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► **To cite this version:**

Natacha Cordonier, Marion Fossard, Yves Tillé, Maud Champagne-Lavau. Exploring Cognitive-Pragmatic Heterogeneity Following Acquired Brain Injury: A Cluster Analysis of Hint Comprehension. *American Journal of Speech-Language Pathology*, 2023, 32 (6), pp.2752-2767. 10.1044/2023_AJSLP-22-00389 . hal-04330850

HAL Id: hal-04330850

<https://hal.science/hal-04330850>

Submitted on 8 Feb 2024

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1 **Exploring cognitive-pragmatic heterogeneity following acquired brain**
2 **injury: a cluster analysis of hint comprehension**

3 Natacha Cordonier*^{1,2}, Marion Fossard¹, Yves Tillés³, Maud Champagne-Lavau²

4

5 1. Université de Neuchâtel, faculté des lettres et sciences humaines, Institut des sciences
6 logopédiques, Neuchâtel, Suisse

7 2. Aix-Marseille Univ, CNRS, LPL, Aix-en-Provence, France

8 3. Université de Neuchâtel, Faculté des sciences, Institut de statistique, Neuchâtel, Suisse

9

10 *Corresponding author information: Natacha Cordonier, Université de Neuchâtel, Rue
Pierre- à-Mazel 7, 2000 Neuchâtel, Suisse, Phone: (+41) 32 718 17 34, email:

11 natacha.cordonier@gmail.com

Abstract

15
16 **Purpose:** Difficulties understanding non-literal language (especially hints) are frequently
17 reported following acquired brain injury (ABI). Several cognitive mechanisms, such as
18 context processing, executive functions, and theory of mind (ToM), may underlie these
19 disorders. However, their role remains controversial, mainly because of the characteristic
20 heterogeneity of this population. Therefore, our study aimed to identify cognitive-pragmatic
21 profiles in ABI individuals. **Method:** A new task of hint comprehension, manipulating
22 executive demand, markers of hints, and ToM, and neuropsychological tests were
23 administered to 33 participants with frontal-ABI and 33 control participants. Cluster analysis,
24 a method sensitive to profile heterogeneity, was applied and coupled with error analysis.
25 **Results:** We highlighted two cognitive-pragmatic profiles. One subgroup of ABI participants
26 exhibited contextual insensitivity, leading them to infer the utterance meaning based on
27 linguistic decoding alone – literal meaning. This difficulty in understanding hints was
28 associated with deficits in working memory, inhibition and ToM. The second subgroup of
29 ABI participants showed difficulty with literal statements, associated with impaired inhibition
30 and ToM. In addition, the two subgroups differed only on the ToM task. This result suggests
31 that various types of ToM deficit (misunderstanding versus incorrect attribution of mental
32 states) could contribute to the variability of the pragmatic profiles observed (difficulties in
33 interpreting hints versus literal statements). **Conclusions:** The experimental design adopted
34 in this study provides valuable insight into the explanatory hypotheses of non-literal language
35 comprehension disorders and has important clinical implications.

36

37 **Keywords:** communication disorders; context; theory of mind; executive function; brain
38 injuries

39

Introduction

40 A speaker wishing to obtain something (e.g., to have a coffee paid for) has a panoply of
41 language strategies available to formulate their request (Blum-Kulka, House, & Kasper,
42 1989). They can thus resort to direct requests ("Buy me a coffee!") or indirect ones. Among
43 the latter, they can opt for conventional indirect requests ("Will you buy me a coffee?") or
44 unconventional indirect requests (also referred to as a hint: "I forgot my wallet."). By its
45 opacity, the latter strategy has the advantage of leaving the speaker and the interlocutor the
46 possibility of disengaging from the request (Weizman, 1989). However, understanding it is
47 more complex. Indeed, hints are coded in the mental lexicon under their more frequent literal
48 meaning (Giora, 2002). Therefore, a context-specific analysis and additional inferential
49 processes are required for an adequate understanding of the request.

50 This complexity is a source of difficulty for individuals who have acquired brain injuries
51 (ABI) following traumatic brain injury (TBI) or stroke. Indeed, several studies have
52 demonstrated that individuals with ABI may have difficulty understanding hints
53 (Champagne-Lavau & Joannette, 2009; Dardier et al., 2011; Evans & Hux, 2011; Hatta,
54 Hasegawa, & Wanner, 2004; Muller et al., 2010; Stemmer, Giroux, & Joannette, 1994).
55 Regarding error types, Evans & Hux (2011) analyzed the incorrect responses given by their
56 TBI participants to prediction probes (What will the speaker do next?) and interpretation
57 probes (What does the speaker mean?) following hints in video vignettes. Their TBI
58 participants mostly produced incorrect non-literal alternative interpretations (e.g., advising
59 ordering more food rather than giving available food to a hungry character), followed by
60 unrelated responses and a small proportion of literal interpretations. On the other hand, Foldi
61 (1987), using a task designed to judge the appropriateness of short conversational exchanges
62 between two characters, showed that right hemisphere damaged (RHD) participants judged

63 literal responses to conventional indirect requests and hints as adequate, unlike control
64 individuals.

65 However, these results are not unanimous: a few studies have reported a preserved hint
66 comprehension in individuals with TBI and RHD (McDonald, 2000; McDonald, Fisher, &
67 Flanagan, 2016). Two explanations could account for these discrepancies. Firstly, the
68 ecological dimension of the tasks used could influence performance: individuals with RHD
69 would perform better in natural or pseudo-natural conversation situations than in non-natural
70 tasks (Vanhalle et al., 2000). Secondly, this lack of consensus might reflect the characteristic
71 heterogeneity of these neurological populations: not all individuals with ABI have pragmatic
72 disorders and, among affected individuals, the altered pragmatic dimensions may diverge
73 (Blake, 2017; Côté, Payer, Giroux, & Joanne, 2007). This second explanation constitutes the
74 starting point of our study. More precisely, our study aimed to analyze the variation in ABI
75 patients' pragmatic profiles in connection with the cognitive mechanisms and processes likely
76 to underpin hint comprehension: context processing, executive functions, and theory of mind.

77 Understanding hints is *context*-dependent. It is based on the early and interactive
78 integration of various contextual factors (Coulson & Lovett, 2010). Several socio-cultural
79 factors may thus influence the understanding of hints. Social distance and speaker status
80 could be determining markers: a hint is more readily understood if formulated by an
81 unfamiliar person and/or of higher hierarchical status (e.g., an employer to his employee)
82 (Blum-Kulka et al., 1989; Holtgraves, 1994; Stemmer et al., 1994).

83 The rapid integration of multiple contextual information can be problematic for individuals
84 with ABI. Consequently, these individuals rely on a limited number of markers, or the most
85 salient meaning of the statement, to interpret hints (Blake, 2010; Champagne-Lavau,
86 Cordonier, Bellmann, & Fossard, 2018; Grindrod & Baum, 2003). Focusing on RHD
87 patients, Stemmer et al. (1994) manipulated the relationship between characters in a story
88 (i.e., social power, familiarity, right to make a request, and obligation to comply with it) to

89 induce direct requests (Type I stories) or hints (Type II stories). After each type of story, a
90 request was formulated directly or as a hint. RHD and control participants were asked to
91 judge the politeness, likelihood, and directness of these direct requests and hints following
92 Type I and Type II contexts. Results showed that, on the one hand, the RHD participants
93 behaved similarly to control participants on direct requests in both story types. On the other
94 hand, unlike the healthy participants, they rated hints more likely after a Type I context
95 (inducing direct requests) than after a Type II context (inducing a hint). The authors
96 concluded that RHD individuals would be sensitive to contextual variations but would rely
97 primarily on linguistic and pragmalinguistic conventions (i.e., grammatical rules, lexical
98 knowledge, and conventions linking linguistic items to specific pragmatic functions) to assess
99 the hints. Therefore, they would treat and rate the hints similarly to the direct requests.

100 According to these authors, this pattern reflects a deficit in integrating contextual information
101 into an overall mental model of the situation. However, Champagne-Lavau et al. (2018) did
102 not share this point of view. In their study on irony, a subgroup of RHD individuals (RHD-I)
103 showed insensitivity to the degree of contextual incongruity between the target utterance and
104 the context. This insensitivity was evidenced by the absence of any difference in performance
105 between a strong incongruity and a weak incongruity context condition. In other words, these
106 RHD-I individuals made more errors when interpreting ironic than literal target utterances
107 (e.g., "How punctual!"), whether the incongruity was weak (a few minutes late) or strong (an
108 hour late), with essentially literal errors. Conversely, control subjects and a second RHD
109 subgroup performed slightly worse only in the weak incongruity, ambiguous condition. The
110 authors concluded that the deficits of some RHD individuals reflected an insensitivity or
111 misperception of these markers, leading them to infer the utterance's meaning based on
112 linguistic decoding (i.e., literal meaning), rather than difficulties in integrating contextual
113 markers, which would have manifested themselves in a gradation of difficulty (low

114 incongruity < high incongruity < no incongruity/literal). These two studies differ significantly
115 in the form of non-literal language considered and their methods (the type of task and
116 contextual markers manipulated), which may explain their discrepancies. However, they
117 agree that RHD individuals make inadequate use of the contextual markers that are supposed
118 to help them understand non-literal language. More studies manipulating contextual factors
119 are nevertheless needed to confirm whether their presence impacts the comprehension of
120 indirect requests and, if so, to better characterize this influence.

