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Individuals with developmental disabilities make their own
stylistic contributions to text written with physical facilitation.

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46 **Abstract**

47 One approach to assisting linguistic expression in individuals with developmental disabilities is to
48 physically assist them, for example by applying touch to their torso or arm, as they type characters
49 on a keyboard or screen. There has been significant controversy over the extent to which the
50 facilitator and not the user authors texts written with such assistance. It has been suggested that
51 these texts are entirely the by-products of the facilitators' unconscious and ideomotor cueing of the
52 users' movements towards the keyboard. Here, we use quantitative linguistic analysis techniques to
53 investigate whether the texts produced by users with developmental disabilities exhibit their own
54 stylistic contributions in addition to the influence of their facilitators. In Study 1, we investigate
55 whether it is possible to identify a set of users' stylistic fingerprints when they are all assisted by the
56 same facilitator. In Study 2, we examine whether the users' texts retain their individual stylistic
57 characteristics even when the texts have been produced with the assistance of multiple facilitators.
58 The results show that the users' stylistic signature is detectable alongside that of their facilitator,
59 suggesting that the texts generated by disabled users with physical assistance should be viewed as
60 co-authored rather than wholly authored by the facilitators. The implications of these results for the
61 users' learning, development and quality of life are discussed.

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64 **Keywords:** Facilitated Communication, Stylometry, Co-authorship, Developmental disabilities,
65 Authorship attribution

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67

68 **Introduction**

69

70 Individuals growing up with a range of developmental disorders face sensorimotor and
71 cognitive deficits that make it difficult to learn a system of communication (1,2). Augmentative and
72 alternative communication (AAC) systems are designed to build upon (augment) existing skills and
73 competencies and ease the learning workload by providing different means or codes through which
74 communicative intentions can be channeled (1,3). Aided AAC methods employ technological
75 extensions (for example, eye-trackers, motion-sensors, input devices, etran table, and so on) whereas
76 unaided ones (for example, sign language and coded behaviors) do not (3). AAC methods also differ
77 in the communicative code they adopt, which can be alphabetical (phonemes associated with
78 graphical orthography), gestural (sign language), haptic (braille), iconographic/ideographic (based on
79 immediate or indexical similarity, or arbitrary convention) (3,4). AAC systems may be used to
80 overcome sensory impairment such as braille or sign language, fine and gross motor impairment such
81 as eye-tracking, or etran table, cognitive/linguistic deficits as picture-based systems, or both motor
82 and cognitive challenges such as picture-based communication software, rapid prompting method,
83 or facilitated communication (3,5,6).

84 Motor-facilitating AAC devices seek to counter users' physical impairment by exploiting residual
85 motor competences, such as eye-fixations or residual goal-directed index movements, to create text-
86 based communication (3). Cognitive and linguistic facilitation enables users to reduce the workload
87 of phonological word-segmentation (required by a text/keyboard-based communication) and the
88 workload of word reading, lexical access and, in some cases, syntactical and morphological planning,
89 by providing picture-based lexical referents from a closed set of options (3,5,6). Combined motor-
90 cognitive facilitation provides a simplification of motor access using technology (for example, eye-
91 tracking), or through the physical support of a facilitator, such as in the rapid prompting method
92 (RPM) or facilitated communication (FC). These methods provide cognitive simplification by

reducing the cognitive demands of formulating a full-language expression (e.g., picture-based exchange systems) or by reducing the overall cognitive demands of the task by supporting attention, providing emotional reassurance and reducing the cognitive demands of the co-occurrent motor task while maintaining a text-based communication, as has been suggested for RPM (7,8) and FC (Nicoli et al. under review).

The development of human-assisted motor-cognitive facilitation systems such as RPM and FC have controversial histories due to concerns over the extent to which the facilitator contributes to the user's communication (9). In the case of FC, for example, where the facilitator assists the user's postural and motor stability by touching their shoulder or holding their arm, it has been suggested that the texts produced are simply by-products of the facilitators' unconscious and ideomotor cueing of the users' movements towards the keyboard (10–14). In this context, the question of authorship has been studied mostly using the message-passing task, in which the user is required to type information about which the facilitator is either unaware or misinformed. As users have not succeeded in this task in most studies (12,15,16), except for some partial exceptions(17), the prevailing view is that authorship should not be attributed to FC users (18,19), and that FC should not be used in formal education (20).

Alternative methods of studying the FC process have suggested a more complex picture of FC users' involvement, such as (21) demonstration of pre-emptive eye-fixations on to-be-typed keys before the typing movements start, or Faure et al's (22) accelerometry study showing that the user's movement towards the keyboard starts before the facilitator's assistive movement. Linguistic analysis of FC users' text have found unexpected or unusual lexical choices (23,24), linguistic idiosyncrasies (23,25,26), spelling errors (25,27), unusual syntax (24,25) and differences in terms of MLU (medium length utterance) when compared with texts written by facilitators (26). These results appear to suggest some active involvement of the user in the text production process.

119 In terms of the properties of the generated text, studies conducted within the EASIEST project
120 (28–34) used hierarchical clustering methods to show that FC users’ texts were stylistically different
121 from those of their facilitator, as indicated by a different ratio in the use of adjective and adverbs (31),
122 an increased number of low-frequency word neologisms and adverbs with the Italian /-mente/ suffix
123 (29,35), and a frequent use of figures of speech such as anastrophe, “tmesis”, metaphors, and word
124 inversions (30). As pointed out by Saloviita (14), differences in style between FC users’ and
125 facilitators’ texts does not prove that users are the true authors of the texts they produce. It could be
126 argued that text produced by FC users with the facilitator’s assistance might be different in style to
127 text produced by FC users without assistance. This scenario is not testable as users adopt FC because
128 they cannot type independently, but it is consistent with Pennebaker’s (36) synergy hypothesis
129 defining the stylistic features of texts produced by multiple authors. Each author involved in the co-
130 creative process is expected to lose their own stylistic fingerprint, creating different stylistic features
131 in the co-created text. Besides, facilitators may simply change their own writing style when involved
132 in the FC process as suggested by Saloviita (14) and Eder (37).

133

134 Rather than trying to address stylistic differences between FC users and facilitators when they
135 operated individually, Emerson (38) considered whether the signatures of both might be embedded
136 in the text they produce together. This approach revealed occurrences of lexical choices that could be
137 linked to the user (words used only by the same user with different facilitators) alongside those that
138 were linked to the facilitator (words used by different users only when assisted by the same
139 facilitator). Such results suggest that FC texts are co-constructed by the user and facilitator (23,39).
140 The plausibility of the co-construction hypothesis depends upon indications of co-authorship at the
141 levels of lexical choice, syntactical patterns (use of function words and word sequences), distribution
142 of morphological markers and phonological/graphemic patterns (through the analysis of short
143 sequence of characters). The potential value of such co-authored text for the communicative,

144 educational, or cognitive and emotional growth of individuals facing the multi-faceted challenges of
145 developmental disabilities is a separate issue, to which we return in the discussion.

146

147 Quantitative methods of linguistic analysis offer several ways to investigate contributions to
148 authorship within corpora of text. Stylometry measures concrete, discrete, non-linear and even non-
149 linguistic (40) textual features to identify authors' 'fingerprints' (41). The linguistic fingerprints can
150 then be compared to address authorship attribution issues. Stylometry allows a "distant reading" (42)
151 of texts, enabling the quantification and comparison of broad textual patterns that are unlikely to be
152 consciously manipulable. One approach is to create a simplified model, such as the bag-of-words,
153 whereby texts are considered as lists of words or character n-grams (sequences of characters of
154 different size), sorted by frequency. Each word appearing within the text is a dimension and its
155 frequency the value along that dimension. Casting pieces of text as vectors occupying a location in a
156 space enables a range of statistical analyses on the stylistic distance between the vectors.

