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A new test of irony and indirect requests comprehension – the IRRI test: validation and normative data in French-speaking Adults

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Abstract

Objective: Non-literal language comprehension disorders in individuals with acquired brain injuries (ABI) are frequently reported in the literature but rarely assessed in clinical settings. A major reason is the lack of tools available to clinicians. Therefore, the present study aimed to further promote the pragmatic assessment routine by creating a new non-literal language comprehension tool for ABI individuals: the IRRI test. This tool is intended to be standardized and capable of directing clinicians to cognitive deficits underlying a poor understanding of non-literal language – context processing, executive functions, and theory of mind. **Method**: Three studies were conducted. The first study aimed at constructing the two IRRI test tasks: the irony and indirect requests comprehension tasks. These tasks integrate the cognitive processes within them. The second study aimed at analyzing the tasks' psychometric qualities in a sample of 33 ABI participants and 33 healthy participants (HC). Preliminary normative data obtained from 102 healthy French-speaking subjects were collected in the third study. **Results**: Significant differences in the IRRI test's performances were observed between the ABI and HC individuals. The indirect requests task demonstrated robust convergent validity and good sensibility to discriminate altered participants among ABI participants. Both IRRI test's tasks also showed excellent test-retest and inter-rater reliability. The preliminary norms were stratified according to the conditions of interest in relation to the cognitive mechanisms underlying the understanding of non-literal language. **Conclusions**: The IRRI test is a promising new standardized test of non-literal language comprehension, which contributes to identifying cognitive-pragmatic profiles to guide therapy.

Keywords: Neuropsychological Assessment; Psychometrics; Test Standardization; Figurative Language; Underlying Cognitive Impairment; Brain Injuries

Introduction

Non-literal comprehension disorders are frequently reported in the clinical descriptions of individuals with acquired brain injuries (ABI) following a traumatic brain injury (TBI) or a stroke in the right hemisphere (see Blake, 2017 and Turkstra & Politis, 2017 for reviews). In a classification of Right Hemisphere Damaged (RHD) subjects according to their pragmatic profile, Côté, Payer, Giroux, & Joanette (2007) reported a poor comprehension of non-literal language in 25% of their participants. This 25% rate was confirmed by two-thirds of speech-language pathologists surveyed by Ramsey & Blake (2020). In addition to being frequent, these disorders are generally severe in TBI and RHD individuals (Martín-Rodríguez & León-Carrión, 2010) and can interfere with returning to work (Dahlberg et al., 2006; Hofgren, Esbjörnsson, & Sunnerhagen, 2010; Yeates et al., 2016). Nevertheless, the understanding of non-literal language and pragmatics more broadly remains rarely assessed in clinical settings (Kelly et al., 2017; Ramsey & Blake, 2020). Reasons reported by clinicians are the lack of adequate tools and limitations inherent to existing tests. By introducing a new tool for evaluating the understanding of irony and indirect requests in ABI participants, this study aims to bridge these gaps and better meet the needs of clinicians.

Tools for evaluating non-literal language are sorely lacking (see Arcara & Bambini, 2016 and Saldert, 2017, for reviews). In French, the existing tools mainly assess metaphors, idioms, and proverbs (ELEA (Evaluation du Langage Elaboré chez l'Adulte; Moreira-Gendreau, 2016); TLE (Test de Langage Elaboré; Rousseaux & Dei Cas, 2012)) or general inferential capacities (ELEA; Gestion de l'implicite (Duchêne May Carle, 2000)). Only the MEC protocol (Protocole Montréal d'Evaluation de la Communication; Joanette, Ska, & Côté, 2004) offers an indirect-speech-act-comprehension subtest. The understanding of irony is the weak link of the French pragmatics tools. To our knowledge, validated and standardized irony tasks are only available in English (TASIT – The Awareness of Social Inference Test

(McDonald, Flanagan, Rollins, & Kinch, 2003); RHCB – Right Hemisphere Communication Battery (Gardner & Brownell, 1986)) and Italian (ABaCo - Assessment Battery for Communication (Sacco et al., 2008)). The IRRI test ("IRonie et Requêtes Indirectes" in French) is thus the first validated and standardized French test to assess the comprehension of irony.

In addition to their scarcity, existing tools for assessing the comprehension of non-literal language have certain limitations. Firstly, while several tools are relevant for diagnosing pragmatic disorders (e.g., the MEC protocol), few provide information for planning therapies in relation to the underlying cognitive impairments (Saldert, 2017; Sohlberg et al., 2019). The term "cognitive-communication disorders" was recently introduced to emphasize that pragmatic disorders are generally secondary to cognitive impairment (Togher et al., 2014). In the case of non-literal language, it is well recognized that pathological pragmatic profiles may be underlying or associated with specific impairments in context processing, executive functions (EF), and Theory of Mind (ToM) (see Martin & McDonald, 2003 for a review). Joint impairment of ToM and EF is generally associated with a general misunderstanding of the non-literal meaning of statements, characterized by insensitivity to context (Bosco, Parola, Sacco, Zettin, & Angeleri, 2017; Champagne-Lavau, Cordonier, & Fossard, 2018; Champagne-Lavau & Joanette, 2009; Cordonier, Fossard, & Champagne-Lavau, 2020). A more specific deficit of executive functions (flexibility or inhibition) could be associated with more circumscribed difficulties at the literal language level or in more cognitively charged tasks (Champagne-Lavau & Joanette, 2009; Cordonier et al., 2020). Regarding working memory, some studies showed that the tasks' cognitive cost might impact the pragmatics and ToM performance of ABI individuals (Cordonier et al., 2020; Honan, McDonald, Gowland, Fisher, & Randall, 2015; Blake, 2017). This link between pragmatic and cognitive pathological profiles is important because it accounts, at least in part, for the known

heterogeneity of the ABI population (Blake, 2017). Consequently, one challenge for clinicians is to identify the cognitive disorders underlying pragmatic disorders specific to each patient. One way to help them on this path is to propose tools that manipulate the cognitive processes within the tasks (Byom & Turkstra, 2017). For example, manipulating the cognitive cost of the test stimuli (e.g., by varying the length of stimuli, the time allocated or the presence of cues facilitating the comprehension of non-literal language) provides valuable information on ABI individuals' cognitive resources and context processing abilities, which may interfere with their understanding of non-literal language (Cordonier et al., 2020). This information can then be incorporated into targeted therapy and taken into account to assess patient progress (Blake, 2007). In the MEC protocol, the length of all stimuli is similar, which prevents assumptions about the patients' cognitive resources. Thus, by manipulating cognitive variables – EF, ToM, and context processing - and offering preliminary stratified normative data according to the cognitive processes involved, the IRRI test is the first French-speaking test built to help clinicians detect cognitive impairment underlying poor comprehension of non-literal language.