121 *Theory of mind* (ToM) deficits constitute a second explanatory hypothesis for hint
122 comprehension disorders. This ability to infer mental states (Premack & Woodruff, 1978)
123 seems essential to bridge the gap between the literal meaning of a statement and the nonliteral
124 meaning intended by the speaker. It is now well-recognized that ToM is frequently impaired
125 in individuals with RHD and TBI (see Lin et al., 2021 and Martín-Rodríguez & León-
126 Carrión, 2010 for reviews), thus raising the question of the links between such deficits and
127 the understanding of non-literal language.

128 This question has been addressed in several studies. Overall, the results tend to converge
129 towards a link between hint comprehension and first-order, second-order ToM, and faux pas
130 detection (Champagne-Lavau & Joannette, 2009; Muller et al., 2010). Furthermore, these
131 results are corroborated by imaging studies, which have shown activation of the ToM
132 network during hint processing (van Ackeren, Casasanto, Bekkering, Hagoot, &
133 Rueschemeyer, 2012; van Ackeren, Smaragdi, & Rueschemeyer 2016).

134 In addition to the nature of the tasks, the type of ToM deficit could also impact the
135 pragmatic profile of ABI individuals. Based on work with several psychiatric populations,
136 Abu-Akel (2003) proposed a model of ToM disorders as a continuum comprising: (1) an
137 absence of understanding of others' mental states, manifested, for example, by egocentricity
138 or difficulties in understanding false beliefs; (2) a good understanding of mental states but a

139 certain inability to attribute them, with a possible tendency to over-inference. This
140 hypertheory of mind, typically observed in schizophrenic individuals with positive
141 symptoms, could be related to cognitive biases or difficulties in selecting the appropriate
142 hypothesis among several (Abu-Akel & Bailey, 2000); and (3) an intact understanding of
143 others' minds but a deterioration in the understanding of one's own mind, typically
144 characterized by low self-consciousness in patients with passivity. Although initially applied
145 to the field of psychiatry, this model, and particularly the first two hypotheses, seems relevant
146 to ABI individuals. Indeed, several studies have reported an inability of ABI individuals to
147 represent the mental states of others through different ToM tasks (see Lin et al., 2021 and
148 MartínRodríguez & León-Carrión, 2010 for reviews). Moreover, negative attribution biases
149 have been demonstrated in ABI individuals (Neumann et al., 2015; Winegardner et al., 2016),
150 suggesting that a hyper-theory of mind may operate in some ABI individuals. This model was
151 applied to hint comprehension in one study (Champagne-Lavau & Joanette, 2009). Based on
152 the cognitive-pragmatic profiles of their RHD participants, these researchers suggested that a
153 lack of understanding of others' mental states (1) might be associated with a
154 misunderstanding of communicative intentions, manifested by difficulties in inferring the
155 non-literal meaning of an utterance – typically a hint. On the other hand, an impaired ability
156 to attribute them (2) might be characterized by a tendency to over-infer non-literal intentions
157 in literal conditions. However, more studies are needed to confirm these associations.

158 Finally, a third cognitive process that may underlie problems in understanding hints relates
159 to *executive functions* (EF). EF encompass a set of high-level cognitive processes that allow
160 us to adapt our behavior in complex goal-directed situations, such as communication
161 situations (Miyake et al., 2000). In the case of preferential but inappropriate activation of
162 literal meaning, EF would allow the speaker to reject irrelevant literal meaning (inhibition)

163 and generate an adequate alternative non-literal meaning (flexibility) based on background
164 and context-specific information manipulated jointly (working memory).

165 Two sub-hypotheses have thus been reported in the literature. The first, the hypothesis of a
166 suppression deficit related to inhibitory capacities, suggests that difficulties in rejecting
167 inappropriate meanings could be the cause of pragmatic disorders (Tompkins, Baumgaertner,
168 Lehman, & Fassbinder, 2000; Tompkins, Blake, Baumgaertner, & Fassbinder 2002). The
169 second hypothesis, cognitive resources, is linked to working memory capacities. Limited
170 working memory resources impact ABI individuals' ability to accomplish cognitively
171 demanding tasks, such as hint comprehension tasks involving metalinguistic skills (Just &
172 Carpenter, 1992; Monetta & Joannette, 2003).

173 Studies that have analyzed the links between the understanding of hints and EF (including
174 inhibition, flexibility, and working memory) in individuals with ABI have led to inconclusive
175 results (Champagne-Lavau & Joannette, 2009; McDonald et al., 2016; Zimmermann, Gindri,
176 de Oliveira, & Fonseca, 2011). Two studies that used co-occurrence analysis demonstrated
177 pragmatic-executive dissociations, with executive impairment without disturbance in
178 understanding hints in some RHD individuals (Champagne-Lavau & Joannette, 2009;
179 Zimmermann et al., 2011). These results led Champagne-Lavau and Joannette (2009) to
180 postulate that a joint deficit of ToM and EF would be more likely to account for the
181 pragmatic deficits observed.

182 Most of the studies mentioned above, having analyzed the links between ToM, EF, and
183 hint comprehension, have used correlation or regression analyses. However, these methods
184 are not sensitive to the well-documented heterogeneity of the ABI population. Cluster
185 analysis is an interesting method for considering inter-individual differences. This method
186 makes it possible to obtain homogeneous subgroups of participants based on their
187 performance in a given task. This method has been adopted in a single study on hint

188 comprehension (Champagne-Lavau & Joannette, 2009). Their results showed three pragmatic
189 performance profiles: one unimpaired in hint comprehension, one impaired in understanding
190 hints, and one impaired in comprehending literal utterances. Each impaired group was
191 associated with a distinct executive profile (e.g., reduced inhibition versus impaired
192 flexibility). However, one limitation of this study lies in the task used (MEC protocol,
193 Joannette, Ska, & Côté, 2004), which does not manipulate all contextual and executive
194 variables of interest. For example, the social relationship between the characters is either
195 equal (two friends) or hierarchical (a boss and his employee). Likewise, the length of the
196 stories is similar throughout the task: the results, therefore, do not make it possible to
197 determine whether the deficits observed constitute primary cognitive-pragmatic disorders or
198 secondary to an overload of cognitive resources (Blake, 2017; Cummings, 2009). In addition,
199 the executive and ToM measures used were independent of the hint comprehension task.
200 Byom and Turkstra (2017) suggested that manipulating cognitive processes within pragmatic
201 tasks themselves would be a better method to examine the links between pragmatics and these
202 processes.

203 Thus, following the paradigm developed in Cordonier, Champagne-Lavau, & Fossard
204 (2021), we used a task of hint comprehension, which manipulates within it the context
205 (inducing a literal or hint meaning), the markers of hints (absence versus presence of a social
206 power), cueing a hint interpretation, and executive demand of the stories (absence versus
207 presence of a distractor paragraph). Thanks to this paradigm and cluster analysis, we aimed to
208 identify hint comprehension profiles in relation to the cognitive mechanisms and processes
209 which likely underlie this understanding. Error analysis was also carried out to clarify these
210 profiles.

211 Based on the literature (Champagne-Lavau & Joannette, 2009; Cordonier, Fossard, &
212 Champagne-Lavau, 2020), the following specific hypotheses were formulated:

- 213 1. Difficulties in processing the context will result in poor hint comprehension in
214 conditions with and without a marker of hints. Errors will be mostly literal.
- 215 2. Executive deficits will be associated with difficulty understanding hints and literal
216 statements in stories with high executive demand. Errors will consist of erroneous
217 literal and non-literal interpretations relating to irrelevant, uninhibited information.
- 218 3. ToM deficits will manifest as difficulties interpreting hints or literal statements
219 (AbuAkel, 2003; Cordonier et al., 2020). Specifically, a lack of understanding of
220 others' mental states (and therefore of the intent to request) will essentially induce
221 errors in hint conditions. An erroneous attribution of mental states will lead to over-
222 inference of hints in literal conditions.
- 223 4. Joint involvement of executive deficits and ToM impairments should be associated
224 with the most severe pragmatic disorders (i.e., impairments in hint understanding
225 whatever the presence/absence of a marker of hint and the low/high EF demand).

226 Method

227 Participants

228 Thirty-three acquired brain-injured (ABI) participants (13 women, 20 men) were recruited
229 from hospitals and clinical centers in the French-speaking part of Switzerland. Thirty of these
230 individuals also participated in a previous study on irony comprehension (Cordonier et al.,
231 2020). In order to be included in the study, participants were required to be aged between 20
232 and 65 years old, right-handed, and native French speakers. They must have suffered, more
233 than six months ago, a stroke in the right hemisphere (RHD) or a moderate to severe TBI
234 (Glasgow Coma Scale score ≤ 13 or post-traumatic amnesia of at least 24 hours (Maas et al.,
235 2008; Teasdale & Jennett, 1974) according to medical or neuropsychological reports). In
236 addition, their brain lesions had to be localized in minima in the right frontal lobe, given its

237 important implication in the understanding of non-literal language (Reyes-Aguilar,
238 VallesCapetillo, & Giordano, 2018). The choice to include participants with two different
239 etiologies (TBI and stroke) is based on a literature that has demonstrated similar pragmatic
240 and cognitive profiles between these two populations (Channon & Crawford, 2010;
241 Cordonier et al., 2020). This inclusion is also of interest for the representativeness of clinical
242 practice and therapeutic needs (Blake, 2007). Nevertheless, analyses will be performed to
243 examine possible neuropsychological and pragmatic differences between these two
244 populations.