157

158 One analysis approach uses unsupervised learning algorithms to calculate the distance
159 between vectors. The shorter the distance, the closer the texts in stylistic features (in terms of lexical,
160 morphological, or syntactic choices). Several algorithms have been proposed for calculating the
161 distance between texts, starting with Burrows' delta or "classical delta" (43,44) to "cosine delta
162 distance" (45,46), which computes a cosine similarity between a matrix of values normalized (z-
163 scored) to minimize matrix size. Once the texts are organized in a distance table (with respect to their
164 distances to other texts), their similarities can be expressed in multiple ways. Hierarchical clustering
165 analysis, for example, displays texts in a dendrogram that progressively pairs them based on
166 similarities. Thus, texts occupying the same leaf are highly similar. Another method of expressing
167 stylistic relationships between texts is the bootstrap consensus network (47), which graphically
168 displays stylistic similarities through linkages of varying thickness.

169

170 These stylometry methods can be valuable in investigating the issue of authorship of texts
171 generated through AAC techniques such as FC as they provide a time-extended perspective on the
172 text construction process as it operates naturally, without the insertion of experimental artifacts. The
173 analysis of text generated over long periods of time, while the user and their partnership with
174 facilitators evolve, provide a stronger test of individual influences than snapshot methods using
175 arbitrary tasks in which the user possibly is not motivationally invested. Linguistic analysis may also
176 address authorship questions at multiple levels: lexical, by investigating lexical choices, syntactical,
177 by focusing on the use of function words and word sequences, morphological, by observing the
178 distribution of morphological markers, and phonological/graphemic, by considering character n-gram
179 patterns.

180

181 The focus of the present paper is to conduct multi-level quantitative linguistic analyses of
182 corpora of text generated by multiple FC users with the same facilitator (Study 1), and text produced
183 by multiple users, each with multiple facilitators (Study 2), to determine whether, or to what extent,
184 the FC users' stylistic signature can be detected alongside that of their facilitators. In both studies, we
185 start from the maximally skeptical position that the facilitator is the sole ordering agent, and that text
186 produced using FC is not objectively attributable to any source other than the facilitator. It should not
187 be possible, then, to find unique stylistic fingerprints associated with specific FC users. We use
188 unsupervised machine-learning methods, particularly cluster analysis, to test whether the stylistic
189 distance between texts (based on intrinsic stylistic features) is governed solely by the characteristics
190 of the facilitator. We first describe the characteristics of the texts that we analyzed, and then present
191 the two studies.

192

193 **The Corpora**

194

195 The texts analyzed in the present studies were collected from two FC centers in Italy. The texts are
196 therefore in Italian and have not been used previously in research. To accumulate a sufficient amount
197 of data for each FC user, we collected pre-existing texts written over the past two decades in the
198 course of each center's usual practice. For the purpose of this project, we asked each center to forward
199 all the pre-existing texts produced by their clients that they had stored in their databases. The centers
200 gave written consent for us to use their data in our analyses under the condition that our reports would
201 be fully anonymized at the levels of the users, facilitators, and the centers. As the present work only
202 reports fully anonymized analysis of pre-existing data, and we obtained consent from the holders of
203 the data, we did not require ethical approval for these analyses.

204 In Center 1 and Center 2, the texts were stored in a specific folder named after each participant,
205 each .docx file within each folder representing the text output of one FC session, held on a weekly
206 basis. Most of the texts were in a dialogue form, therefore they contained lines from the user and lines
207 from the facilitator (highlighted in caps lock). Each document identified the facilitator who assisted
208 the FC session reported in it.

209 The texts were then pre-processed in the following steps.

210 First, the texts were divided by user-facilitator pairings. All the users from Center 1 wrote with the
211 same facilitator, but the users from Center 2 were assisted by multiple facilitators. Second, the users'
212 lines were automatically separated from facilitators' lines using a python script. Any references to the
213 users' or facilitators' names were then removed from each file. Finally, all the files for each user-
214 facilitator pairing were grouped into a unique .txt file and coded in UTF-8 to allow R software to run
215 the analyses on the files. These operations created Corpus 1 for Center 1 and Corpus 2 for Center 2
216 (see Figs 1 I and 2 I). Corpus 1 had 7 participants (3 Female, 4 Male; Age: 19-44yrs , mean = 25.8; >
217 10yrs since FC adoption), and Corpus 2 had 10 participants (7 Female, 3 Male; Age: 21-54yrs, mean=
218 38.9; > 10 yrs since FC adoption). All the users involved in this study could not communicate
219 independently through writing and in some cases, they were diagnosed with mild to severe intellectual
220 disability. The users' information is shown in Fig 3. The users' names were coded by assigning to

each user a number (U1, U2, and so on). For Corpus 2, the facilitators' names were coded with the "F" letter followed by a progressive number (F1, F2 and so on). The users' and facilitators' names were separated by an underscore ("_"). According to the needs of the studies, these files were then assembled into different corpora created specifically to address the research questions (see the Materials section of each study).

Before addressing these texts quantitatively in Study 1 and Study 2, we consider both corpora in their entirety, focusing on the global characteristics of the writings of FC users. Corpus 1 is composed of 84001 occurrences (tokens, the number of total words used in the corpus) resulting from the use of 10552 words (types, number of different forms that appears in the corpus). Corpus 2 consists of 481228 occurrences (tokens) resulting from the use of 20021 words (types).

Fig 1: Corpora from Center 1:

I: Corpus_1. Texts collected from Center 1. All texts were written with a single facilitator.

II: Corpus 1_A, Corpus 1_B, and Corpus 1_C. The text production of each user, after being divided in four homogeneous chunks, is merged in three different ways. In Center1_A, the first chunk is merged with the second chunk, and the third and the fourth chunks are merged together. In Center1_B, the first chunk is merged with the third, and the second and the fourth chunks are merged together. In Center1_C the first chunk is merged with the fourth, and the second and the third chunks are merged together.

Fig 2: Corpora from Center 2.

I: Corpus_2. Texts collected from Center 2. Users were assisted by multiple facilitators.

II: Corpus 2_1. Texts from Corpus 2 written solely with F1.

III: Corpus 2_1_A, Corpus 2_1_B, and Corpus 2_1_C The text production of each user, after being divided into four homogeneous chunks, is merged in three different ways. In Corpus 2_1_A, the first chunk is merged with the second chunk, and the third and the fourth are merged. In Corpus 2_1_B, the first chunk is merged with the third, and the second and the fourth chunks are merged together. In Corpus 2_1_C, the first chunk is merged with the fourth, and the second and the third are merged together.

Fig 3: Description of FC Users: For each FC user, gender, age, diagnosis, years of FC use and the actual level of facilitation are shown. Users U1 - U7 came from Center 1, and users U8 - U17 from Center 2. All the users reported in the table could not communicate independently through writing. Note that the terminology that was used in the original diagnoses is retained in this figure.

According to Bernardi (28), the linguistic production resulting from a process of facilitated communication presents some peculiarities that separate it from neurotypical communication. Some characteristics appear to have nothing idiosyncratic or individual (30) about them, and appear instead to be a trait common to the population who write with FC. The peculiarities of the (Italian) language

257 of facilitated communication, explored in Cortelazzo (29), Benelli and Cemin (35) and Di Benedetto
258 (30) can be summarized as follows: (1) the presence of a varied and non-repeating lexicon, with the
259 presence of numerous Hapax legomena (words that appears just once in the corpus), (2) the
260 occurrence of uncommon words of the Italian language, (3) the use of common words isolated from
261 their context of natural occurrence, (4) the presence of words that do not exist in the Italian language
262 but are possible, (5) frequent use of forms with the prefix / in /, (6) the intensified use of adverbs in /
263 -mente /, (7) the presence of marked syntactic structures alongside unmarked syntactic structures, and
264 (8) strong incidence of left-side dislocations (focalization of a word by putting it first in syntactical
265 construction) .