A second limitation is that several tests neither manipulate nor control for the psycholinguistic variables known to influence non-literal language comprehension. In the context of irony, for instance, it was shown that the gender and profession of the speaker and the presence of the victim targeted by the ironic statement influenced the understanding of irony (Katz, Blasko, & Kazmerski, 2004; Pexman & Olineck, 2002; Rivière & Champagne-Lavau, 2020). A statement is considered more ironic if uttered by a man or speaker who has a profession that is stereotypically linked with irony (e.g., a comedian or a film director). Similarly, the presence of hyperbole and particular prosody is conducive to an ironic interpretation of a statement (Kreuz & Roberts, 1995). Existing tools assessing the understanding of irony (e.g., the TASIT and ABaCo tests) have generally opted for

audiovisual dialogues and, consequently, manipulated paralinguistic variables such as prosody and facial expressions. The written modality was favored in the IRRI test because it allows precise control and manipulation of variables of interest such as lexical (i.e., adverb and adjective of an exaggeration) and sociocultural (i.e., occupation stereotypes) variables. Regarding indirect requests, the conventionality of the indirect request and the relationship's symmetry between the interlocutors are primary influencing factors, as are the situational variables (Holtgraves, 1994; Stemmer, Giroux, & Joanette, 1994). In the MEC protocol, the indirect requests are all non-conventional, but the relational symmetry between the characters is not controlled. This limitation was remedied in the IRRI test. The control of these factors within the assessment tools promotes internal consistency between test items and provides valuable insight into patients' abilities to integrate this contextual information. Finally, many existing tools were criticized because they are not available or accessible due to their cost or for lack of publication in the public domain, or what has been published does not contain validity measures and normative data (Saldert, 2017; Sohlberg et al., 2019).

To bridge these gaps, we developed a new standardized French tool for assessing non-literal language comprehension in ABI individuals: the IRRI test. This test complements the aforementioned pragmatic tools, allowing a fine-grained analysis of the mechanisms involved in understanding non-literal language (i.e., the cognitive cost of stories and the integration of lexical and sociocultural cues). It consists of two tasks – irony and indirect requests – taking the form of short written texts. Three studies contributed to the construction of the IRRI test and are described below. The first study aimed to develop the IRRI test tasks, taking into account the psycholinguistic and cognitive variables of interest. The consideration of these variables is intended to facilitate the identification of cognitive-pragmatic profiles and the planning of subsequent therapies. The objective of the second study was to explore the psychometric properties of the test to establish its validity and reliability. We expected the

IRRI test to distinguish ABI individuals from healthy subjects, to correlate with an existing non-literal language comprehension test, and to correctly identify the altered ABI individuals among ABI participants. We also hypothesized that the IRRI test would have good temporal and rating stability. Finally, the third study aimed to report preliminary normative data for the two tasks of the IRRI test from a sample of healthy French-speaking adults.

Study 1. Development of the IRRI test

The IRRI test comprises two tasks assessing the comprehension of irony (IR, task 1) and the comprehension of non-conventional indirect requests (RI, task 2). Each task includes 18 written scenarios, depicting an interaction between two characters of different gender and ending with a statement from one of the characters. After each scenario, two questions are asked: a question on the speaker's intent ("What does X (the speaker) mean?") and a control question on contextual information. The written format was favored to neutralize psycholinguistics (e.g., prosody, facial and bodily expressions) and cognitive (e.g., memory) influencing factors.

One of the goals of the IRRI test is to help clinicians identify the cognitive impairment underlying poor comprehension of non-literal language (i.e., the context processing, EF, and ToM), responsible for the heterogeneity of performances amongst ABI participants (Blake, 2017; Champagne-Lavau et al., 2018; Champagne-Lavau & Joanette, 2009; Cordonier et al., 2020). To this end, each scenario was divided into six conditions by manipulating three factors. The first factor is the *context* preceding the target statement, inducing a literal or non-literal meaning of the statement. This factor is used to assess the patient's ability to integrate relevant contextual information to infer a correct intention. The second factor is the *EF demand* of the stories (whether high or low). In half of the literal and non-literal stories, a 4-sentence distractor paragraph, introducing a new character and information which is

irrelevant for interpreting the target statement, was added. This manipulation of the length of the stories helps determine whether the objectified disorders may result from an overload of the cognitive system or genuine pragmatic deficiencies. Thirdly, *cues* that have been demonstrated to facilitate the comprehension of the irony or indirect requests were added in half of the non-literal stories (with high or low EF demand). These cues consist of an occupation stereotype associated with the speaker and a lexical term of exaggeration for irony (Kreuz & Roberts, 1995; Pexman & Olineck, 2002), and a lower social status associated with the character for indirect requests (Holtgraves, 1994). Their presence allows the assessment of the patients' sensitivity to contextual cues and introduces an intermediate condition in terms of the cognitive EF demand of the story.

The manipulation of these three factors thus enabled the constitution of 6 conditions per scenario, for a total of 108 stories per task: Literal with low EF demand, Literal with high EF demand, Non-literal (Irony/indirect request) with low EF demand and no cue, Non-literal (Irony/indirect request) with high EF demand and no cue, Non-literal (Irony/indirect request) with low EF demand and cues, Non-literal (Irony/indirect request) with high EF demand and cues. Figures 1 and 2 show examples of stories in the six conditions for the two tasks. The following sections describe the construction (i.e., the structure, controlled variables, and pilot studies) of each task and their presentation format.