245 Participants were excluded from the study in case of psychiatric disorders, alcohol or drug
246 dependence history. Language difficulties (aphasia, reading disorders), objectified in
247 neuropsychological reports or during the administration of the DTLA (Détection des troubles
248 du langage chez l'adulte et la personne âgée; Macoir et al., 2017) and the MT-86 reading
249 comprehension subtest (Nespoulous et al., 1992) were also grounds for exclusion. The sample
250 thus included 19 TBI individuals and 14 RHD individuals, with an average time postonset of
251 55.36 months (SD: 61.00). Further clinical details are available in Table 1.

252 Thirty-three healthy participants (HC; 19 women, 14 men) with no neurological or
253 psychiatric history were also included in the study. Their overall cognitive functioning,
254 assessed by the MoCA test (Nasreddine et al., 2005), had to have remained intact (score >
255 26/30). They were individually matched with the ABI participants for age (ABI: mean: 50.97,
256 SD: 11.11; HC: mean: 51.09, SD: 11.10; $t(64) = -0.44, p > .05$) and education level (according
257 to the Swiss system: level 1 = obligatory school; level 2 = vocational training; level 3 =
258 university education). Gender matching was not strictly controlled, as a gender effect on
259 pragmatic and theory of mind skills is not generally reported in the literature (Neumann et al.,
260 2022; Turkstra et al., 2020).

261 The local ethics committee (Commission cantonale d'éthique de la recherche sur l'être
262 humain – CER-VD) approved the study and all participants gave written informed consent.

263

264 INSERT TABLE 1

265

266 **Materials and procedure**

267 Participants were tested individually in a quiet room, in one to four sessions, depending on
268 their fatigue. The testing included standardized tests assessing ToM and EF, and an
269 experimental measure of hint comprehension. The order of administering the tests was
270 counterbalanced among the participants.

271 **Neuropsychological assessment.**

272 *Theory of mind.* The faux pas test (Social Cognition & Emotional Assessment (MiniSEA);
273 Bertoux, 2014), consisting in detecting in written stories if a character had said something
274 that they should not have said, was administered. The faux pas stories (/ 30), control stories (/ 10), and total (/40) scores were used as indexes of ToM.

276 *Executive functions.* The Hayling Test (Rouleau, 1998) automatic and inhibition scores,
277 calculated from response accuracy and response latencies in two conditions of sentence
278 completion (expected and unexpected word), assessed inhibition ability. The total number of
279 words for two letters of verbal fluency tasks (letters D (DTLA, Macoir et al., 2017) and F
280 (MoCA, Nasreddine et al., 2005) was used as a measure of flexibility. Finally, the forward
281 and backward digit spans (WAIS-III; Wechsler, 1997) and the reading span test (RST;
282 Desmette, Hupet, Schelstraete, & Van der Linden, 1995) examined short-term and working
283 memory.

284 **Experimental task: hint comprehension.**

285 A hint comprehension task, including 18 written scenarios described in Cordonier et al.
286 (2021), was used. Each scenario featured two characters of different gender and ended with
287 either a literal statement or a hint from one of the characters. Two questions were asked at the
288 end of each story: a question on the speaker's intent (“What does X (the speaker) mean?”) and
289 a control question relating to contextual information (see figure 1). In order to control
290 prosodic and memory parameters, the stories were presented in writing and remained visible
291 to the participants when administering the written questions. The participant was asked to
292 read each story silently and then orally answer the questions.

293 In order to explore the mechanisms possibly involved in hint comprehension, the scenarios
294 were derived in six conditions through the manipulation of three factors. The first factor, the
295 *context* preceding the target statement, was adjusted to induce a literal or indirect meaning.
296 The second factor, *executive demand* (EF demand), was increased in half of the stories (high
297 EF demand) by adding a distractor paragraph introducing a new character. This paragraph
298 was absent in the conditions with low EF demand. Finally, a *marker* facilitating the
299 understanding of hints – a power relationship between the characters – was introduced in half
300 of the non-literal stories (with a marker of hints). A low status (e.g., secretary) was associated
301 with the character to whom the request was addressed in the story's second sentence and
302 recalled just before the target statement. This marker was absent in the hint conditions with
303 no marker (with low or high EF demand). These factors allowed us to assess the participants'
304 ability to integrate various contextual information in inferring a literal or indirect meaning,
305 the facilitating effect of the speaker status (Holtgraves, 1994), and the influence of cognitive
306 overload on hint comprehension. The six conditions resulting from the manipulation of these
307 factors were:

- 308 (1) literal with low EF demand,
- 309 (2) literal with high EF demand,
- 310 (3) hint with low EF demand and no marker of hints,

311 (4) hint with high EF demand and no marker of hints,

312 (5) hint with low EF demand and a marker of hints,

313 (6) hint with high EF demand and a marker of hints.

314

315 INSERT FIGURE 1

316

317 All stories were controlled for length and structure and were subjected to pilot studies
318 described in Cordonier et al. (2021). Due to the many stimuli (18 stories x 6 conditions), the
319 stories were divided into three equivalent versions of the test according to a Latin square plan.
320 Each version included the 18 derivative scenarios in two different conditions, for a total of 6
321 stories per condition. Each ABI and HC participant was then randomly assigned to one of the
322 three groups.

323 **Scoring.** Verbal answers to questions on the speaker’s intent were audio-recorded and
324 transcribed. A binary scoring system was defined based on data from a pilot study and request
325 strategy types reported by Stemmer et al. (1994). In the literal conditions, any clear
326 paraphrase of the utterance was scored one point. In the indirect conditions, one point was
327 awarded to responses mentioning a request with a mood derivable (e.g., linking to the
328 example in Figure 1: “Bring me the report!”), a performative (“He is asking her to bring the
329 report.”), a locution derivable (“She should bring him the report.”), a want statement (“He
330 would like the report.”) or a preparatory (“Could you bring the report?”). All other responses
331 were scored 0 and classified according to the following error categories: “incorrect indirect
332 request” (in the literal conditions; “He asks him for the report.”), “Incorrect literal response”
333 (in the hint conditions; “He informs her that he cannot finish.”), "Erroneous mental inference"
334 (“He is looking for an excuse not to work.”), "Non-mental logical inference" (“He cannot
335 finish because the report is in Jeanne's office.”) and “other” (off-topic responses,

336 nonresponses). A maximum score of 6 was thus obtained for each of the six conditions.
337 Twenty percent of the data (N = 792) were double scored by a research assistant who was
338 blind to the condition of the participants tested (ABI or HC). Inter-rater reliability was strong,
339 with an agreement rate of 92.43% and a Cohen's Kappa of $K = .834$; $p < .0001$.
340 Disagreements were resolved by discussion.

341 Responses to control questions were half affirmative and half negative. They were also
342 scored binarily, depending on the accuracy of the response.

343 **Data analyses**

344 As a first step, RHD, TBI, and HC participants were compared to have a general
345 neuropsychological and pragmatic profile. For the sociodemographic and neuropsychological
346 measures, one-way ANOVAs and post-hoc unpaired t tests were used. For the hint
347 comprehension task, two repeated measures ANOVAs were performed. The first repeated
348 measures ANOVA – 3 (Group: RHD, TBI, HC) x 2 (Context: Literal, Hint) x 2 (EF demand:
349 Low, High) – was performed on the mean of correct responses to the questions on the
350 speaker's intent and the control questions. Because the factor marker was not manipulated in
351 the literal conditions, only the hint conditions with no marker were considered in this
352 analysis. The second repeated measures ANOVA – 3 (Group: RHD, TBI, HC) x 2 (Marker of
353 hints: Without, With) x 2 (EF Demand: Low, High) – was performed on the mean of correct
354 responses to the questions on the speaker's intent and the control questions for the hint
355 conditions only.

356 Then, to identify pragmatic profiles, the k -means clustering method was performed on the
357 ABI individuals' responses to the questions on the speaker's intent in the six conditions of the
358 hint comprehension task. This partitioning method consists in analyzing, by successive
359 iterations, the center of gravity of participant data (Jain, 2010). It thus allows to group
360 individuals with the most similar characteristics within k groups to minimize the sum of

361 within-cluster sum of the square over k clusters. To determine the optimal number of clusters,
362 we used the elbow, silhouette and gap statistic methods. The elbow method (Kodinariya &
363 Makwana, 2013) is a visual method of gradually increasing the number of clusters to examine
364 the percentage of variance explained by each number of clusters. At some point, the gain
365 from adding a new cluster drops, forming an "elbow" in the graph. This elbow indicates the
366 optimal number of clusters. The silhouette method (Rousseeuw, 1987) is another visual
367 method that analyzes for each participant the difference between the average distance to
368 participants in the same group (cohesion) and the average distance to participants in other
369 neighboring groups (separation). A negative value will therefore indicate a misclassification
370 of the participant. The gap statistic method (Tibshirani, Walther, & Hastie, 2001) finally
371 measures the difference between the intra-cluster dispersion and that of a zero reference
372 distribution for each cluster. The optimal number of clusters will be where the largest jump in
373 intra-cluster distance has occurred, based on a random uniform distribution of points.

374 In the end, the participants who had similar performances were grouped in the same
375 subgroup, named *a posteriori* according to the conditions of interest highlighted during
376 statistical analyses. Specifically, one-way ANOVAs and post-hoc *t*-tests were performed to
377 explore differences between the ABI sub-groups and the control group on neuropsychological
378 data. For the hint comprehension data, two repeated measures ANOVAs – 3 (Group: ABI-L,
379 ABI-H, and HC) x 2 (Context: Literal, Hint) x 2 (EF demand: Low, High) and 3 (Group:
380 RHD, TBI, HC) x 2 (Marker of hints: Without, With) x 2 (EF Demand: Low, High) – were
381 performed on the mean of correct responses to the questions on the speaker's intent and the
382 control questions of the hint comprehension task.