266 The texts of Corpus 1 and 2 have many features in common with the texts of the EASIEST
267 project (29). Corpus 1 and 2 exhibit a non-repetitive and rich lexicon, and also behave in a similar
268 way to the texts used in Bernardi (28) with regard to uncommonly used word forms. The analysis
269 with respect to the frequency of the different words, conducted with the ColFIS software shows that
270 there are numerous uncommon forms within the corpus. Thus, among the words of uncommon use,
271 as in those of common use, the presence of numerous forms introduced by the in- negative prefix is
272 confirmed. As described in Bernardi (28), it is also possible to identify some words within Corpus 1
273 and 2 that are not part of the Italian language lexicon but which are possible as they are constructed
274 according to the rules of word formation. Among these, it is possible to notice that the adjective
275 formation from a nominal base through the suffix /-oso/ is very frequent and used correctly in most
276 cases to indicate the presence and abundance of the quality expressed by the name from which it
277 derives. Similarly, we noted the tendency to form denominal verbs (for example "vacanzare") or de-
278 aggettival (for example "tristeggiare"). Finally, the production of new possible words is productively
279 originated through the creation of adverbs in /-mente/: in the corpus we can in fact observe forms
280 such as "narcisamente" (narcissistically), not present in the Italian vocabulary.

281 From a syntactical standpoint, we noticed that in Corpus 1 and 2 there are sentences with a marked
282 syntactic structure, although less frequent compared to the texts described in Bernardi (28). It is
283 possible to observe constructions that are freed from the SVO structure through the anticipation of
284 the second argument or the postposition of the predicate (see examples 1-4 below), by reversing the
285 noun adjective order (examples 5, 6), or by avoiding articles and other grammatical elements
286 (examples 7,8,9). However, the incidence of these marked structures is lower than that described in
287 the EASIEST research. These could be the sign of a higher editorial intervention from the facilitators
288 or the result of a process of style development or teaching within each Center. Examples:

- 289 1. “suoni buoni faccio” (U15_F1) [I make good sounds]
290 2. “forte molto grande mi sembra” (U14_F5) [It seems very big and strong]
291 3. “bravi e testardi operatori ho trovato” (U17_F8) [I found good and stubborn operators]
292 4. “io donna silenziosa sono” (U9_F2) [I am a silent woman]
293 5. “sono come vulcanosi monti ormai svuotati che hanno bruciato le loro emozioni” (U9_F4) [I am
294 like vulcanous but emptied mountains that have burned their emotions]
295 6. “forte senso di piacere nei rigidi muscoli” (U11_F2) [strong sense of pleasure in rigid muscles]
296 7. “io dico che importante problema si verifica” (U12_F5) [I say that it is verifying an important
297 problem]
298 8. “rabbioso momento interno mi ha colpito” (U13_F3) [a rabid internal moment hit me]
299 9. “gambe non aiutano ma mani si” (U16_F2) [legs do not help, but hands do]

300

301 **Study 1**

302

303 In this study, we investigate the stylistic characteristics of text produced over 10 years by sets
304 of FC users each working with the same facilitator. We collect and separately analyze, using identical
305 methods, texts from two independent FC centers in Italy. The users in each center produced their texts
306 with a single facilitator. Our null hypothesis is that texts from each center carry a single stylistic
307 influence – the facilitator. As the FC user is not a significant linguistic agent in this view, texts
308 produced by an individual user are not expected to be more similar to other texts by the same user
309 than to texts by other users. We use unsupervised machine-learning techniques to carry out this
310 similarity analysis. To allow user-to-user comparison, we split each user's text into two chunks of
311 equal length in three different ways. We then measure the stylistic distance between texts and display
312 them on cluster dendrograms. If the facilitator is the sole stylistic agent at each center, the clusters
313 should exhibit no user-related grouping, with texts by the same user unlikely to be paired at the leaf
314 level of the dendrogram.

315

316 **Materials**

317 As previously introduced, Corpus 1 consisted of seven users' texts written with a single
318 facilitator. From Corpus 2, texts that were written with Facilitator 1 (who was the facilitator most
319 represented in the corpus) were selected to create Corpus 2_1 (Fig 2 II), which consisted of 10 users'
320 texts. Thus, the included users from both Corpus 1 and 2 had written with a single facilitator at their
321 Center, and each user's text was more than 5000 words in length (48)
322 For cluster analysis, each text was split into 4 equal-length fragments that were subsequently
323 assembled in three different ways to create two equal-length chunks for each text. The chunking was
324 done using different combinations of text fragments, and the analyses repeated for each method of
325 chunking, so that the results could not be dependent upon the accident of a specific chunking
326 approach. First, the texts were merged chronologically (thus, fragment 1 and fragment 2 created
327 chunk 1-2, and fragment 3 and fragment 4 created chunk 3-4). This constituted Corpus 1_A and

Corpus 2_1_A (recall that Corpus 2_1 contained texts from Center 2 that were written with facilitator 1). Second, chunks were created by joining fragments 1 and 3 (chunk 1-3) and fragments 2 and 4 (chunk 2-4). This created Corpus 1_B and Corpus 2_1_B. Finally, fragments 1 and 4 were merged to give chunk 1-4 and fragments 2 and 3 gave chunk 2-3. The results of these operations were Corpus1_C and Corpus 2_1_C. As seen in Figs 1 I and 2 I, the division of U7 and U17's texts would result in chunks of less than 5000 words. These users were therefore not included for cluster analysis. The texts were named after the user's code and a numerical code referring to the merged chunks (for example, U1_1-2 signified chunks 1 and 2 of U1 merged). The corpora are displayed in Fig 1 II for Center 1 and Fig 2 III for Center 2.

337

338 **Methods**

Corpus1_* and Corpus 2_1_* were analyzed separately using the clustering method implemented within Stylo for R (48). The analysis was performed based on the first 1000 most frequent words and on the first 1000 most frequent character-trigrams. Textual distance was calculated using cosine delta distance (45).

343

344 **Results**

The cluster analysis (Figs 4 and 5) showed that texts by the same user consistently produced the closest pairing. In the case of Corpus 1_* (Fig 4), whether using the 1000 most frequent words or character-trigrams, the closest pairings were always of texts by the same user. This was also the case for Corpus 2_1_* (Fig 5) using words, but there was one notable exception in the analysis by character-trigrams. In one of the three ways of splitting users' text (Corpus2_1_A, where the first two quarters of each user's text were separated from the last two quarters), one of U12's chunks (U12_1-2) was grouped with U11's texts, and the other (U12_3-4) was grouped with U14's texts. This suggests the possibility that U12's style is similar to U11 and U14.

353

354 It is also interesting to note the pair relationships across the dendrograms. In the case of Corpus
355 1_* (Fig 4), U1 is consistently on the lowest, most distant branch. In the upper branch, U2 and U3
356 are grouped the closest, followed by U5 and U4. This pattern of similarity between users is stable
357 across all three ways of separating their texts and analysis by the most used words or character-
358 trigrams. In the case of Corpus 2_1_* (Fig 5), U10, U11 and U12 always occupy the inferior major
359 branch, separated from all the other users. U15 and U16 are often paired together, as are U13 and
360 U14.

361 **Fig 4. Cluster analysis of texts from Corpus 1_A, Corpus 1_B and Corpus 1_C_.** Features' selection 1000
362 most frequent words (left column) and 1000 most frequent characters' trigrams (right column). Distance:
363 cosine delta. Texts were firstly divided into 4 quarters, then reassembled in three different ways. The code
364 following the underscore indicates the merged quarter. Thus U3_1-2 indicates the first and second texts'
365 quarters of participant 3 merged together. In all conditions and features' selection texts of the same user are
366 systematically paired together at dendrograms' leaves level. U1 occupy singularly one of the two major
367 branches, opposed to all the other users.