INSERT FIGURES 1 AND 2

Construction of the irony task

The irony task stories, inspired by Spotorno et al. (2012) and Champagne-Lavau et al. (2012), are 70-80 words long and consist of five sentences. The first two sentences introduce the two characters and their neutral relationship, the protagonists being portrayed as colleagues or

neighbors. The third sentence exposes the contextual element, positive or negative, that induce the literal or ironic interpretation. In the literal conditions, the target statement is always preceded by a positive context, whereas it is preceded by a negative context in the ironic conditions. A fourth neutral sentence is followed by the target statement of the speaker. This statement is 5-8 words long and stated fifty percent of the time by a male speaker. Half of the ironic statements are ironic blames that target a victim (e.g., “You are the best runner”); the other half are situational ironies, without victims (e.g., “We are lucky with the weather”). In high EF conditions, a distractor paragraph is added between the third and fourth sentences. In the ironic stories with cues, an occupation stereotype (e.g., actor, considered conducive to irony) is associated with the ironic character in the second and last sentence, and a lexical term of exaggeration is incorporated into the target utterance (“e.g., “the meal will be *extremely* hearty!”).

Two pilot studies were conducted to identify the occupation stereotypes added in the ironic conditions with cues and to select the scenarios for the final version. These pilot studies were reported in Cordonier et al. (2020). At the end of these pilot studies, 18 scenarios with a high success rate were selected for the final version of the task.

Construction of the indirect requests task

The indirect requests task’s stories are 50-70 words long and have the following structure: the first two sentences introduce the two characters and the activity at the origin of a possible request. The third sentence sets out the element leading or not to a request. The fourth sentence comprises the target statement, which is 5-8 words long and stated fifty percent of the time by a male speaker. Indirect request statements always take the form of hints (Stemmer et al., 1994). In high EF conditions, a distractor paragraph is added between the third and fourth sentences. In the indirect request stories with cues, information concerning

the social relationship between the protagonists (with lower social status, as an employee, associated with the person to whom the request is addressed) is depicted in the second and last sentences.

Two pilot studies, an online survey and an interview, were conducted during October 2017 to select the scenarios for the final version. Only the most basic conditions, i.e. the literal with low EF demand and indirect request with low EF demand and no cue conditions, were used in these pilot studies. The purpose of the first pilot study (online survey) was to ensure a good understanding of the statements' non-literal versus literal intent in the built scenarios. Forty-one undergraduate students (mean age: 21.73, SD: 4.71) from XXXX (Switzerland) were recruited in university classes. The survey was divided into two sub-surveys so that students saw the scenarios in only one condition. For each scenario, the students were asked to judge if the final statement should be interpreted literally or as a request, with an "I do not know" answer available. Stories with a low success rate were removed. The average success rates for the 18 remaining scenarios were 81.94% (SD: 15.85) for the indirect request stories and 80.83% (SD: 21.76) for the literal stories.

In the second pilot study (interview), we administered the scenarios to 20 participants in their final form, with the open question on speaker intent. This study aimed to analyze the clarity of the instructions, the presence of misunderstandings, and the answers provided. The participants (11 females / 9 males), native French speakers, were recruited in the local community by the first author and speech-language pathology students among their relatives. They were between 20 and 59 years old (mean: 37.8, SD: 13.41) and had between 9 and 25 years of education (mean: 15.4; SD: 3.70). They were divided into two equivalent subgroups in order to see each scenario in only one condition (9 in the literal condition and 9 in the indirect request condition). All participants were tested individually on the indirect requests task in a quiet room at their homes. They had to read each story on a computer screen and

then respond orally to the question "What does X (the speaker) mean?" related to the target statement. There was no time limit to complete the test. Responses were recorded and scored 0 or 1, depending on the accuracy of the response. The average success rates were 80.28 (SD: 18.58) for the indirect request stories and 84.03 (SD: 15.03) for the literal stories. Minor edits were made based on participants' feedback. No difficulties were reported concerning the instructions.

Tasks format

The final version of the test comprises 18 scenarios per task, derived in the six conditions described above. Due to a large number of stimuli, three versions of the test were created, each comprising the 18 scenarios in two different conditions. The distribution of the stories in the three versions was established according to a Latin square plan. This configuration limits the redundancy of the scenarios seen by each participant while allowing for an adequate number of items per condition (N = 6 per condition). The three versions of the test were built in a PowerPoint Presentation. The presentation starts with the instructions, followed by two familiarization examples. Each story is then presented on one single slide. The story remains visible to the participants during the administration of two successive written questions, presented in two stages under the story (the question on the speaker's intent first) with no time limit. The oral responses given by the participants were recorded and transcribed. A paper scoring sheet was also constructed for each version of the test. The scoring criteria were adopted from the literature and the pilot studies (see Appendix 1). All material is available from the first author upon request.

Study 2. Validity and reliability of the IRRI test

The second study aimed to establish the psychometric qualities of the IRRI test. More precisely, the validity (i.e., construct, convergent, and criterion validity) and reliability (i.e., test-retest and inter-rater reliability) were analyzed.