383 Measures of effect sizes were also calculated for each effect of interest by providing the
384 partial eta squared for ANOVAs and the Cohen's *d* for *t* tests. The effect size was small if its
385 value was between 0.01 and 0.05, moderate if between 0.06 and 0.13, and large if above 0.14

386 for the partial eta squared. For Cohen's *d*, the effect size was small if between 0.2 and 0.4,
387 moderate if between 0.5 and 0.7, and large if above 0.8. Given the multiple testing, the alpha
388 level was adjusted with the False Discovery Rate (FDR) method using the Benjamini -
389 Hochberg procedure. Results were considered significant below an alpha level of 0.05 (after
390 FDR correction). Statistical analyses were performed using IBM SPSS version 25 and R
391 Software version 4.0.2.

392 Since the main question of this paper is the identification of cognitive-pragmatic profiles,
393 only the results of cluster analyses will be detailed in this manuscript. Statistical tests for the
394 RHD, TBI, and HC group differences are presented in the supplementary material.

395

396

Results

397 **Comparison of the RHD, TBI, and HC participants**

398 These results are presented in detail in the supplementary material. Comparisons of the
399 RHD and TBI individuals showed that the TBI participants were significantly younger than
400 the RHD participants. No further measure (sociodemographic, neuropsychological, and hint
401 comprehension) differentiated between the two subgroups.

402 Comparisons with the HC group showed that both RHD and TBI participants performed
403 worse than HC participants in answering the questions on the speaker's intent, but not in
404 answering the control questions of the hint comprehension task. Regarding the
405 sociodemographic and neuropsychological data, the RHD individuals performed more poorly
406 than the HC group on flexibility (letter fluency), verbal inhibition (Hayling inhibition),
407 working memory (Digit Span, backward), and ToM (mini-SEA total and faux pas) measures.

408 For their part, the TBI individuals had worse performance than the HC participants on
409 inhibition (Hayling automatic and inhibition) and ToM (mini-SEA total and faux pas)
410 measures.

411 **Cluster Analysis**

412 The *k*-means method was performed with 1000 sets of initial values for a number of
413 clusters from 2 to 6. The various clustering were then evaluated using the elbow method, the
414 silhouette method, and the gap statistic method (see Figure 2). The majority of these methods
415 suggested that the optimal number of clusters would be two, which is the reason for our
416 choice. Therefore, these two subgroups were named *a posteriori* according to the condition(s)
417 of interest evidenced in the statistical analyses: ABI-L (impaired in the Literal conditions)
418 and ABI-H (impaired in the Hint conditions).

419

420 **INSERT FIGURE 2**

421

422 **Neuropsychological assessment.**

423 Means, standard deviations, and p-values for sociodemographic variables and
424 neuropsychological tests are detailed in Table 2. One-way ANOVAs (or Kruskal-Wallis tests
425 when appropriate) were performed to compare the sociodemographic and neuropsychological
426 data of the various participant subgroups (ABI-L, ABI-H, and HC). Significant differences
427 were observed in the performance of the Digit Span (forward and backward), Hayling
428 (automatic and inhibition), and Mini-SEA (total, faux pas, and control) tests.

429 Post-hoc unpaired *t*-tests showed that the ABI-L subgroup performed significantly worse
430 than the HC group on verbal inhibition (Hayling) and ToM (Mini-SEA total and faux pas)
431 measures. Significant differences between the ABI-H and HC groups were found on the Digit

432 Span (forward and backward), Hayling (automatic and inhibition), and Mini-SEA (total, faux
433 pas, and control) tests. The two subgroups of ABI participants differed only on one measure
434 of the mini-SEA (total score), with poorer performance in the ABI-H subgroup.

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INSERT TABLE 2

437

438 **Experimental task: hint comprehension**

439 The three participant subgroups performance in the hint comprehension task are shown in
440 Figure 3.

441 *Hint with no marker of hints versus Literal – Questions on the speaker’s intent.* The 3
442 (Group: ABI-L, ABI-H, HC) x 2 (Context: Literal, Hint) x 2 (EF demand: Low, High)
443 repeated measures ANOVA on the number of correct responses to the questions on the
444 speaker’s intent showed a main effect of group, $F(2,63) = 25.528, p < .001; \eta_p^2 = .448$, with
445 the ABI-H participants having a significantly worse performance than the HC participants
446 (FDR-corrected $p < 0.001$) and the ABI-L participants (FDR-corrected $p < 0.001$). There was
447 no significant difference between the ABI-L and HC participants (FDR-corrected $p > .05$).
448 There was no main effect of context, $F(1,63) = .998, p > .05; \eta_p^2 = .016$, and no main effect
449 of EF demand, $F(1,63) = 2.137, p > .05; \eta_p^2 = .033$. The results also showed a significant
450 context x group interaction, $F(1,63) = 14.743, p < .001; \eta_p^2 = .319$. This interaction was
451 broken down according to group. The ABI-L subgroup made more errors in the literal
452 conditions than in the hint conditions ($p < .03$), whereas the ABI-H subgroup made more
453 errors in the hint conditions than in the literal conditions ($p < .001$). These differences did not
454 exist in the HC group ($p > .05$). No further interactions were significant.

455 *Hint with no marker of hints versus Literal – Control questions.* The 3 (Group: ABI-L,
456 ABIH, HC) x 2 (Context: Literal, Hint) x 2 (EF demand: Low, High) repeated measures

457 ANOVA on the number of correct responses to the control questions showed a main effect of
458 group, $F(2,63) = 8.473, p < .01; \eta_p^2 = .212$, with the ABI-H participants having a significantly
459 worse performance than the HC participants (FDR-corrected $p < 0.001$) and the ABI-L
460 participants (FDR-corrected $p < 0.01$). There was no significant difference between the ABI-
461 L and HC participants (FDR-corrected $p > .05$). There was no main effect of context, $F(1,63)$
462 $= 5.024, p > .05; \eta_p^2 = .074$, and no main effect of EF demand, $F(1,63) = .510, p > .05; \eta_p^2 =$
463 $.008$. No interactions were significant.

464 *Hint with a marker of hints versus Hint with no marker of hints– Questions on the*
465 *speaker's intent.* The 3 (Group: ABI-L, ABI-H, HC) x 2 (Marker of hints: Without, With) x 2
466 (EF Demand: Low, High) repeated measures ANOVA on the number of correct responses to
467 the questions on the speaker's intent showed a main effect of group, $F(2,63) = 68.395, p <$
468 $.001; \eta_p^2 = .685$, with the ABI-H participants having a significantly worse performance than
469 the HC participants (FDR-corrected $p < 0.001$) and the ABI-L participants (FDR-corrected p
470 < 0.001). There was no significant difference between the ABI-L and HC participants (FDR-
471 corrected $p > .05$). There was no main effect of the marker, $F(1,63) = 4.142, p > .05; \eta_p^2 =$
472 $.062$, and no main effect of EF demand, $F(1,63) = 2.260, p > .05; \eta_p^2 = .035$. No interactions
473 were significant.

474 *Hint with a marker of hints versus Hint with no marker of hints– Control questions.* The 3
475 (Group: ABI-L, ABI-H, HC) x 2 (Marker of hints: Without, With) x 2 (EF Demand: Low,
476 High) repeated measures ANOVA on the number of correct responses to the control questions
477 showed a main effect of group, $F(2,63) = 8.503, p < .01; \eta_p^2 = .213$, with the ABI-H
478 participants having a significantly worse performance than the HC participants (FDR-
479 corrected $p < 0.001$) and the
480 ABI-L participants (FDR-corrected $p < 0.01$). There was no significant difference between
481 the

482 ABI-L and HC participants (FDR-corrected $p > .05$). There was no main effect of the marker,
483 $F(1,63) = 1.398, p > .05; \eta_p^2 = .022$, and no main effect of EF demand, $F(1,63) = .247, p >$
484 $.05; \eta_p^2 = .004$. No interactions were significant.

485

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INSERT FIGURE 3

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488 **Profile summary**

489 The ABI subgroup profiles can be summarized as follows:

490 ABI participants impaired in the Literal conditions (ABI-L; 9 TBI and 8 RHD): these ABI

491 participants performed similarly to the HC participants in the hint comprehension task.

492 Contrary to the latter, however, they had poorer performance in the literal conditions,

493 compared to the hint conditions. The analysis of errors (N= 162) showed a majority of

494 incorrect indirect requests (in the literal conditions; “He asks him for the report.”; 31%) and

495 non-mental logical inferences (“He cannot finish because the report is in Jeanne’s office.”;

496 29%). On the neuropsychological measures, they performed worse than the HC participants

497 on inhibition (Hayling) and ToM (Mini-SEA total and faux pas) measures.

498 ABI participants impaired in the Hint conditions (ABI-H; 10 TBI and 6 RHD): these ABI

499 participants demonstrated poorer performance than the HC group and the ABI-L subgroup in

500 the hint comprehension task. Unlike the other two groups, they performed worse in the hint

501 conditions, compared to the literal conditions. Out of the 323 errors, the majority (35%) was

502 incorrect literal interpretations, whereas 28% of the errors were non-mental logical

503 inferences. This pragmatic profile coexisted with worse performance in short-term memory,

504 working memory, inhibition (Hayling automatic and inhibition), and ToM measures in

505 comparison with the HC group. Only one ToM measure (mini-SEA total) differentiated the

506 two subgroups of ABI participants, with poorer performance in the ABI-H participants.

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Discussion

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33 ABI and 33 matched control participants.