368
369
370 **Fig 5. Cluster analysis of texts from corpora Corpus 2_1_A, Corpus 2_1_B and Corpus 2_1_C_.** Features'
371 selection 1000 most frequent words (left column) and 1000 most frequent characters' trigrams (right column).
372 Distance: cosine delta. Texts were firstly divided into 4 quarters, then reassembled in three different ways. The
373 code following the underscore indicates the merged quarter. Thus U13_2-3 indicates the second and the third
374 texts' quarters of U13 merged together. In all conditions and features' selection texts of the same user are
375 systematically paired together at dendrograms' leaves level, with the sole exception of Corpus 2_1_A
376 characters' trigrams where participant U12 is paired once with U11, once with U14. Two major users' groups
377 are displayed. U13, U14, U15, U16, and U8 on the one side, U9, U11, U12, and U10 on the other.

379 Summary

380 The study set out with the assumption that the facilitator is the sole stylistic influence on each
381 of the two corpora. If this was the case, the cluster analysis results would not be expected to show
382 any pattern of stylistic similarities between texts. This would apply both to the similarity between
383 chunks of text by the same user and to the stylistic proximity of texts across users. The cluster analysis
384 results were not consistent with the starting assumption. As is clear from Figs 4 and 5, chunks of text
385 by the same user were almost perfectly grouped together, suggesting that the unsupervised machine-
386 learning algorithm could reliably detect the unique stylistic signature of most of the users. There were

also clear and stable patterns of differential similarity between users, which is also not consistent with the starting hypothesis.

Study 2

In Study 1, we considered texts from multiple users who worked with the same facilitator. For both the FC centers from which we collected texts, we tested and rejected the hypothesis that the facilitator was the sole detectable stylistic influence on the texts produced by users at each center. In this study, we analyze texts produced over a period of 10 years by FC users who were assisted by a pool of facilitators, each user working with multiple facilitators. From Center 2 (introduced in Study 1), we included texts of users who wrote consistently with at least two facilitators. As in Study 1, our starting hypothesis was that only the facilitators' stylistic characteristics should be distinguishable in the corpus. As, in this view, the users have no stylistic signatures of their own, texts by different users should group only according to the facilitators who assisted their production. Equally, texts by the same user with different facilitators should also group only with the facilitators. As in Study 1, we use unsupervised machine-learning to organize the texts by stylistic similarity. , We consider all the texts that were produced by each user-facilitator pairing and investigate the extent to which texts group according to the facilitator. If the facilitators are the only contributors to the stylistic characteristics of these texts, then we should not see any indications of similarity between texts by the same user.

Materials

For this study, we used texts from Corpus 2 (Fig 2 I) as this corpus satisfied the conditions we wanted to test. As many FC users at Center 2 have typed texts with the assistance of multiple facilitators, it was possible to consider texts of more than 5000 words written by FC users who had written consistently (>5000 words) with at least two different facilitators. Corpus 2 contains 28 pieces

412 written by 10 FC users with 7 different facilitators. As is clear from Fig 2 (I), texts for each user-
413 facilitator pairing were longer than 5000 words, but the sizes were not balanced. The distribution of
414 facilitators was uneven as well. F1 assisted all ten users, F2 six users, F3 four users, and so on.

415

416 **Methods**

417 The key question in this study is: do texts written by users with the assistance of multiple
418 facilitators show that the only detectable stylistic signature is that of the facilitator? This question
419 was addressed through two methods, reported in Study 2A and Study 2B. In study 2A, Corpus 2, was
420 analyzed using the hierarchical clustering mechanism implemented in Stylo for R (48). The analysis
421 was conducted on both the 1000 most frequent words and the 1000 most frequent character-trigrams.
422 Cosine delta distance was adopted as the measure of distance (45,46). The cluster analysis returned a
423 distance table where, for each text, its distance from all the other texts involved in the analysis is
424 computed. Since the analyses by words and trigrams produced very similar results, we have reported
425 the analysis by words only.

426 In study 2B, Corpus 2 was analyzed using the bootstrap consensus network method
427 implemented in Stylo for R (48). The bootstrap consensus network was used to highlight all the
428 relationships existing between texts that could not be visualized in the dendrogram, nor quantified by
429 distance tables. The bootstrap consensus network allows a multiple and progressive evaluation of the
430 corpus using different sets of features (37), in this context vectors of most frequent words ranging
431 from 100 up to 5000. Again, this analysis conducted with character bigrams and trigrams yielded very
432 similar results, and so are not separately reported. Cosine delta distance was used to compute texts
433 similarity, as it is known to provide highly reliable results (45,46)

434

435 **Study 2A: Cluster analysis**

436 When texts by each user-facilitator pairing are considered, texts mainly group according to
437 the facilitator rather than the user (Fig 6). However, the distance table associated with this cluster
438 analysis showed patterns that are not seen in the dendrograms. Since words and trigrams distance
439 tables provide similar results, we concentrated just on the words analysis.

440

441 **Fig 6: Corpus 2 cluster analysis.** Features' selection: 1000 most frequent words (**I**) and 1000 most frequent
442 characters trigrams (**II**). Distance: Cosine Delta. Clustering ratio seems to be facilitator dependent. Texts
443 written with the same facilitator are, in fact, grouped together. For example, texts written with facilitator 1
444 occupy mainly the upper branch of the dendrogram, while texts written with 2 occupy the lower one.
445

446 The ranking of each text was analyzed to look for patterns of similarities between texts. If n
447 is the number of texts written with the same facilitator, and the facilitator is the only stylistic source
448 in these texts, the distance table should place in the first $n-1$ positions only those texts that shared the
449 same facilitator. In the case of the user-facilitator pair U8_F1, for example, as facilitator 1 assisted in
450 10 texts, the first nine positions of similarity (i.e., rows in the distance table) should be occupied by
451 the other texts written with facilitator 1 (that is, U9_F1, U10_F1, U11_F1, U12_F1, U13_F1, U14_F1,
452 U15_F1, U16_F1, and U17_F1). The $n-1$ value for each facilitator (reflecting the number of
453 users they assisted) is graphically displayed in the Fig 7 by a thick red line ($n=10$ for F1, $n=6$ for F2,
454 $n=4$ for F3, $n=2$ for F4, and $n=3$ for F8; F7 worked with only one user).

455

456 If the users made no stylistic contribution, their texts should rank randomly below the n value
457 for each facilitator. This red line represents the landmark we refer to in our observations. Texts of the
458 same user (expressed by each column) that rank above the red line, are colored red. Similarly, texts
459 that rank below the red line are reported in orange if they belong to the user expressed by the column.
460 The analysis of texts that rank below the red line is particularly interesting for those facilitators that
461 are less represented (as F7). In those cases, since a smaller number of texts could rank above the red
462 line, the ranking of texts that come right below is worth noting.

463

As we can see from distance tables (Fig 7), 27 texts breach the red line, which means that the users' stylistic contribution in 27 out of 60 cases breach the facilitator-influence barrier, contrary to what is expected from the null hypothesis. Moreover, in 22 cases, the user's texts classify in the first three rank positions, on 32 in the first 5 rank positions, and on 54 occasions out of 60 in the first 10 rank positions. On 11 occasions, texts of different users and facilitators also breach the red line. In most of these cases, the users are the same as the ones that occur in the first rank positions. Consider for example U8_ F1. In the first two rank positions, we find U16_ F1 and U14_ F1. Then at rank 7 and 9 we find respectively U16_ F3 and U14_ F5. Since U8_ F1 is very similar to U16_ F1 and U14_ F1, its similarity with U16_ F3 and U14_ F5 may be due to inter-user stylistic similarity; texts representing the same user but not the same facilitator (i.e., not the one expressed by the column) that rank above the red line might indicate inter-user similarities, as between U8 and U16, that are not determined by the facilitator's influence.