Method

Participants. Between February and September 2018, 33 individuals with ABI and 33 Healthy participants (HC) were recruited. The sociodemographic characteristics of both groups are detailed in Table 1. The two groups did not significantly differ with regard to age ($t(64) = -.044$, $p > .05$) and educational level ($t(64) = .000$, $p > .05$). All participants were right-handed and native French speakers with no previous psychiatric history according to the DSM-V, no substance or alcohol abuse, and no uncorrected vision or audition problems. The individuals with ABI were recruited by speech-language pathologists and neuropsychologists from different hospitals and rehabilitation centers in the French-speaking part of Switzerland. They had suffered a single moderate-to-severe TBI (Glasgow Coma Scale score of 13 or below or post-traumatic amnesia (PTA) of at least 24 hours (Maas et al., 2008; Teasdale & Jennett, 1974)) or stroke in the right hemisphere within a minimum of 3 months before the assessment. They were excluded in cases of aphasia or reading difficulties according to neuropsychological reports and scores on DTLA (Détection des Troubles du Langage chez l'Adulte et la personne âgée; Macoir et al., 2017) and a reading subtest of MT-86 test (Nespoulous et al., 1992). HC participants were recruited in the local community by the first author and speech-language pathology students among their relatives. They had no self-reported neurological history and no cognitive impairment, according to the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005). The local ethics committee (Commission Cantonale d'Ethique de la Recherche sur l'Être-Humain – CER-VD) approved

the study (N° 2017-01174), and all participants had given their written informed consent before inclusion in the study.

Material and procedure. The IRRI test was administered to all participants individually in one to two sessions at their homes (see study 1 for the administration procedure). The order of administration of the two IRRI tasks was randomized among participants. All participants were assigned to one of the three versions of the IRRI test. Non-parametric tests (Kruskal Wallis) revealed that the three subgroups of participants were equivalent in terms of age (Group 1 mean: 52.41, SD: 11.84, Group 2 mean: 49.63, SD: 11.44, Group 3 mean: 51.20, SD: 9.86; X^2 (2) = 1.233, $p > .05$), education (Group 1 mean: 12.91, SD: 2.22, Group 2 mean: 13.25, SD: 2.61, Group 3 mean: 12.20, SD: 2.31; X^2 (2) = 2.146, $p > .05$) and performance to the two IRRI tasks (irony: Group 1 mean: 32.14, SD: 5.29, Group 2 mean: 33.00, SD: 3.21, Group 3 mean: 31.45, SD: 5.50; X^2 (2) = .934, $p > .05$; indirect requests: Group 1 mean: 24.73, SD: 6.68, Group 2 mean: 24.92, SD: 6.37, Group 3 mean: 23.90, SD: 6.30; X^2 (2) = .423, $p > .05$). Given the equivalence of the three versions of the IRRI tasks, the data were subsequently analyzed together. In addition to the IRRI tasks, the indirect requests comprehension subtest from the standardized protocol Montréal Evaluation de la Communication (MEC; Joanette et al., 2004) was also administered to the individuals with ABI to establish convergent validity.

Results

The scores obtained by the two groups of participants in the IRRI test and by the ABI participants in the MEC protocol subtest are presented in Table 1.

INSERT TABLE 1

Validity. Three types of validity were analyzed: construct, convergent and criterion validity. The *construct validity* was determined by comparing the performance of the 33 ABI participants with the 33 HC participants on the two IRRI tasks, using unpaired t-tests. If the IRRI test correctly assesses the target construct, ABI individuals, known to be pragmatically affected, should perform worse than HC subjects. As expected, the mean score of the participants with ABI was significantly lower than that of HC participants on both IRRI tasks - irony ($t(64) = -3.333$, $p < .002$) and indirect requests ($t(64) = -4.964$, $p < .0001$). The convergent and criterion validities were analyzed only for the IRRI indirect requests task given the absence of standardized tests assessing the understanding of irony in the French language. To establish the *convergent validity*, a Spearman correlation between the MEC subtest and the IRRI indirect requests task was calculated. The ABI participants' scores on the IRRI indirect requests task correlated positively with the MEC protocol indirect requests subtest scores ($r_s = .647$, $p < .0001$). The *criterion validity* refers to the ability of a tool to distinguish people from each other on relevant variables, in our case ABI individuals who have pragmatic deficits from those who do not (Le Corff & Yergeau, 2017). Therefore, we categorized each ABI participant based on their raw scores in both indirect requests' tasks (MEC and IRRI tests) as being below or above the cut-off score. Following the MEC protocol procedure, the cut-off score was defined at the 10th percentile and was based for the IRRI test on the preliminary normative data from study 3. We then compared the participants' classification for each task to check if they matched. This classification showed that the IRRI task was able to identify pragmatic difficulties in seven more participants than the MEC protocol. This result suggests that the IRRI test could be more sensitive than the MEC protocol in identifying individuals with pragmatic disorders. Moreover, only two of the twelve participants with scores below the MEC test cut-off were not below the IRRI test cut-off, suggesting correct specificity.

Reliability. Test-retest and inter-rater reliabilities were then analyzed. To determine the *test-retest reliability*, nine HC participants (mean age = 39.44, SD = 14.92; mean education = 15.22, SD = 2.95) were tested again 6 months later. Intraclass correlation coefficients (ICC) and their 95% confident intervals, based on absolute-agreement and 2-way mixed-effects model, were calculated to attest to performance stability over time. The reliability was considered poor if the ICC was less than .5, moderate between .5 and .75, good between .75 and .9, and excellent if greater than .9 (Koo & Li, 2016). The performance's stability of the nine HC participants over the two testing spaced six months apart was excellent for the irony (ICC = .913; 0.58–0.98; lower and upper 95% confidence intervals) and indirect requests (ICC = .948; 0.79–0.99) tasks. Finally, the *inter-rater reliability* was calculated using Cohen's Kappa. Twenty percent of the data, randomly selected from the 66 participants' data set, was scored blindly by a second judge. Only the score on the question on the speaker's intent was considered in all of these analyses. The inter-rater reliability was 96.59% for the irony task and 92.43% for the indirect requests task, with a Cohen's Kappa respectively k = .828; $p < .0001$ and k = .834; $p < .0001$.

Study 3. Preliminary normative data

The third study, conducted between September 2018 and October 2019, aimed to provide preliminary normative data for the IRRI test from healthy adults from the French part of Switzerland. In order to help detect the cognitive deficits associated with non-literal language comprehension disorders, the normative data were stratified according to the variables of interest, namely: (1) literal or non-literal interpretation in relation to theory of mind; (2) low or high cognitive cost related to EF; (3) presence or absence of cues facilitating non-literal understanding in relation to the context processing and EF.