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The present study aimed to identify hint comprehension profiles in ABI individuals in relation to the cognitive mechanisms and processes likely to underlie this understanding (i.e., context processing, ToM, and EF). To this end, we used the hint comprehension task developed by Cordonier et al. (2021), which manipulates these mechanisms. The executive demand in literal and hint stories was thus modulated by adding (high EF demand) or not (low EF demand) a distractor paragraph that introduced information irrelevant to the interpretation of the target utterance. In the hint conditions (with low or high EF demand), a marker of hints promoting the understanding of hints (a balance of power between the characters) was added in half of the stories to test participants' contextual integration abilities. Finally, the presence of hints and literal conditions allowed us to evaluate ToM by questioning the speaker's intent ("What does the speaker mean?"). We administered this task and neuropsychological tests assessing inhibition, flexibility, working memory, and ToM to 33 ABI and 33 matched control participants.

The results revealed the presence of two profiles, which were socio-demographically similar, but differed in pragmatic and neuropsychological terms. This variation in performance thus confirms the heterogeneity of the hint comprehension difficulties in ABI populations and consolidates the results of previous studies (Champagne-Lavau & Joanne, 2009; Côté et al., 2007; Dardier et al., 2011). Furthermore, the detailed analysis of the various profiles suggests that different cognitive impairments could account for this pragmatic heterogeneity.

Context processing deficit appeared to characterize one subgroup of ABI participants (ABI-H). These participants demonstrated difficulty inferring hints in all conditions, regardless of the presence or absence of a marker of hints and the executive demand of the

532 stories. This result thus confirms our first hypothesis and previous studies, which suggested
533 that some ABI individuals could be insensitive to the context (Champagne-Lavau et al., 2018;
534 Cordonier et al., 2020). Consequently, they would interpret the statement based on its most
535 common meaning (i.e., literal), as evidenced by the majority of literal errors. On the other
536 hand, the lack of effect of the contextual marker could be explained by the marker used in the
537 hint comprehension task (i.e., the power relationship between the characters). As
538 demonstrated for irony comprehension in healthy individuals (Rivière & Champagne-lavau,
539 2020), socio-cultural markers might not be powerful enough to aid the understanding of
540 indirect requests.

541 The role of *ToM* should be considered in both ABI participant subgroups. Indeed, the ABI-
542 H subgroup, more altered in the hint conditions, demonstrated poorer performance than the
543 HC group on all scores of the faux pas task (total, faux pas, and control). The ABI-L
544 subgroup, which performed less well in the literal conditions, had more difficulties than the
545 control group in understanding faux pas only¹. The two ABI participant subgroups ultimately
546 differed on the total score of the faux pas test. Overall, these results are in line with the study
547 by Muller et al. (Muller et al., 2010), which demonstrated a link between indirect speech act
548 comprehension and faux pas comprehension. Regarding the various ToM-pragmatic profiles,
549 several hypotheses can be put forward. Firstly, the severity or the type of ToM deficit could
550 underlie these various pragmatic disorders. According to our third hypothesis, a lack of
551 understanding of others' mental states could essentially induce errors in the hint conditions
552 (ABI-H), whereas a good understanding of mental states but a certain inability to attribute
553 them could lead to worse performance in the literal conditions (ABI-L) (Abu-Akel, 2003;
554 Cordonier et al., 2020). A second hypothesis, related to a general insufficiency of cognitive
555 resources (Just & Carpenter, 1992; Monetta & Joanette, 2003), is explored below.

556 The role of executive functions was assessed in two ways in our study: by standardized
557 executive tests and the manipulation of the EF demand within the stories of the hint
558 comprehension task. Regarding the neuropsychological assessment, both ABI groups
559 demonstrated executive difficulties in addition to ToM deficits, thus confirming our fourth
560 hypothesis and the joint role of ToM and EF in pragmatic impairment reported in several
561 studies (Bosco, Parola, Sacco, Zettin, & Angeleri, 2017; Champagne-Lavau & Joannette,
562 2009). However, while the executive impairment was limited to inhibition in the ABI-L
563 subgroup, it was more general in the ABI-H subgroup, with impairment in short-term
564 memory, working memory, and inhibition. This profile raises the question of insufficient
565 cognitive resources in this subgroup. This insufficiency would induce difficulties in
566 cognitively demanding tasks, such as understanding hints and faux pas. It would also explain
567 the slightly lower performance of the ABI-H subgroup in answering the control questions of
568 the hint comprehension task and the faux pas task. However, this hypothesis should be
569 viewed with caution in that cognitive resource availability is difficult to assess directly
570 (Monetta et al., 2006) and is based on limited neuropsychological examination in our study.

571 In addition, our hypothesis of an association between executive deficits and difficulty in
572 stories with high executive demand, based on the study by Cordonier et al. (2020), was not
573 supported in the present study. Indeed, the effect of the EF demand was not significant. This
574 discrepancy between these two studies can be explained by the form of non-literal language
575 considered in these two studies – irony in the study by Cordonier et al. (2020) and hints in the
576 present study. Several studies have indeed suggested that irony is more complex to process
577 than indirect requests (Angeleri et al., 2008; Champagne, Virbel, Nespoulous, & Joannette,
578 2003). Adding a distractor paragraph in ironic stories further increases the EF demand, which
579 is already considerable. Difficulties may therefore arise under conditions of high EF demand
580 in patients with milder or circumscribed executive difficulties (the ABI-LH and ABI-INH

581 subgroups in the study by Cordonier et al., 2020). Patients with more limited cognitive
582 resources (the ABI-I subgroup in the study by Cordonier et al., 2020 study), on the other
583 hand, did not demonstrate an effect of EF demand insofar as low EF demand stories already
584 proved problematic. In the present study, since hint comprehension could be less cognitively
585 demanding, adding a distractor paragraph might be insufficient to impact this comprehension
586 in patients with circumscribed executive difficulties (i.e., ABI-L subgroup). However, the
587 cognitive demand for hint comprehension, although less, is still present and could be
588 sufficient to impact patients with minimal cognitive resources (i.e., ABI-H subgroup). This
589 impact would be observed in all conditions, although visual analysis of the results suggests a
590 slight pejoration in stories with high EF demand. However, more studies are needed to clarify
591 the EF demand inherent in hint comprehension and its relation to standardized executive tests,
592 with a possible even finer gradation of the task's difficulty.

593 This result has important clinical implications. It raises the question of the differential
594 diagnosis of cognitive-pragmatic disorders in connection with the cognitive demand of the
595 tasks (Blake, 2017). Some ABI participants could indeed present "secondary" pragmatic
596 disorders, reflecting mostly executive and general cognitive impairment. Thus, when
597 assessing pragmatic disorders, attention should be paid to the cognitive demand or the
598 ecological dimension of tasks. In addition, this differential diagnosis will promote the
599 establishment of specific, more effective therapeutic objectives (Blake, 2007; Tompkins,
600 2012).

601 Another relevant result of our study relates to the etiology of the participants. Interestingly,
602 our two subgroups of patients included a relatively equal number of TBI and RHD
603 participants. Group comparisons also showed no differences between TBI and RHD
604 participants – except for age. Therefore, although these two etiologies differ regarding the
605 type of lesion (focal/diffuse, unilateral/bilateral damage) and demographical features (TBI

606 participants were younger than RHD participants), similar cognitive-pragmatic profiles may
607 result from it. This pragmatic and cognitive similarity has already been demonstrated for
608 irony (Channon & Crawford, 2010; Cordonier et al., 2020). With respect to hints,
609 Zimmermann et al. (2011) observed poorer performance in TBI than in RHD individuals. The
610 TBI individuals, however, also differed in executive tasks. All of these observations have
611 clinical implications. They suggest that faced with empirical deficiencies in the field of
612 pragmatics, data from related pathologies (e.g., TBI and RHD) are relevant sources of
613 inspiration for studying pragmatic disorders and developing assessing tools or treatments
614 (Blake, 2007; Cassel, McDonald, Kelly, & Togher, 2019).

615 Finally, several limitations of our study can be noted. First, patient subgroups included a
616 modest number of individuals. However, this drawback is reduced due to the replicability of
617 the profiles identified. Indeed, the two profiles of the present study are quite similar, both in
618 pragmatic and neuropsychological terms, to the profiles by Champagne-Lavau and Joanne
619 (2009). This concordance strengthens the profiles' validity described, although more studies
620 are needed. A second limitation concerns the lack of more precise data on lesion location. It
621 would have been interesting to compare the lesion sites of the participants presenting the two
622 cognitive-pragmatic profiles and to observe their possible overlap with the ToM neural
623 network. A final limitation concerns the written format of the hint comprehension task. This
624 format is justified by our decision to control for prosody, given the multiple other variables
625 manipulated and the possible deficits in prosody comprehension in ABI individuals (see Ferré
626 et al., 2011, and Ilie et al., 2017 for reviews). It also limits working memory load and partly
627 reflects our everyday reality, as non-literal language is frequently produced in written media
628 such as emails (Whalen et al., 2009). However, a vast swath of spoken communication is
629 obscured by this modality. Future studies using an oral format, as opposed to a written

630 format, would therefore be relevant. These would promote broader generalization and enrich
631 our knowledge about the effect of task modality on pragmatic performance.