Fig 7 : Corpus 2 cluster analysis: distance table. 1000 most frequent word. Cosine delta distance . Texts are grouped by the facilitator shared, thus the first 10 columns are occupied by those texts written with facilitator 1. Facilitators are cipher coded, users are alphabetically coded. Each row represents a rank position. Higher the rank, stylistically closer the texts. For example, considering U8_F1 in Fig 7 its closest texts are U16_F1, U14_F1, U15_F1 and U8_F3. For U9_F1, U15_F1, U11_F1, U13_F1 and U16_F1 occupy the first four rank position. The thick red line (named Facilitator's line) represent the line above which we should expect to find just those texts that share the same facilitator expressed at the top of the column, according to the hypothesis that facilitators are the sole source of text production. For F1 it is positioned between position 9 and 10, as F1 assisted 10 different users. Texts coded in red refer to texts of the same user (of the one expressed by each column) that rank above the red line. In orange texts that belong to the same user that rank below the red line. 27 (words) and 28 (trigrams) texts are red colored; therefore they have broken the red line. 22 (words) and 23 (trigrams) texts are ranked in the first three rank position, indicating clear user-driven similarity. 8 users out of 10 has at least one text that classify in the top three rank position.

Another aspect that is worth noting is that texts of the same user (i.e., the one expressed by the column) rank above all the other texts written with the same facilitator (56/60, see Fig 8). Consider U8_ F1 as an example. U8_ F3 is the first text written with F3 in the ranking; also, U8_ F2 is the first text written with F2 that appears in the distance table relative to U8_ F1. This happens systematically for all texts' relationships and shows that it is the user's contribution, rather than the facilitator's one, that determines the similarity. If no stylistic contribution is made by the user, these consistent and

498 systematic patterns of rankings should not occur; texts by the same user written with different
499 facilitators should rank randomly.

500

501 **Fig 8 : Corpus 2 cluster analysis: texts' rank positons according to the facilitator they share, in words**
502 **analysis.** For each user-facilitator pair, the first three rank positions of texts grouped by a shared facilitator are
503 displayed. Let us consider U8_1; since U8 wrote with FAC2 and FAC3, the ranking order of texts written with
504 FAC2 and FAC3 relative to U8_1 is reported. If no user contribution is expected, we should not find consistent
505 ranking patterns. Texts coded in yellow refer to texts that belong to the same user. 60 texts out of 60 rank at
506 least in second position. 56/60 texts classify in the first rank position.
507

508 Texts of both different users and facilitators that appear below the red line, do not show a clear
509 and unique pattern of interpretation. The unbalanced nature of the corpus does not allow for direct
510 and exhaustive considerations of the different relationships that are consolidated in the corpus. For
511 that, we would need a 10x10 corpus (10 users all assisted by 10 facilitators). However, we can observe
512 some general patterns in terms of distance: inter-facilitator similarities (F1 appears similar to F3 and
513 distant from F2), inter-user similarities (U8 is similar to U16, U9 to U11, U10 to U12, U11 to U9,
514 U10 and U12; U12 to U14 and U10; U13 to U15 and U16; U14 to U12 and U13; U15 to U13, U9
515 and U16; U16 to U8, U15, and U13), and user to facilitator similarities (U8_F3 and U16_F3 to F8,
516 U9_F4 to F2).

517

518 **Study 2B: Bootstrap consensus network analysis**

519 The analysis with the bootstrap consensus network computes and graphically displays all the
520 linkages existing between each text (Fig 9). The consensus network is composed of nodes (that
521 represent each text candidate in the corpus) and undirected links. Two nodes are connected when they
522 show stylistic similarities. The weight of this similarity is proportional to the thickness of the link in
523 the graph. Stylistically similar texts have thicker linkages in the graph. Together with the graphical
524 report of these relationships (Fig 9) the R package returns a hedge table where, for each node,
525 undirected links and their weight are reported (see Fig 10). As before, this table was investigated to
526 address the hypothesis that facilitators are the sole contributors to the production of texts. The color

coding is the same as the one adopted for the cluster analysis distance tables. A blue code is added to highlight texts that share neither the facilitator nor the user with the node.

529

Fig 9: Bootstrap consensus network: graphical display. Nodes represents texts, linkage represents stylistic similarities between texts. The thickness of the linkage is directly proportional to the strength of the similarity. The more the linkage is thick the more the texts that it connects are similar. In the figure above the focus is on U10_F1 and its link with U10_F2, U10_F4, U10_F8, U11_F1, U11_F1 and U17_F1.

Fig 10: Bootstrap consensus networks: undirected links and weight table. Range: 100 to 5000 most frequent words. The table represent for each text the links established with the other texts in the corpus and the strength of their relationship, also named weight. Texts are grouped by the facilitator shared; the red line indicate the limit above which we should find just texts written by the facilitator expressed by the column. Red code is used for those texts of the same user expressed by the columns that rank above the red line. As seen in Fig 7, the red line is given by the number of texts written with the same facilitator as the one expressed by the column. So, in the case of column U10_F1, U10_F8, U10_F2 and U10_F4 rank above the red line, respectively at 1st 2nd and 4th position. As for U10_F1 the red line is defined at position 10 all these texts are red coded. These ranks provide a meaningful hint of how texts written by U10 are inherently similar independently of the facilitator involved in the communication. Texts of the same user expressed by the column that rank below the red line are reported in orange. The orange coding is particularly meaningful for those facilitators (as F4, F5, F7 and F8) where the red line is particularly high placed (above the third rank position). 23 texts (out of 60) rank above the red line. 25 texts (out of 60) rank in the first three rank positions. 38 texts (out of 60) rank in the first five rank positions.

Twenty-five texts rank above the red line, 23 texts classify in the first three positions and 38 in the first 5 positions. Thus, texts of the same user consistently occupy higher ranking positions than would be expected if users did not make a stylistic contribution, and very often they are in the closest neighborhood of similarity. It should be also noted that of the 190 links recognized by the analysis, 100 out of a possible 140 are between texts that share the same facilitator. The count of 140 refers to the total number of possible combinations of links that can be established between texts written with the same facilitator. For example, since ten users wrote with F1, each text written with F1 can be linked, in theory, to nine other texts written with F1 (thus, 90 links can be established for F1), 30 for F2 (6 users with 5 links each), 12 for F3 (4 users with 3 links each), 2 for F4 and F5 (2 users with 1 link each), and 6 for F8 (3 users with 2 links each). Thus, 42 out of a possible 60 links are between texts that share the same user, and 48 out of a possible 554 links are between texts that share neither the facilitator nor the user. However, if the weight of each link is considered (the higher the weight, the closer the texts), then 96% of the weights of the links are saturated by user-to-user and facilitator-

564 to-facilitator links (27% and 69%, respectively). Moreover, if we consider the average weight for
565 each class (user-to-user, facilitator-to-facilitator, and user-to-facilitator) we see that relationships
566 between texts of the same user, and between texts that share the same facilitator, have a similarly high
567 weight average, while texts that do not share either the facilitator or the user have a lower weight
568 average (see Table 1). Finally, it should be noted how even in the consensus network analysis inter-
569 user similarities can be detected. Relationships are mostly created between the same array of users,
570 independently of the facilitator involved in the communication process. U8 is linked across different
571 facilitators to U16, and U10; U9 to U11 and U10; U10 to U12; U11 to U9, U12, and U10; U12 to
572 U11, U14, and U10; U13 to U15, and U16; U14 to U13, and U12; U15 to U16, U9, and U13; U16 to
573 U13, U8, and U15; U17 to U12, and U10 . These links are consistent with the inter-user similarities
574 found in the analysis of the distance tables (Fig 9).

