vita, ha sempre sudato molto sulla fronte* (Carlo, during his life, has always sweated a lot on his brow)

Appendix 3. Example from the Picture Metaphor test

The given plate with drawings



Metaphorical sentence: *La casa può passare di mano non appena il contratto è stipulato* (The house can pass into other hands as soon as the contract is drew up).

Appendix 4. Example from the Inference test

The given text: *"Sono veramente affamato" – disse Marco. "Tieni gli occhi aperti dalla tua parte, Anna". Proseguirono ancora velocemente per qualche minuto. "Guarda lungo quella strada secondaria" – disse lei. "Fermati il prima possible."* ("I'm quite hungry" Marco said. "Keep your eyes on your side, Anna". They carried on quickly for several minutes. "Look, along that secondary road" – she said. "Stop as soon as you can")

Open questions:

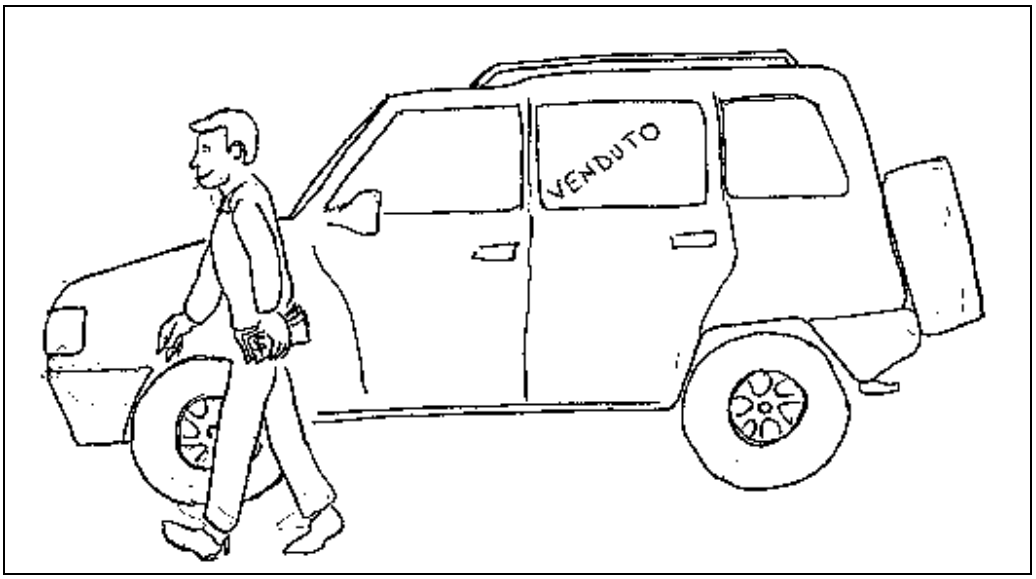
1. *Quante persone ci sono in questo racconto?* (How many people are there in this story?). Correct answer: two
2. *Con che mezzo di trasporto stanno viaggiando?* (Which mean of transport were they using?) Correct answer: car or motorcycle.
3. *Chi stava guidando?* (Who was driving?) Correct answer: Marco.
4. *Che cosa stavano cercando?* (What were they looking for?) Correct answer: a restaurant.

Appendix 5. Example from the Humour test

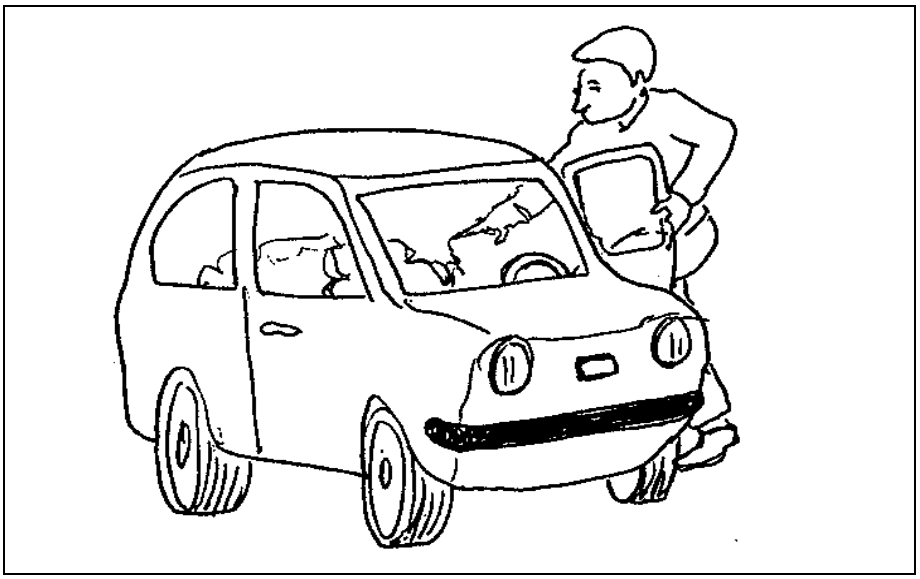
The given humour story: *Un uomo sta annegando nel fiume e urla come un forsennato: "Aiuto, aiuto, non so nuotare!". Un tale che passa di lì lo guarda e gli dice…* (A man is drowning in a river and is bellowing like a lunatic: "Help, help, I cannot swim!" Someone who's passing by looks at him and says…).

1. Humour ending: *"Anch'io non so nuotare ma non urlo come lei!"* ("Neither I cannot swim, but I don't bellow like you!").
2. Neutral ending: *"Non si preoccupi, ho già chiamato i soccorsi"* (Don't worry, I have already asked for help").
3. Emotional ending: *"La aiuterei volentieri, ma non so nuotare neanch'io"* (I'd willingly help you, but neither I can swim").
4. Incorrect ending: *"Gli alberi sono in fiore"* ("Trees are in blossom").

Appendix 6. Example from the Emphatic Accent test



The drawing to be given whilst reading the first half of sentence: *Lui ha venduto la macchina grande e*… (He sold the big car – *big emphasised* – and…)



The second drawing to be given in order to make the patient complete the sentence: …*ha comprato la macchina piccola* (he bought a small one – *small to be emphasised*)