Method

Participants. Participants were recruited in the local community by the first author and by speech-language pathology students among their relatives. They were between 18 and 65 years old and native French speakers. Exclusion criteria included self-reported neurological, psychiatric or alcoholic history, reading disabilities, uncorrected vision or audition problems, and a score below 26 on the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005), a screening tool for neurocognitive impairment. The study was approved by the local ethics committee (Commission Cantonale d'Ethique de la Recherche sur l'Être-Humain – CER-VD – N° 2017-01174), and all participants had given their written informed consent before inclusion in the study.

The final sample was composed of 102 healthy adults (53 females and 49 males), aged from 20 to 65 (mean = 43.70; SD = 13.80) and with an educational level ranging from 9 to 21 years (mean = 14.32; SD = 2.92). Table 2 describes the distribution of participants by gender, educational level and age. The education level categories are based on the dual Swiss school system: (1) obligatory school with or without two-year vocational education characterizing level 1 (≤ 11 years); (2) vocational education or Matura characterizing level 2 (12-15 years); (3) University or high school education (Bachelor, Master, Ph.D.) characterizing level 3 (≥ 16 years). The women and men did not significantly differ according to age ($t(100) = -.731$, $p > .05$) and educational level ($t(100) = .758$, $p > .05$).

INSERT TABLE 2

Material and procedure. All participants were tested individually in a quiet room during an average 1.5-hour session. After completing the MoCA test (Nasreddine et al., 2005), the two

IRRI tasks were administered according to the procedure described in study 1. The order of the two tasks was randomized between the participants.

Results

Statistical analyses were conducted using IBM SPSS Version 25. In order to determine the distribution of the data, descriptive analyses were performed on the total scores of participants in irony and indirect requests tasks. Given the non-normal distributions of the data, partial Spearman rank correlation coefficients were performed to study the influence of sociodemographic variables on performance in the IRRI test. Results showed that the performances on the two IRRI tasks were not correlated with age (Irony : $r_s = .088$, $p > .05$; Request : $r_s = -.078$, $p > .05$), educational level (Irony : $r_s = .193$, $p > .05$; Request : $r_s = .047$, $p > .05$) and sex (Irony : $r_s = .037$, $p > .05$; Request : $r_s = -.022$, $p > .05$). Therefore, the norms were not stratified according to sociodemographic variables.

Percentiles were then calculated for each task for the total score and the conditions of interest (see Table 3). The selected percentiles follow the recommendations of the Swiss Association of Neuropsychologists (ASNP, 2018), meaning that the scores are much lower than the norm for a percentile <2, lower than the norm between the 2nd and 5th percentile, and at the limit of the norm between the 6th and 16th percentile. The 10th percentile, used for criterion validity analyses, was also added.

INSERT TABLE 3

Discussion

Pragmatic disorders, including non-literal language comprehension disorders, are frequently reported in the literature but rarely evaluated in clinical settings (Kelly et al., 2017; Ramsey & Blake, 2020). The lack of tests, the absence of relevant information to plan therapies, the poor control of psycholinguistic variables and the weakness of the tests' normative data and psychometric qualities are several reasons cited by clinicians to justify this. Therefore, the objective of our study was to respond to a clear clinical need. By developing a test for understanding irony and indirect requests that integrates the cognitive mechanisms involved in this understanding, we aimed to make up for lack of French standardized tools and help in the differential diagnosis of pragmatic disorders related to underlying cognitive impairment. Three studies were carried out for this purpose.

In the first study, we showed that the IRRI tasks were constructed to control psycholinguistic influencing variables (e.g., information on speakers and context) and to manipulate cognitive mechanisms influencing non-literal language comprehension (i.e., context processing, EF, and ToM). A distractor paragraph and cues facilitating the understanding of non-literal meaning were added in some stories to test the participants' cognitive resources and context processing abilities. The context was also manipulated to induce a literal or non-literal meaning of the utterance, to assess the ability to infer a correct intention. Hence, the six resulting conditions, depending on whether they are preserved or altered, allow hypotheses to be made about pragmatic profiles related to the underlying cognitive disorders. In a recent study using the IRRI irony task (Cordonier et al., 2020), the authors demonstrated that impairment in all the ironic conditions, regardless of the cognitive cost and cues, was associated with joint ToM and EF deficit in a subgroup of ABI patients. On the other hand, an isolated executive deficit was associated with difficulties in inferring the literal or ironic meaning of the statement only in high EF conditions and without cues. The IRRI test,

therefore, seems sensitive in identifying various pathological pragmatic profiles. Naturally, and as our study suggested, it is essential to couple the IRRI test with other neuropsychological measures to consolidate the hypotheses on the links between pragmatics, ToM, and EF. The identified cognitive-pragmatic profiles can then be taken into account when planning therapy (Blake, 2007; Tompkins, 2012). For example, deficits in the high EF conditions of the IRRI test, associated with deficient EF tests, could reflect insufficient cognitive resources (Cognitive Resources Hypothesis; see Monetta & Joanette, 2003 for a review). Manipulating the complexity of the stimuli used in therapy will, therefore, be of primary importance.

Interestingly, the results of the second study demonstrated that the IRRI test had good to excellent psychometric properties. It allowed differentiating ABI patients from HC participants. This result suggests good construct validity and confirms the known difficulties in understanding non-literal language reported in the ABI population (Blake, 2017; Turkstra & Politis, 2017). The robust convergent validity obtained with the MEC subtest provided evidence that our tool evaluates the targeted construct, namely the understanding of indirect requests. The IRRI task's ability to identify seven additional participants with pragmatic disorders compared to the MEC protocol subtest suggests that our tool might be even more sensitive. Finally, the IRRI test showed excellent rating (inter-rater agreement) and temporal (test-retest) stability. These findings are significant, given the open format of the test stimuli questions, which can generate many responses. It suggests that the administration and scoring procedures of the IRRI test are well-specified. Moreover, the good test-retest reliability and the three parallel versions of each task also make it relevant for repeated administration to assess a patient's evolution.