	N° of links	Total weight	Weight %	Average
Same user	42	4571	27%	109
Same facilitator	100	11554	69%	115
Different U-F	48	674	4%	14

575
576 **Table 1: Bootstrap consensus network: links and weight analysis.** Statistic regarding links between texts
577 of the same user, between texts written with the same facilitator and links between texts that shared nor the
578 user nor the facilitator are reported. The number of links column counts for each group the number of existing
579 relationships within the corpus. The total weight column indicates for each group the sum of the strength of
580 each existing link. The weight percentage column reports for each group how much the weight strength impact
581 on the analysis. The average column report for each group the average weight that characterizes links. While
582 links between texts of the same user are fewer than all the other possible link, their weight account for the 27%
583 of the total. The average weight existing between texts of the same user is quite similar to the one that exists
584 between texts written with the same facilitator. Interestingly, this table shows that the bootstrap consensus
585 network is able to detect similarities between texts that share the user or the facilitator.
586

587 Summary

588 This study was designed to test the assumption that FC users do not contribute stylistic
589 characteristics to the texts they produce with the assistance of multiple facilitators. If this was the
590 case, cluster analysis and bootstrap consensus network results would not show any grouping between
591 texts of the same user, nor any pattern of similarity between texts of the same user. Cluster analysis

592 results were not consistent with this assumption. The cluster analysis conducted on texts divided by
593 user-facilitator pairs (Figs 6 I and II, 7 and 8) shows how relationships are detected mainly between
594 texts that share either the user or the facilitator. This claim is also supported by the bootstrap
595 consensus network analysis (Figs 9, 10 and 11) that shows that two major stylistic forces can be
596 ascertained: that of the facilitator and that of the user. If facilitators were the only authors of texts, no
597 significant similarities between texts of the same user across different facilitators should have been
598 observed. Clearly, these results are not consistent with the starting assumption. Besides, there were
599 also patterns of inter-user similarity, consistent with what was shown in Study 1. The existence of
600 these similarities also refutes the starting hypothesis.

601

602 **General discussion**

603

604 The reported studies challenge the maximally skeptical starting position, namely that the
605 facilitator is the sole agent to whom text written by FC users can be attributed. The results clearly
606 show that texts written via FC generally present two sources of authorship: the user and the facilitator.
607 Based on this result, FC is better described as a co-creation process in which two distinct and active
608 participants collaborate in the production of linguistic content. It is worth noting that this
609 acknowledgement of dual stylistic sources cannot fully account for the nuances of the text production
610 dynamic of FC. The nature of the corpora and these methods do not allow us to discern the details of
611 what originates with the user and the facilitator. The scope of these analysis is at the stylistic level
612 with no presumption nor power to distinguish facilitators' traits from users' features on a sentence-
613 by-sentence basis. Also, these analyses do not allow any comment on how the facilitator exerts
614 influence on the user, be it via an ideomotor effect or some form of accommodative communication.
615 These questions require other methods and task-oriented analyses. What the present results clearly

616 show is that the user is not linguistically passive, and the facilitator molds rather than suggests and
617 constructs the typed text.

618

619 Acknowledging two stylistic forces in the production of FC text does not alleviate doubts
620 about the nature of the contents expressed in the texts. Co-authorship does not offer certainty that a
621 message written by integrating two linguistic sources fully mirrors the FC user's own intention. The
622 existence of user-dependent similarities at the lexical level suggests, however, that users are actively
623 involved in the selection of lexical forms, the linguistic components specifically deputed to convey
624 meaning. This demonstrates the FC users' ability to transform semantic concepts into linguistic code,
625 coherently within given syntactical and pragmatic contexts. This suggests that FC users possess a
626 level of literacy skills, which any AAC intervention should seek to nurture and develop to improve
627 users' quality of life.

628 It could be argued that an AAC technique that cultivates co-authorship may not foster the users'
629 autonomy and independence. This issue of autonomy, alongside that of authorship, has often been
630 central to the debate on the utility of FC. These two issues should be considered and addressed
631 separately as they may reflect two different goals. This research addressed the issue of authorship and
632 the possibilities of increasing the AAC users' communication options. The results clearly show that
633 a technique like FC extends users' ability to express themselves linguistically. A co-authorship
634 framework does not guarantee independence, which may reach different levels in the case of different
635 users. These differences may originate in the users' inherent characteristics or in the stage of
636 development in FC training. Over time, significant autonomy of expression may be achievable for
637 some, but not for others. In both cases, however, using an AAC technique fostering co-authorship
638 may provide developmental and quality of life advantages through increased communication options
639 that might not otherwise become available.

640

641 Finally, it is important to consider the extent to which stylistic characteristics may be
642 consciously or unconsciously modified or adapted in a collaborative setting such as FC. Stylometry
643 and authorship attribution models are built on the general assumption that each person possesses a
644 unique and unconscious stylistic fingerprint that can be detected and quantified through statistical
645 procedures. This notion, first introduced by Lutoslawsky (1898) is widely held in the field of
646 stylometry (40,49) as it has been proven valid in multiple authorship attributions. However, the
647 possibility that authors can directly manipulate their own style for privacy or falsification has been
648 addressed in recent times. For example, Brennan et al. (50) showed how non-expert users can
649 obfuscate their own stylistic fingerprint or imitate the one of a given model. To what extent the results
650 provided in this paper can be interpreted as the effect of facilitators' style imitation requires comment.

651

652 It could be argued that user-dependent stylistic similarities detected in Study 1 and 2, are nonetheless
653 the results of facilitators modifying their style to render it more attributable to the FC user. All studies
654 conducted so far on adversarial stylometry have dealt with conscious and deliberate style modification
655 (50). Suggesting that facilitators deliberately modify their own style to suit the user they are working
656 with would imply that the facilitators' influence on the generated text is conscious. The sceptical
657 position on this has been that the facilitators' influence is an unconscious ideomotor effect (11,14).
658 This contradiction must be addressed if an imitation hypothesis is adopted. Moreover, no studies have
659 so far demonstrated the possibility of imitating more than one style simultaneously. This hypothesis,
660 while logically possible, requires demonstration. Besides, even if we assume that facilitators
661 consciously manipulate their style such that statistical models end up attributing texts to users instead,
662 and also that facilitators can maintain up to ten different stylistic systems and use them in the correct
663 contexts, we must contend with the issue of stylistic models. Style imitation research has always dealt
664 with participants that deliberately conform their style to that of a model (50–52). However, in the
665 case of FC, facilitators have no external models to which they can refer, so it is unclear on which
666 basis they would organize their imitation. The users would have to have their own styles for the

667 facilitator to imitate and mix with their own. It is unclear how these styles would become known to
668 the facilitator if the users can only express themselves through collaboration with the facilitator in the
669 first place.

670

671 It could still be argued that a model is created by the first or most consistent user-facilitator
672 pairing. The first facilitator of each user may develop a style that obfuscates their own and has some
673 unique and individual characteristics that individuate the user, as the results of Study 1 may suggest.
674 Other facilitators who work with the user later might imitate the style developed by the first facilitator
675 for that specific user. If this is how FC develops, we would expect that the imitation would reflect all
676 the stylistic characteristics of the produced text, including those that are due to the facilitator. The
677 results of Study 2 show that independent stylistic signatures are detectable for the facilitators and
678 user. It is unclear how a later facilitator can purposely select user-dependent characteristics in their
679 imitation, but leave out those of the original facilitator, especially at the level of word and character-
680 trigram frequency. This would require discriminating patterns that are facilitator-dependent from
681 those that are user-dependent, and only mixing the user-dependent ones with their own style. This
682 would need to be done separately for every user with whom the facilitator works. It is highly unlikely
683 that such stylistic imitation is feasible. A more likely, and certainly more parsimonious, explanation
684 of the results obtained here is that both the facilitator and user contribute to the style of jointly
685 produced text.

686

687 One possible dynamic underlying the observed co-authorship is that facilitators create
688 syntactical structures within which users can fill in their own content. Whether this form of
689 scaffolding occurs would need to be investigated using qualitative analysis. Syntactical scaffolding
690 by the facilitator may also involve adjusting morphological endings, suggesting linkers or auxiliary
691 verbs, or providing syntagmatic prompts to help begin communication (e.g, “I think that ...”, or “I
692 feel that ...”). These prompting actions could be unique to each facilitator, which could lead to

693 algorithms recognizing text with these expressions as authored by facilitators. In this respect, the
694 facilitators' work would be comparable to that of editors. As described in the case of Hildegard of
695 Bingen(53), the editorial effort of adjusting sentences online (Hildegard could not write so she
696 dictated her thoughts) can lead to algorithmic detection of the stylistic fingerprint of the editor, very
697 much like the present results obtained for FC facilitators.