632 In conclusion, the present study contributes to a better understanding of the
633 cognitivepragmatic disorders of ABI individuals, using the first task manipulating the
634 underlying cognitive mechanisms and processes, and adopting an analysis method that took
635 the heterogeneity of the ABI population into account. The hypothesis of contextual
636 insensitivity in some ABI individuals is thus reinforced by the absence of the marker effect
637 and the executive demand in one subgroup (ABI-H). Moreover, various types of ToM deficits
638 (lack of understanding (ABI-H) versus poor attribution of mental states (ABI-L) could
639 explain, at least in part, the variability of the pragmatic profiles observed (difficulties in
640 interpreting hints versus literal statements). Limited cognitive resources could also lead to
641 difficulties in pragmatic and ToM tasks, which are cognitively demanding. Finally, the
642 similarity of the cognitive-pragmatic profiles observed in the TBI and RHD individuals
643 underlines the
644 relevance of a transdiagnostic approach.

645

Acknowledgments

646 We are grateful to the ABI and healthy individuals for participating in this study and to the
647 neuropsychologists for recruiting participants (Virginie Descloux, Aline von Siebenthal, and
648 Camille Herrmann (Hôpital Fribourgeois), Victorine Zermatten (Valais de Coeur), Anne
649 Bellman, Christelle Aubert, Emilie Byland (Clinique Romande de réadaptation) and Delphine
650 Frochoux (Hôpital Neuchâtelois)).

651 This work was supported by Swissuniversities under Grant number FR17/19 to Natacha
652 Cordonier

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Data Availability Statement

655 The datasets generated using and/or analyzed during the current study, as well as the hint
656 comprehension task, are available from the corresponding author on reasonable request.

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Conflict of interest

659 None.

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885

886

887

Figure captions

888 **Figure 1.** Example and structure of the hint comprehension task

889

FIGURE 1

890 *Note.* Example and structure of the hint comprehension task varying the context (literal vs.
891 hint), the EF demand (low vs. high), and, in the hint condition, the presence of a cue of hint
892 (no vs. with)

893

894

895 **Figure 2.** Optimal number of clusters according to the elbow method (a), the silhouette
896 method (b), and the gap statistic method (c)

897 FIGURES 2(a), 2(b), 2(c)

898 *Note.* The elbow method is an heuristic method that consists of plotting the within cluster sum
899 of squares and to pick the elbow of the curve as the number of clusters to use. In Figure 2a, a
900 slight curvature is visible for a cluster number equal to 2. The optimal number of groups
901 could also be the one that maximizes the overall average silhouette and is indicated in Figure
902 2b by the dotted line ($N = 2$). Finally, the gap statistic method suggests that the optimal
903 number of clusters could be the smallest one that is such that $Gap(k) \geq Gap(k) - s_{k+1}$, where
904 $Gap(k)$ is the Gap statistic computed for k clusters and s_{k+1} is the standard deviation of the
905 Gap statistic. According to this methodology, the optimal number of clusters is indicated by
906 the dotted line in Figure 2c.

907
908

Footnotes

909 1. This association of difficulties in literal stories and faux pas stories only (and not control
910 stories) may be explained by the fact that, although involving many common processes, these
911 two tasks do not assess exactly the same thing (Bosco et al., 2018). In addition, the different
912 response modalities between these two tasks (i.e., elaboration of meanings in the hints task
913 versus detection for the false task) could induce various performances, as the detection of
914 mental states is generally mastered before their comprehension (Wang & Su, 2006).

915

Supplemental material description

916 Since the main question of this paper is the identification of cognitive-pragmatic profiles,
917 only the results of cluster analyses are detailed in this manuscript. Descriptive data and
918

919 statistical tests for the RHD, TBI, and HC group differences are presented in the
920 supplementary material.