Finally, the third study provided preliminary normative data based on a sample of healthy Swiss citizens. Sociodemographic variables did not affect the IRRI test's performance and

were thus not considered in the stratification of the norms. On the other hand, we stratified the norms according to the conditions of interest to strengthen the test's ability to discriminate between diverse cognitive-pragmatic profiles. Given the characteristic heterogeneity of the ABI population, differentiated diagnosis and personalized treatments seem essential.

Several limitations and considerations related to the present study need however to be addressed. Firstly, participants with less than 11 years of education were under-represented in our study (10% of the total sample). Nevertheless, this proportion reflects the swiss society. According to the Federal Statistical Office (2019), only 10.99% of Swiss individuals have no post-compulsory school education. Furthermore, the number of participants in study 3 is small. However, results from this study are preliminary and aimed at strengthening the analysis of the psychometric qualities of the test (i.e., criterion validity) and at introducing the differential diagnostic interest of a stratified normalization. It would be relevant to include older participants in future studies and initiate collaboration with other French-speaking countries (e.g., France, Belgium, or Canada), as was done for many French language tests (Bézy et al., 2016; Bourgeois et al., 2019; Coulombe et al., 2019; Macoir et al., 2017). This would enable us to strengthen our findings and broaden the scope of the tool, both in terms of cultural replicability and populations to be considered for future validations. Secondly, the convergent and criterion validity of the IRRI irony task could not be analyzed due to the lack of a French tool assessing the understanding of irony. On the other hand, this limitation illustrates the need to develop pragmatic tests. Thirdly, the task administration time is long (approx. 30 minutes per task). It is essential to note that the IRRI test was designed to specify a diagnosis provided by a more general test (e.g., the MEC protocol) for the purpose of differential diagnosis or planning of therapy. A large number of items is also of interest for use in research. Given this study's encouraging results, we plan to develop a short version of the IRRI test, more responsive to the time constraints reported by clinicians (Sohlberg et al.,

2019). Finally, reflections on transfers between clinical and research environments would be beneficial. In recent years, many researchers have developed pragmatic and social cognition tests to promote a better evaluation of these aspects in the clinic (Arcara & Bambini, 2016; Kelly & McDonald, 2020; McDonald et al., 2003; Sacco et al., 2008). These researchers took into account the concerns of clinicians to best meet clinical needs. The question now arises on the reception of these tools by the clinicians. In the context of implementation sciences, Bauer, Damschroder, Hagedorn, Smith & Kilbourne (2015) reported that, on average, 17 years are necessary for evidence-based practice to become part of clinical routines. A reflection on the tools and modes of transmission in therapy (e.g., training, forum, tutorials) would be beneficial for a better implementation of the new pragmatic tools in clinical practice.

To conclude, the IRRI test is a valuable tool for identifying non-literal comprehension impairments, both for research and clinical purposes. Its good psychometric qualities make it a sensitive and stable tool. To our knowledge, it is also the only test that includes the cognitive mechanisms underlying the understanding of non-literal language (i.e., context processing, EF, and ToM). Coupled with neuropsychological tests, it can contribute to clarifying the links between cognitive functions and pragmatics and help plan targeted therapies.

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Appendix 1: Rating criteria

Irony task

Condition	Score : 1 point	Score : 0 point
Literal	Clear and adequate rephrasing of the statement	Wrong attribution of an intention (e.g., irony, flirt), off topic answers
Examples of answers for the statement: "The meal tonight will be hearty."	*"They will eat well because they caught a lot of fish"* *"We did some great fishing"*	*"He says that to brag, to flirt with her"* *"Small fish in the water" [song]*
Ironic	Clear and correct attribution of irony (mention of irony, mention of the opposite idea or opposite rewording of the statement)	Literal interpretation, wrong attribution of an intention (e.g., flirt, kindness), off topic answers
Examples of answers for the statement: "The meal tonight will be hearty."	*"It is ironical"* *"He means they won't have much to eat tonight"* *"He means the opposite of what he just said since they did not catch any fish"*	*"If they haven't caught a lot of fish, they've caught enough to make a nice dish"* *"There will be enough"*

Indirect requests task

Condition	Score : 1 point	Score : 0 point
Literal	Clear and adequate rephrasing of the statement	Wrong attribution of an intention (indirect request, intention not deductible from the context), off topic answers
Examples of answers for the statement: "I can't finish this project without the report."	*"He must wait to receive the report by mail to continue"* *"He can't move on without the report so he goes home"* *"He justifies why he is leaving"*	*"You have to finish it for me"* *"He would like her to send him the report"* *"I am available to come with you"*
Indirect request	Verbalization of the indirect request in one of the forms defined by Stemmer et al. (1994): mood derivable, performatives, locution derivable, want statement and preparatory	Literal rewording of the statement, mention of the contextual element at the origin of the request, causal link without request, attribution of an incorrect intention, off topic answers
Examples of answers for the statement: "I can't finish this project without the report."	*"Bring me the report!"* *"He asks her to bring him the report"* *"She should bring him the report"* *"He would like her to bring him the report"*	*"Robert cannot complete his work because the report is in Jeanne's office."* *"He's unhappy he doesn't have the report."*

	"Could you bring me the report"	*"He is looking for an excuse to stop working."*

Figure 1.