698

699 Even if the presented evidence of FC users' stylistic contribution is accepted, consideration
700 shifts to the utility of an AAC technique that promises at best the potential for the user to co-author
701 texts with trained facilitators. Clearly, a technique that, in due course, leads demonstrably to
702 independent text production ought to be preferred over one that involves dependence on the assistance
703 of a trained facilitator who also co-authors the user's texts. The issue of assisted communication only
704 arises, however, in the context of significant sensorimotor and cognitive disabilities. Depending on
705 the level of these disabilities, developing towards autonomous linguistic expression may not be a
706 feasible goal. What must be judged in such cases is the potential utility of providing the individual
707 with an effective means of text co-production that may not ever result in autonomy. The present
708 results clearly demonstrate that the latter option does result in the individual producing a personal
709 linguistic signature, even though this happens only with the availability of co-productive assistance.
710 Given the limited prospects of these individuals conducting any aspects of their lives autonomously,
711 and their expected dependence on others' care for the rest of their lives, we submit that co-creating
712 text using a technique such as FC is very likely to be a developmentally and psychologically valuable
713 exercise so long as the co-creative nature of the output is acknowledged.

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828 [letteraria/la-letteratura-vista-da-lontano-franco-moretti-9788806172893/](https://www.einaudi.it/catalogo-libri/critica-letteraria-e-linguistica/filologia-e-critica-letteraria/la-letteratura-vista-da-lontano-franco-moretti-9788806172893/)

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Corpus 1	Words	Types
U1	20449	3865
U2	11631	2772
U3	13568	3162
U4	12379	3257
U5	15564	3479
U6	3370	1203
U7	7040	2142

I

Corpus 1_A	Words	Corpus 1_B	Words	Corpus 1_C	Words
U1_1-2	10268	U1_1-3	10293	U1_1-4	10196
U1_3-4	10210	U1_2-4	10185	U1_2-3	10282
U2_1-2	5934	U2_1-3	5955	U2_1-4	5674
U2_3-4	5724	U2_2-4	5703	U2_2-3	5984
U3_1-2	7052	U3_1-3	7173	U3_1-4	6472
U3_3-4	6542	U3_2-4	6457	U3_2-3	7122
U4_1-2	6476	U4_1-3	6469	U4_1-4	5974
U4_3-4	5932	U4_2-4	5939	U4_2-3	6434
U5_1-2	8363	U5_1-3	8270	U5_1-4	7247
U5_3-4	7231	U5_2-4	7325	U5_2-3	8347

II

Corpus 2	Words	Types
U8_F1	17710	2727
U8_F2	5007	1430
U8_F3	18091	2834
U9_F1	28857	3494
U9_F2	6438	1721
U9_F4	6065	1454
U10_F1	16192	3035
U10_F2	47476	6113
U10_F4	6961	1940
U10_F8	25718	3913
U11_F1	21829	3300
U11_F2	11586	2560
U12_F1	22927	3892
U12_F2	15337	3516
U12_F5	5100	1229
U12_F7	27634	4962
U12_F8	6395	1700
U13_F1	12954	2177
U13_F3	7750	1663
U14_F1	64202	5738
U14_F5	5464	1321
U15_F1	38549	3531
U15_F3	5021	1172
U16_F1	14575	2061
U16_F2	8816	1994
U16_F3	24654	3273
U17_F1	5705	1492
U17_F8	4954	1470

I

Corpus 2	Words
U8_F1	17710
U9_F1	28857
U10_F1	16192
U11_F1	21829
U12_F1	22927
U13_F1	12954
U14_F1	64202
U15_F1	38549
U16_F1	14575
U17_F1	5705

II

Corpus 2_1_A	Words	Corpus 2_1_B	Words	Corpus 2_1_C	Words
U8_1-2	9073	U8_1-3	9090	U8_1-4	8678
U8_3-4	8642	U8_2-4	8625	U8_2-3	9037
U9_1-2	14372	U9_1-3	14538	U9_1-4	14285
U9_3-4	14491	U9_2-4	14325	U9_2-3	14578
U10_1-2	8481	U10_1-3	8332	U10_1-4	7988
U10_3-4	7716	U10_2-4	7865	U10_2-3	8209
U11_1-2	11195	U11_1-3	11151	U11_1-4	10604
U11_3-4	10639	U11_2-4	10683	U11_2-3	11230
U12_1-2	11743	U12_1-3	11625	U12_1-4	11283
U12_3-4	11189	U12_2-4	11307	U12_2-3	11650
U13_1-2	5423	U13_1-3	6147	U13_1-4	5626
U13_3-4	7537	U13_2-4	6813	U13_2-3	7334
U14_1-2	31566	U14_1-3	32812	U14_1-4	33806
U14_3-4	32642	U14_2-4	31396	U14_2-3	30402
U15_1-2	17690	U15_1-3	17853	U15_1-4	17799
U15_3-4	20866	U15_2-4	20727	U15_2-3	20757
U16_1-2	7572	U16_1-3	7607	U16_1-4	6889
U16_3-4	7008	U16_2-4	6973	U16_2-3	7690

III

Participant	Gender	Age	Diagnosis	Experience with FC	Level of facilitation (to date)
U1	Female	25	ASD	21	Shoulder
U2	Male	20	Expressive language disorder	13	Elbow
U3	Male	26	ASD	17	Shoulder
U4	Male	22	Cerebellar ataxia	11	Hand
U5	Female	20	Intellectual disability	8	Wrist
U6	Female	42	ASD	26	Wrist
U7	Male	44	Autism	20	Elbow
U8	Female	47	Down Syndrome	18	Elbow
U9	Female	44	Chromosomal alteration	18	Hand
U10	Female	34	Tuberous sclerosis	18	Hand
U11	Female	47 (died in 2018)	Cerebral Palsy	16	Hand
U12	Male	56	Severe mental retardation	18	Hand
U13	Male	36	Encephalopathy	14	Forearm
U14	Male	52	Severe mental retardation	10	Hand
U15	Female	24	Severe mental retardation	10	Hand
U16	Female	28	Cerebral Palsy	14	Hand
U17	Female	39	Cerebral Palsy	15	Hand

Most frequent words **Most frequent characters' trigrams** **Corpus 1_A** **Corpus 1_B** **Corpus 1_C**

Corpus 2_1_A

Corpus 2_1_B

Corpus 2_1_C

Fig 6

[Click here to access/download;Figure;FIG 6.tif](#)