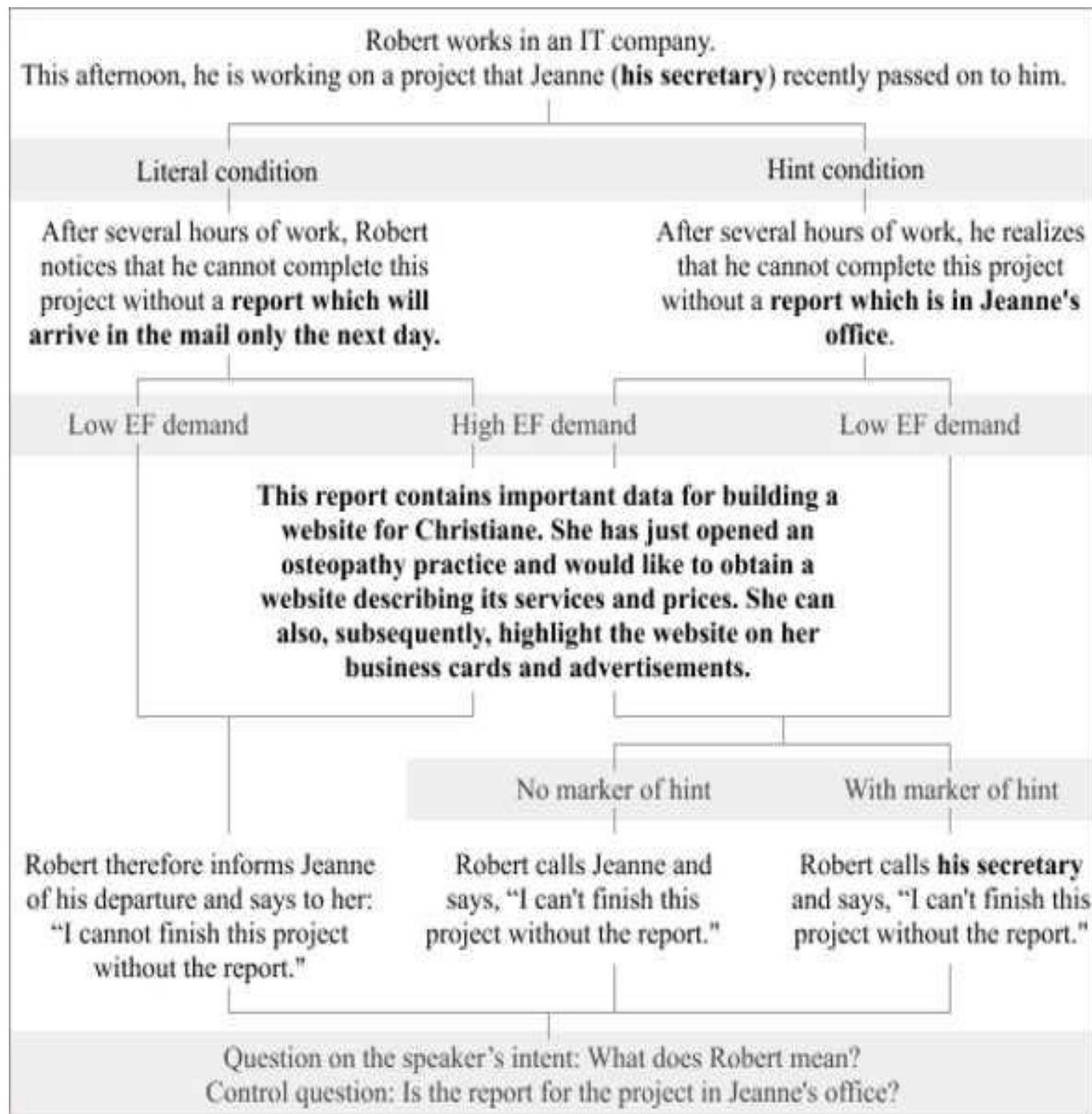


Figure 1

Figure 2a

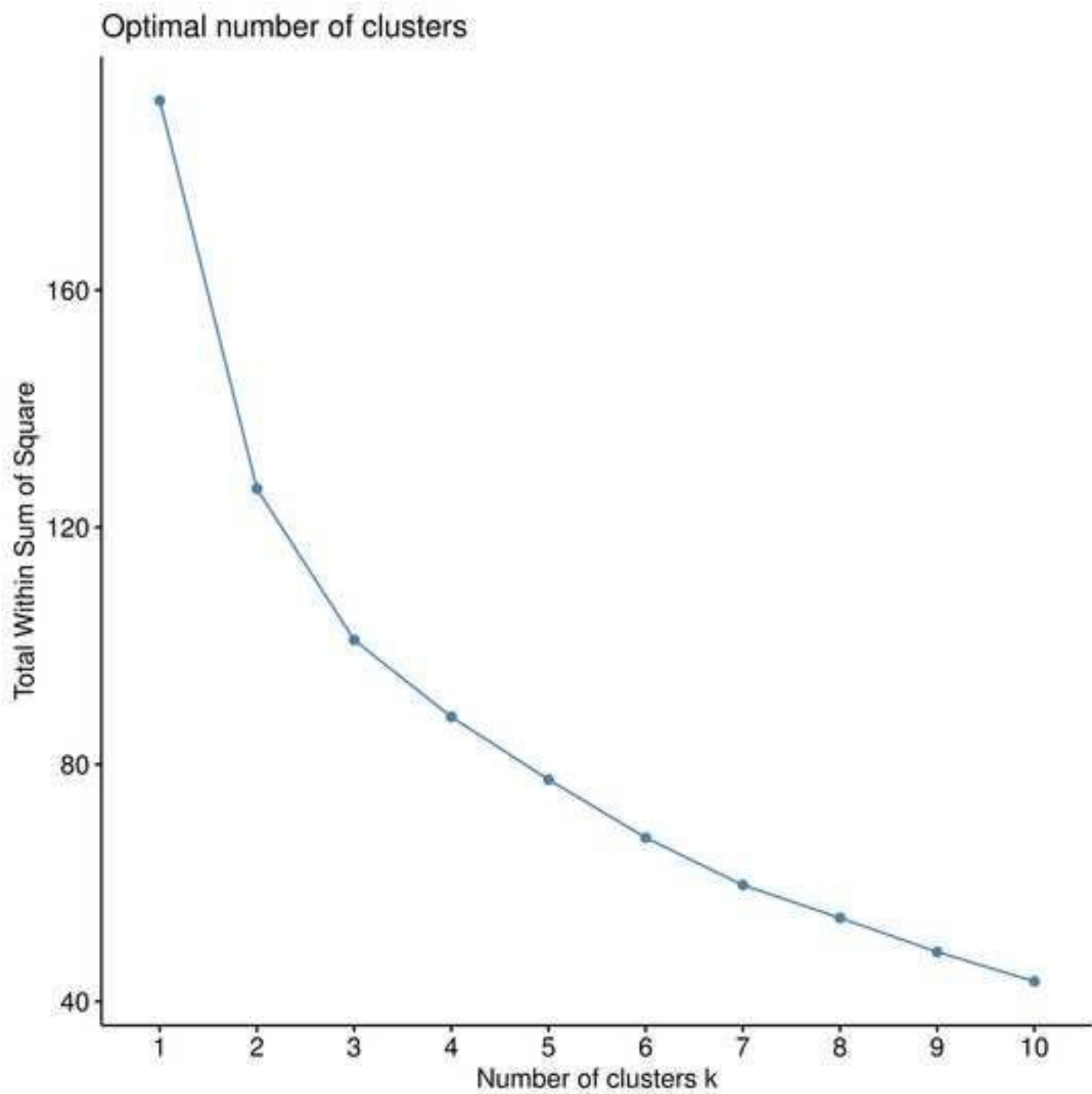


Figure 2b

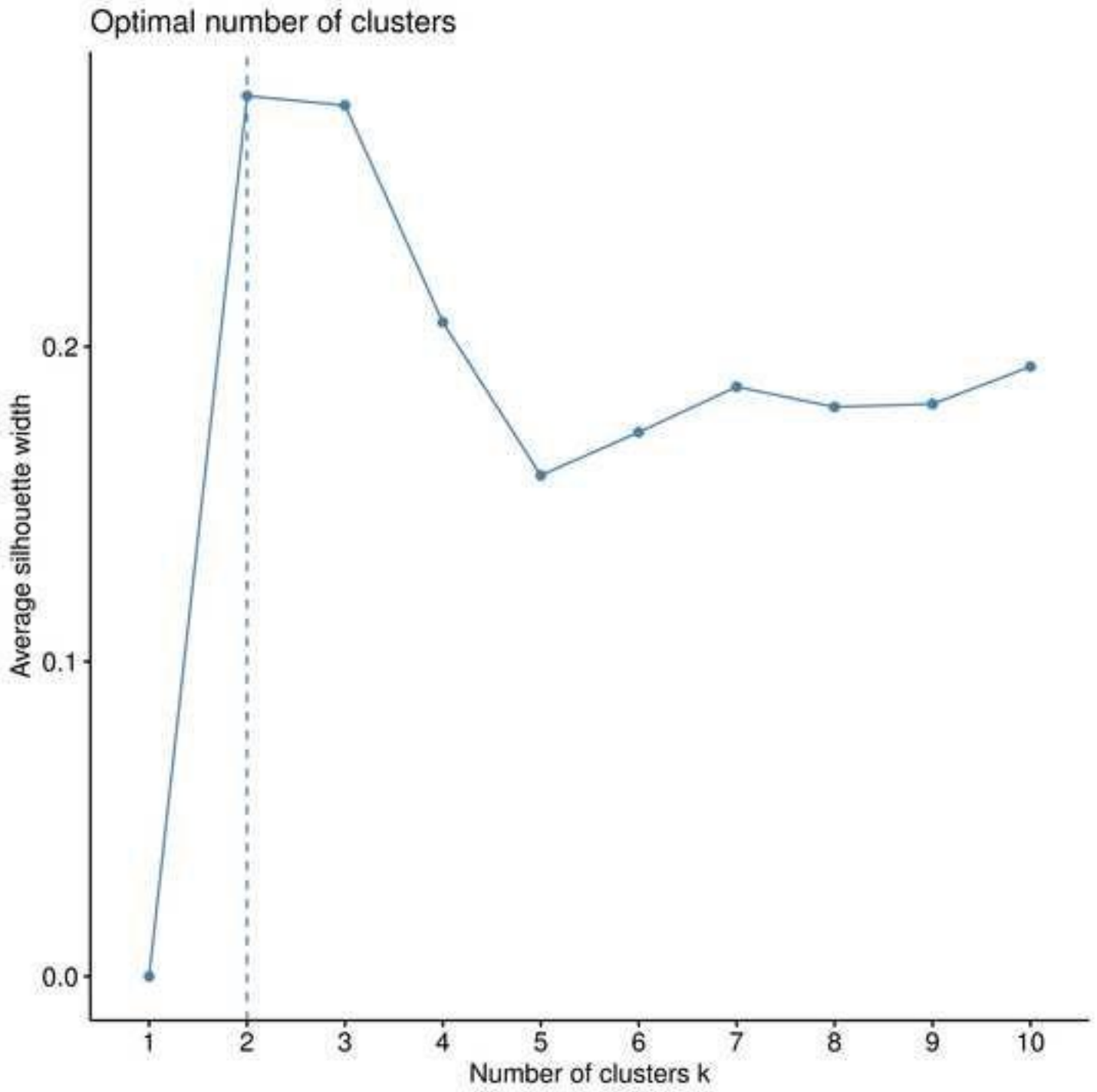


Figure 2c

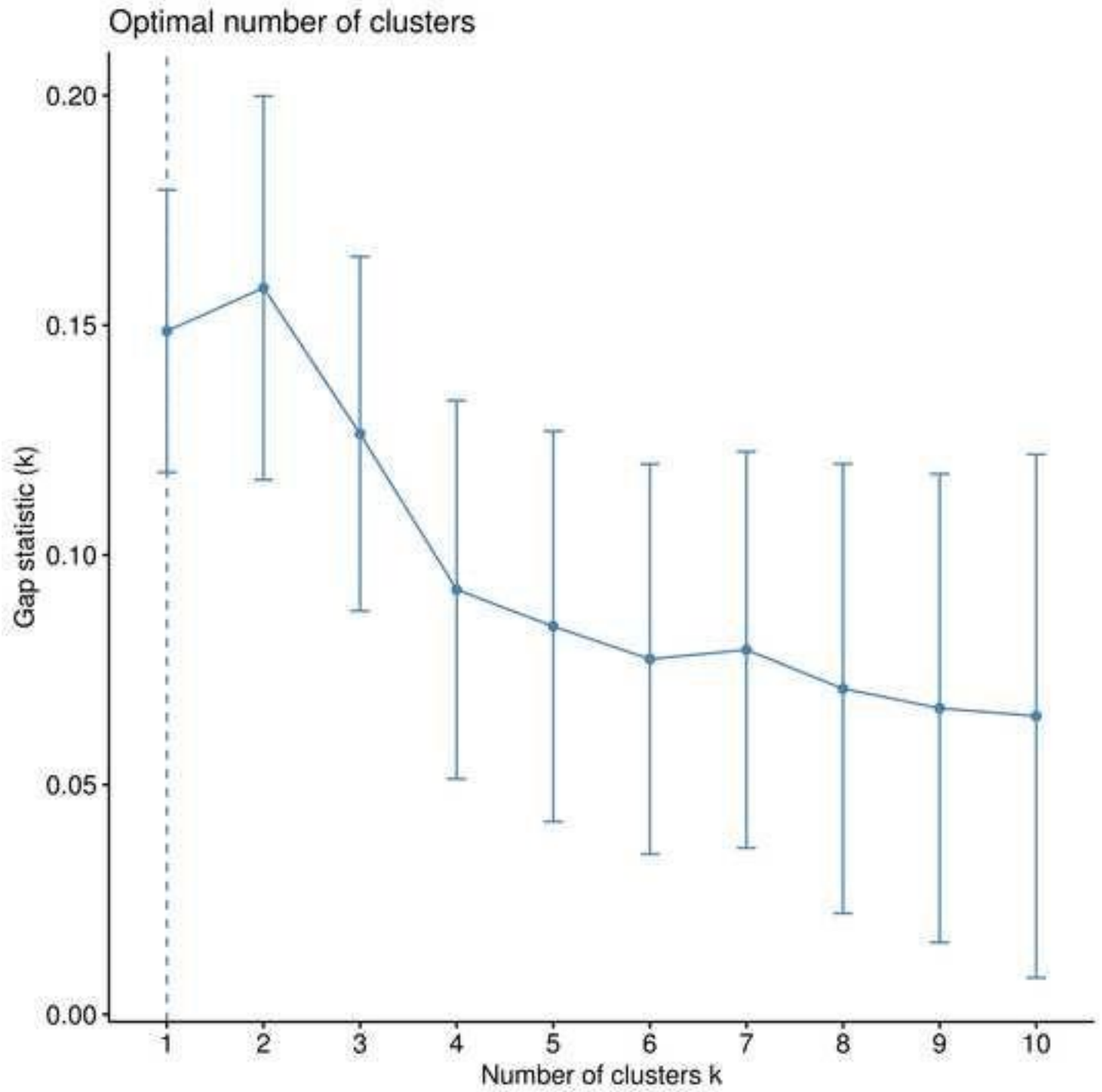


Figure 3. Correct responses to the questions on the speaker's intent (a) and to the control questions (b) in each condition for the ABI sub-group impaired in the Literal conditions (ABIL), the ABI subgroup impaired in the Hint conditions (ABI-H) and the healthy control (HC) group.