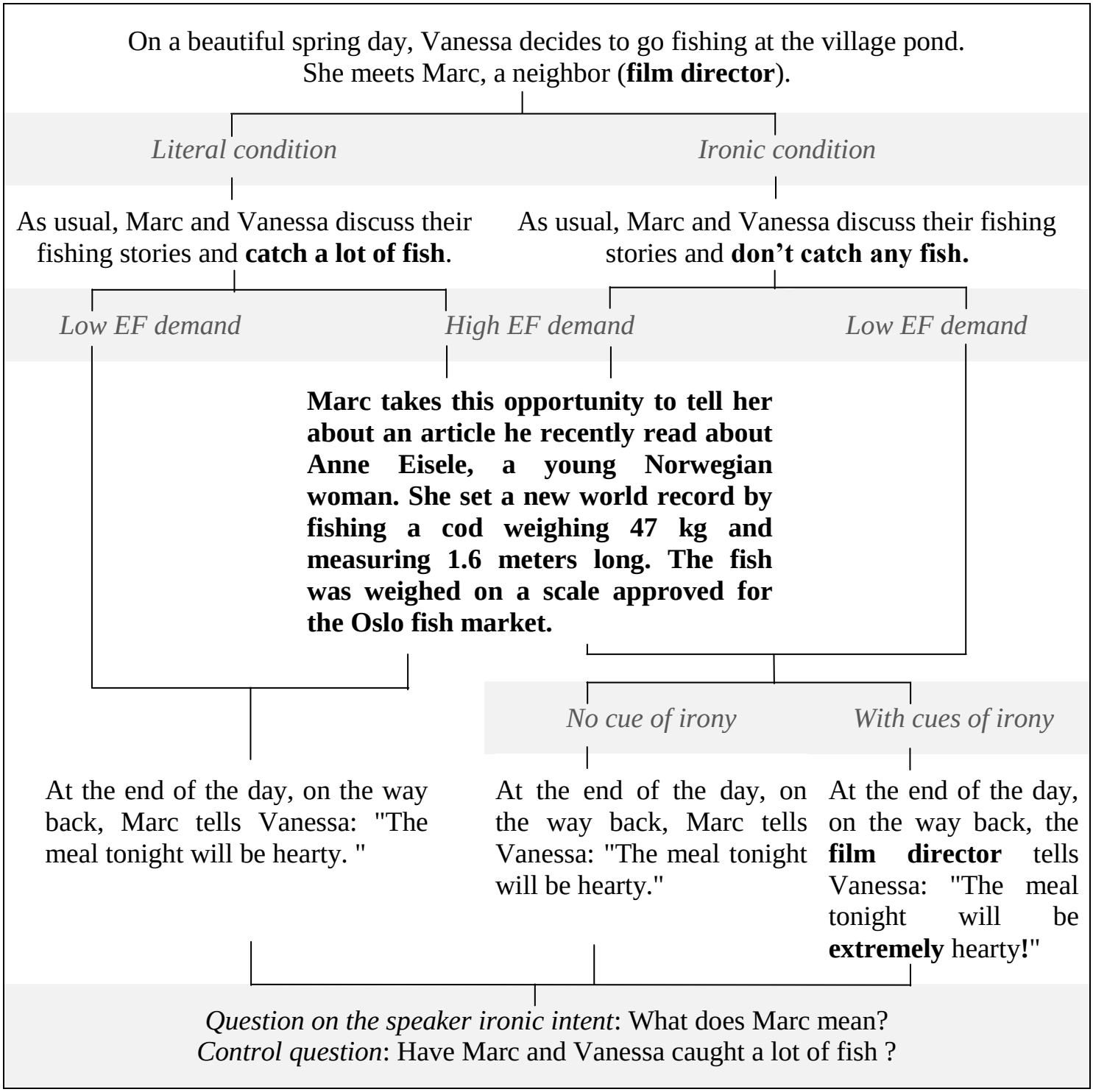
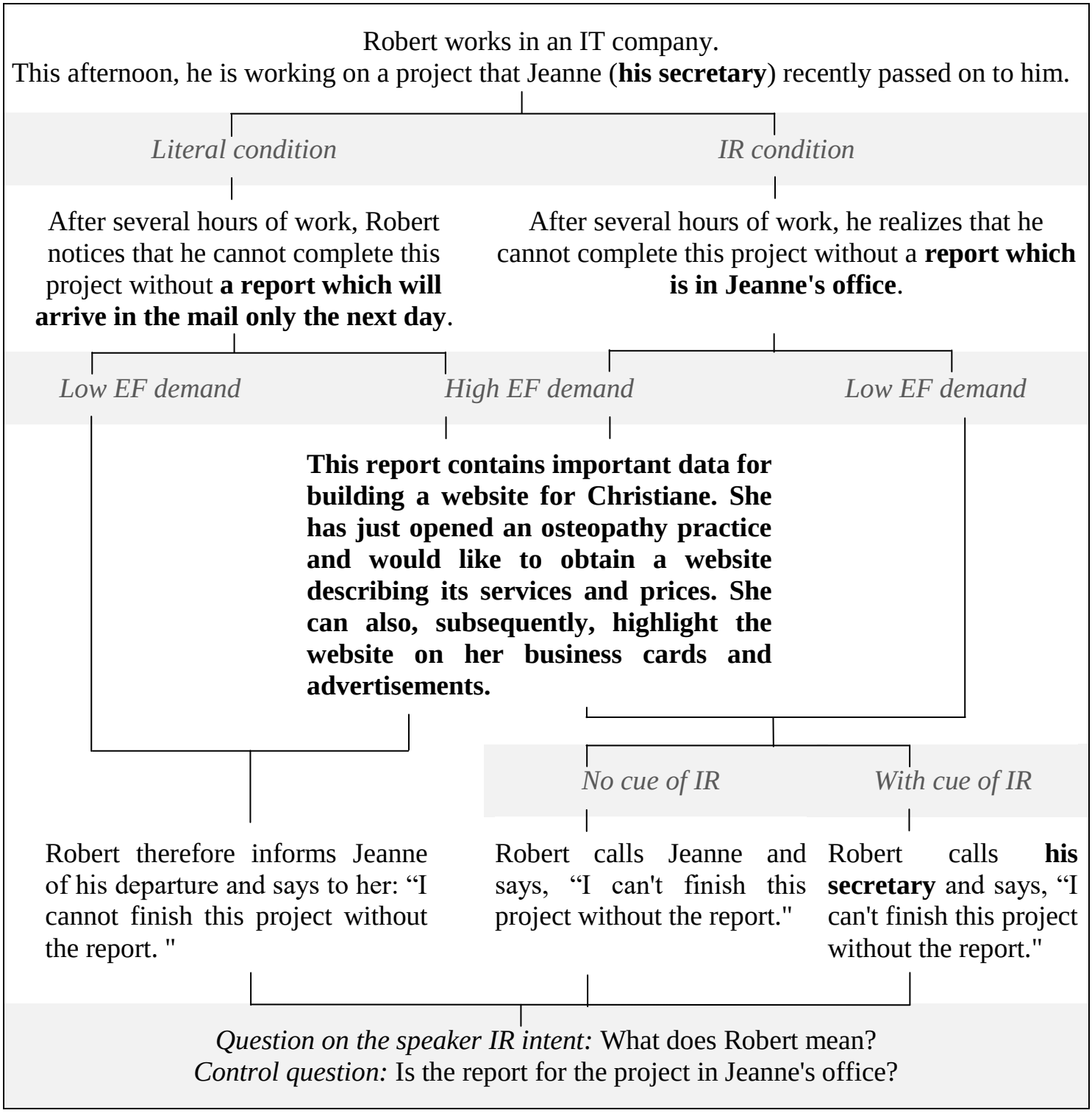