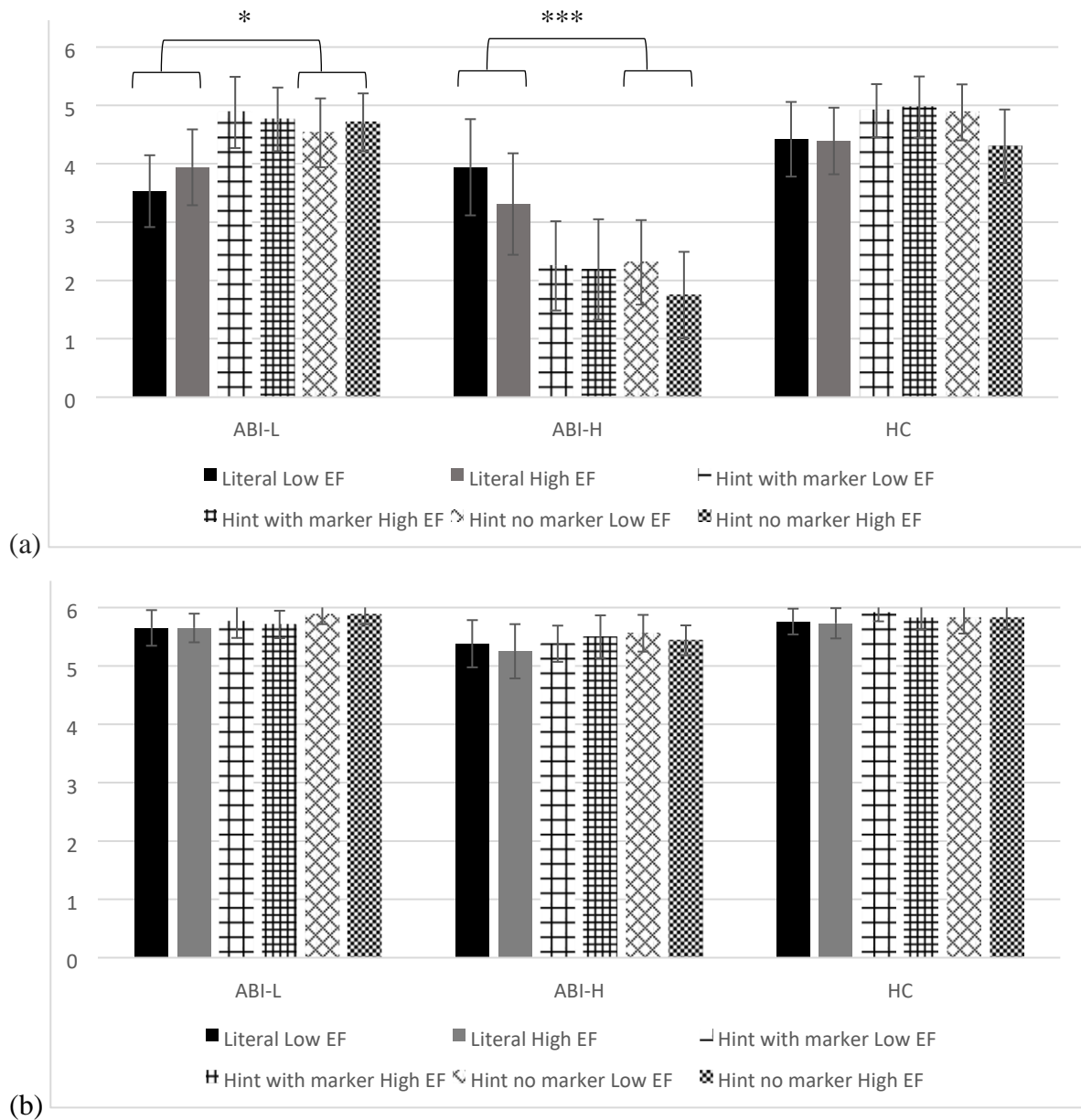


Table 1. Demographic and clinical data for the acquired brain injured (ABI) participants

Participants	Gender	Age (years)	Education (level)	Etiology	Time post-onset (months)	Lesion site
ABI1	F	30	1	TBI	6	Right fronto-temporal – Diffuse injury
ABI2	F	48	2	TBI	251	Right fronto-temporo-parietal
ABI3	M	36	2	TBI	12	Bilateral frontal, subcortical – Diffuse injury
ABI4	F	57	2	TBI	60	Right fronto-temporal, bilateral parietal – Diffuse injury
ABI5	M	34	2	TBI	80	Right fronto-temporal, subcortical – Diffuse injury
ABI6	F	49	2	TBI	20	Right fronto-temporo-parieto-occipital, left temporal
ABI7	M	44	2	TBI	82	Right fronto-temporal
ABI8	M	24	3	TBI	24	Right frontal
ABI9	M	59	2	TBI	48	Bilateral fronto-temporal, right parieto-occipital
ABI10	M	42	2	TBI	246	Bilateral frontal, right temporal
ABI11	F	59	1	TBI	149	Bilateral frontal, right temporal, subcortical–Diffuse injury
ABI12	M	49	2	TBI	45	Bilateral frontal, right temporal, white matter
ABI13	M	57	3	TBI	20	Right frontal
ABI14	M	59	3	TBI	44	Bilateral frontal, left temporal
ABI15	F	53	2	TBI	21	Right fronto-temporal
ABI16	M	49	2	TBI	14	Bilateral fronto-parietal
ABI17	M	59	3	TBI	17	Right fronto-tempo-occipital – Diffuse injury
ABI18	M	24	3	TBI	38	Bilateral fronto-parietal
ABI19	M	45	3	TBI	7	Bilateral fronto-temporal, left parietal
ABI20	F	52	2	CVA	30	Right fronto-parieto-temporal
ABI21	M	58	2	CVA	30	Right anterior cerebral artery
ABI22	F	54	1	CVA	18	Right middle cerebral artery, right frontal
ABI23	F	54	2	CVA	16	Right frontal
ABI24	F	59	2	CVA	62	Right frontal
ABI25	M	64	1	CVA	83	Right middle cerebral artery
ABI26	M	64	2	CVA	108	Right fronto-occipital
ABI27	M	60	2	CVA	90	Right frontal
ABI28	M	61	2	CVA	99	Right fronto-temporal
ABI29	F	63	1	CVA	31	Right frontal
ABI30	M	55	3	CVA	62	Right middle cerebral artery
ABI31	F	52	1	CVA	5	Right middle cerebral artery (M1, M2)
ABI32	M	64	2	CVA	3	Right middle cerebral artery, subcortical
ABI33	F	45	2	CVA	6	Right fronto-temporo-parietal

Note. CVA: cerebrovascular accident, TBI: traumatic brain injury; educational level: according to the Swiss system: level 1 = obligatory school; level 2 = vocational training; level 3 = university education

Table 2. Comparison of the sociodemographic and neuropsychological data between the healthy control (HC) group, the ABI sub-group impaired in the Literal conditions (ABI-L), and the ABI subgroup impaired in the Hint conditions (ABI-H).

	ABI-L		ABI-H		HC		Test statistic		ABI-L vs HC	ABI-H vs HC	ABI-L vs ABI-H
	Mean	SD	Mean	SD	Mean	SD	<i>F</i> / <i>H</i>	<i>p</i> -value (η_p^2)	<i>Post-hoc p</i> -value (Cohen's <i>d</i>)	<i>Post-hoc p</i> -value (Cohen's <i>d</i>)	<i>Post-hoc p</i> -value (Cohen's <i>d</i>)
Age	50.18	12.20	51.81	10.15	51.09	11.10	.09	.940	-	-	-
Educational level (1/2/3)	2/9/6		4/11/1		6/20/7		3.74	.154	-	-	-
Time post-onset (month)	35.94	31.90	76.00	77.28	-	-	3.87	.111	-	-	-
Digit SPAN (forward)	8.94	2.19	7.19	1.94	9.76	2.50	6.73	.008 (.176)	.373	.006 (1.100)	.053
Digit SPAN (backward)	7.35	1.94	6.13	1.63	8.55	2.04	8.78	.000 (.218)	.105	.000 (1.258)	.111
RST SPAN	2.59	.80	2.31	.79	2.85	.62	3.17	.100	-	-	-
RST (total words)	18.00	9.54	14.19	6.99	20.03	6.73	3.19	.099	-	-	-
Letter fluency (D + F)	22.12	8.30	21.19	7.41	27.03	7.40	4.13	.053	-	-	-
Hayling (automatic)	6.24	.437	5.81	.83	6.48	.51	7.08	.008 (.183)	.139	.006 (1.066)	.134
Hayling (inhibition)	9.06	3.42	7.25	2.35	11.55	1.89	17.52	.000 (.357)	.031 (.993)	.000 (2.097)	.153
Mini-SEA (total)	29.71	6.22	22.13	10.39	33.79	4.62	15.82	.000 (.334)	.034 (.784)	.000 (1.667)	.049 (.892)
Mini-SEA (faux-pas)	19.94	6.25	14.8	8.39	23.91	4.59	11.82	.000 (.276)	.037 (.763)	.006 (1.516)	.110
Mini-SEA (control)	9.76	.66	8.80	1.97	9.88	.49	5.68	.017 (.155)	.611	.017 (.930)	.153

p-values adjusted with the False Discovery Rate (FDR) method using the Benjamini - Hochberg procedure; the bold font indicates significant differences between the groups; educational level: according to the Swiss system: level 1 = obligatory school; level 2 = vocational training; level 3 = university education