On a beautiful spring day, Vanessa decides to go fishing at the village pond.
She meets Marc, a neighbor (**film director**).
Literal condition
Ironic condition
As usual, Marc and Vanessa discuss their fishing stories and **catch a lot of fish**.
As usual, Marc and Vanessa discuss their fishing stories and **don't catch any fish.**
Low EF demand
High EF demand
Low EF demand
Marc takes this opportunity to tell her about an article he recently read about Anne Eisele, a young Norwegian woman. She set a new world record by fishing a cod weighing 47 kg and measuring 1.6 meters long. The fish was weighed on a scale approved for the Oslo fish market.
No cue of irony
With cues of irony
At the end of the day, on the way back, Marc tells Vanessa: "The meal tonight will be hearty. "
At the end of the day, on the way back, Marc tells Vanessa: "The meal tonight will be hearty."
At the end of the day, on the way back, the **film director** tells Vanessa: "The meal tonight will be **extremely** hearty**!**"
Question on the speaker ironic intent: What does Marc mean?
Control question: Have Marc and Vanessa caught a lot of fish ?

Figure 2.


Robert works in an IT company.
This afternoon, he is working on a project that Jeanne (**his secretary**) recently passed on to him.
Literal condition
IR condition
After several hours of work, Robert notices that he cannot complete this project without **a report which will arrive in the mail only the next day**.
After several hours of work, he realizes that he cannot complete this project without a **report which is in Jeanne's office**.
Low EF demand
High EF demand
Low EF demand
This report contains important data for building a website for Christiane. She has just opened an osteopathy practice and would like to obtain a website describing its services and prices. She can also, subsequently, highlight the website on her business cards and advertisements.
No cue of IR
With cue of IR
Robert therefore informs Jeanne of his departure and says to her: “I cannot finish this project without the report. "
Robert calls Jeanne and says, “I can't finish this project without the report."
Robert calls **his secretary** and says, “I can't finish this project without the report."
Question on the speaker IR intent: What does Robert mean?
Control question: Is the report for the project in Jeanne's office?

Figures captions

Figures 1 and 2. Examples of stories of the irony comprehension task (figure 1) and indirect requests (IR) comprehension task (figure 2) varying the context (literal vs. non-literal), the EF demand (low vs. high) and, in the non-literal conditions, the presence of cues (no vs. with)

Tables

Table 1. Sociodemographic characteristics and correct responses to the question on the speaker's intent in the irony and indirect requests comprehension tasks of the IRRI test and to the indirect requests comprehension subtest from the MEC protocol in acquired brain injured (ABI) participants and healthy control (HC) participants

	ABI Participants		**HC Participants**	
Test	**Mean**	**SD**	**Mean**	**SD**
Number of participants (F/M)	33 (19/14)		33 (13/20)	
Age (years)	51.09	11.10	50.97	11.11
Education (years)	12.82	2.47	12.82	2.37
Irony – Total score (/36)	30.45	5.88	34.03	1.85
Indirect Requests – Total score (/36)	21.21	6.60	27.88	3.99
MEC – ALI (/40)	31.33	5.01		

Table 2. Distribution of participants by age, educational level (years of education), and sex

Years of education	**≤ 11 years**		**12-15 years**		**≥ 16 years**	
Sex	**M**	**F**	**M**	**F**	**M**	**F**
20-35 years	1	-	8	6	10	9
36-50 years	1	1	7	8	5	8
51-65 years	1	6	9	7	7	8
Total	3	7	24	21	22	25

Table 3. Preliminary normative data of the two IRRI tasks for the 102 healthy participants

Task	Score max	Mean	SD	C16 Limit	C10	C5 Low	C1 Very low
Irony task							
Question on the intent							
Total score	36	34.56	1.70	32	32	31	29
Literal stories	12	11.65	.66	11	11	10	9
Ironic stories	24	22.78	1.61	21	20	20	17
Without cue	12	11.31	1.07	10	9	9	8
With cues	12	11.47	.88	11	10	9	9
Low EF stories	18	17.53	.70	17	16	16	15
High EF stories	18	16.90	1.40	15	15	14	12
Control question							
Total score	36	35.60	.75	35	34	34	33
Indirect requests task							
Question on the intent							
Total score	36	29.01	3.87	25	23	22	18
Literal stories	12	9.19	1.78	8	6	5	4
Request stories	24	19.82	3.21	17	16	14	7
Without cue	12	9.71	1.93	8	7	6	3
With cue	12	10.12	1.64	8	8	7	4
Low EF stories	18	14.84	2.04	13	12	10	9
High EF stories	18	14.17	2.33	12	11	9	8
Control question							
Total score	36	35.20	1.10	34	34	33	31

Note. Score max = maximum possible score ; SD = Standard deviation ; C16 = Percentile 16, limit of the norm (6th-16th percentile); C5 = Percentile 5, lower than the norm (2nd-5th percentile); C1 = Percentile 1, much lower than the norm.