1000 MFW Culled @ 0%
Distance: wurzburg

I Most frequent words

1000 MFC 3-grams Culled @ 0%
Distance: wurzburg

II Most frequent characters

Rank	U8_F1	U9_F1	U10_F1	U11_F1	U12_F1	U13_F1	U14_F1	U15_F1	U16_F1	U17_F1	Rank	U8_F2	U9_F2	U10_F2	U11_F2	U12_F2	U16_F2
1	U16_F1	U15_F1	U10_F1	U9_F1	U11_F1	U14_F1	U13_F1	U16_F1	U15_F1	U12_F1	1	U16_F2	U11_F2	U12_F2	U10_F2	U10_F2	U10_F2
2	U14_F1	U11_F1	U10_F1	U12_F1	U12_F1	U15_F1	U15_F1	U9_F1	U8_F1	U11_F1	2	U10_F2	U10_F2	U11_F2	U9_F2	U12_F2	U8_F2
3	U15_F1	U13_F1	U10_F1	U10_F1	U14_F1	U16_F1	U12_F1	U10_F1	U13_F1	U14_F1	3	U11_F2	U12_F2	U16_F2	U12_F2	U11_F2	U11_F2
4	U10_F1	U16_F1	U11_F1	U14_F1	U12_F1	U9_F1	U8_F1	U13_F1	U9_F1	U16_F1	4	U12_F2	U10_F2	U10_F2	U16_F2	U16_F2	U12_F2
5	U13_F1	U15_F1	U8_F1	U17_F1	U12_F1	U8_F1	U9_F1	U14_F1	U14_F1	U15_F1	5	U10_F2	U10_F2	U10_F2	U8_F2	U9_F2	U9_F2
6	U10_F1	U14_F1	U12_F1	U12_F1	U17_F1	U12_F1	U16_F1	U8_F1	U10_F1	U10_F1	Technician's line						
7	U16_F1	U10_F1	U17_F1	U13_F1	U10_F1	U15_F1	U11_F1	U17_F1	U15_F1	U12_F1	6	U9_F2	U16_F2	U8_F2	U9_F2	U10_F2	U9_F2
8	U9_F1	U10_F1	U14_F1	U15_F1	U12_F1	U11_F1	U17_F1	U11_F1	U17_F1	U9_F1	7	U16_F2	U8_F2	U10_F2	U11_F2	U12_F2	U13_F2
9	U14_F1	U8_F1	U12_F2	U16_F1	U13_F1	U12_F1	U15_F1	U10_F1	U13_F1	U8_F1	8	U9_F2	U17_F2	U12_F2	U10_F2	U8_F2	U16_F2
Technician's line											9	U17_F2	U10_F2	U9_F2	U10_F2	U9_F2	U16_F2
10	U17_F1	U17_F1	U12_F1	U9_F1	U10_F1	U14_F1	U14_F1	U13_F1	U11_F1	U13_F1	10	U10_F2	U12_F2	U9_F2	U8_F2	U12_F2	U15_F2
11	U17_F1	U14_F1	U16_F1	U12_F1	U14_F1	U17_F1	U10_F1	U16_F1	U16_F1	U17_F1	11	U10_F2	U11_F1	U8_F1	U12_F1	U10_F1	U15_F1
12	U15_F1	U12_F1	U12_F1	U14_F1	U9_F1	U12_F1	U12_F1	U16_F1	U17_F1	U15_F1	12	U16_F1	U12_F1	U17_F1	U9_F1	U14_F1	U9_F1
13	U10_F1	U11_F1	U15_F1	U12_F1	U13_F1	U16_F1	U12_F1	U8_F1	U10_F1	U12_F1	13	U13_F1	U10_F1	U13_F1	U12_F1	U10_F1	U17_F1
14	U10_F1	U12_F1	U8_F1	U9_F1	U11_F1	U12_F1	U12_F1	U14_F1	U14_F1	U14_F1	14	U10_F1	U12_F1	U11_F1	U12_F1	U8_F1	U17_F1
15	U11_F1	U16_F1	U9_F1	U8_F1	U9_F1	U10_F1	U12_F1	U17_F1	U8_F1	U8_F1	15	U12_F1	U8_F1	U16_F1	U12_F1	U12_F1	U12_F1
16	U13_F1	U10_F1	U14_F1	U10_F1	U8_F1	U17_F1	U13_F1	U9_F1	U8_F1	U12_F1	16	U15_F1	U15_F1	U12_F1	U17_F1	U11_F1	U11_F1
17	U10_F1	U13_F1	U8_F1	U15_F1	U10_F1	U16_F1	U9_F1	U12_F1	U12_F1	U16_F1	17	U10_F1	U17_F1	U12_F1	U15_F1	U14_F1	U10_F1
18	U12_F1	U17_F1	U12_F1	U10_F1	U9_F1	U9_F1	U16_F1	U9_F1	U10_F1	U9_F1	18	U15_F1	U13_F1	U14_F1	U13_F1	U17_F1	U12_F1
19	U12_F1	U12_F1	U13_F1	U12_F1	U15_F1	U8_F1	U8_F1	U12_F1	U9_F1	U16_F1	19	U17_F1	U14_F1	U12_F1	U10_F1	U13_F1	U13_F1
20	U12_F1	U8_F1	U17_F1	U16_F1	U15_F1	U12_F1	U9_F1	U12_F1	U12_F1	U8_F1	20	U11_F1	U13_F1	U17_F1	U16_F1	U16_F1	U10_F1
21	U12_F1	U16_F1	U9_F1	U10_F1	U8_F1	U9_F1	U16_F1	U11_F1	U12_F1	U10_F1	21	U12_F1	U12_F1	U8_F1	U14_F1	U13_F1	U14_F1
22	U16_F1	U10_F1	U15_F1	U12_F1	U8_F1	U12_F1	U8_F1	U10_F1	U9_F1	U9_F1	22	U14_F1	U15_F1	U13_F1	U17_F1	U17_F1	U8_F1
23	U9_F1	U12_F1	U11_F1	U8_F1	U17_F1	U8_F1	U17_F1	U8_F1	U11_F1	U10_F1	23	U12_F1	U10_F1	U14_F1	U13_F1	U15_F1	U10_F1
24	U9_F1	U12_F1	U9_F1	U8_F1	U10_F1	U11_F1	U10_F1	U10_F1	U10_F1	U13_F1	24	U13_F1	U14_F1	U15_F1	U15_F1	U9_F1	U8_F1
25	U10_F1	U10_F1	U13_F1	U17_F1	U16_F1	U10_F1	U10_F1	U10_F1	U10_F1	U12_F1	25	U9_F1	U16_F1	U16_F1	U16_F1	U8_F1	U14_F1
26	U11_F1	U10_F1	U16_F1	U16_F1	U16_F1	U10_F1	U11_F1	U12_F1	U12_F1	U10_F1	26	U12_F1	U8_F1	U15_F1	U8_F1	U15_F1	U12_F1
27	U12_F1	U8_F1	U16_F1	U13_F1	U16_F1	U10_F1	U10_F1	U12_F1	U12_F1	U11_F1	27	U14_F1	U16_F1	U9_F1	U14_F1	U16_F1	U12_F1

Rank	U8_F3	U13_F3	U15_F3	U16_F3	Rank	U9_F4	U10_F4	Rank	U12_F5	U14_F5	Rank	U12_F7	Rank	U10_F8	U12_F8	U17_F8	
1	U16_F3	U16_F3	U15_F3	U13_F3	1	U10_F4	U10_F4	1	U12_F5	U12_F5	1	U12_F7	1	U17_F8	U10_F8	U10_F8	
2	U10_F3	U10_F3	U9_F3	U8_F3	Technician's line				2	U12_F5	U12_F5	2	U12_F7	2	U10_F8	U17_F8	
3	U10_F8	U15_F3	U13_F3	U10_F3	2	U11_F4	U12_F4	2	U14_F5	U14_F5	3	U12_F7	3	U10_F3	U12_F3	U8_F3	
Technician's line					3	U10_F4	U10_F4	3	U12_F5	U8_F1	4	U10_F2	4	U12_F8	U12_F5	U16_F3	
4	U13_F3	U8_F3	U16_F1	U15_F3	4	U9_F1	U10_F1	4	U12_F7	U13_F1	5	U12_F5	5	U10_F4	U8_F3	U9_F2	
5	U17_F8	U16_F1	U16_F3	U8_F1	5	U16_F2	U9_F4	5	U17_F1	U9_F1	6	U9_F4	6	U8_F3	U12_F7	U8_F1	
6	U10_F2	U16_F2	U13_F1	U16_F2	6	U12_F7	U12_F2	6	U10_F4	U13_F3	7	U10_F8	7	U12_F7	U14_F5	U17_F1	
7	U12_F8	U14_F5	U14_F1	U8_F2	7	U10_F2	U11_F2	7	U12_F2	U12_F1	8	U8_F3	8	U11_F2	U12_F2	U16_F1	
8	U12_F7	U15_F1	U8_F1	U17_F8	8	U8_F2	U12_F5	8	U14_F1	U12_F2	9	U11_F2	9	U12_F2	U9_F4	U10_F4	
9	U11_F2	U12_F5	U17_F1	U12_F8	9	U12_F2	U12_F1	9	U11_F1	U12_F2	10	U14_F5	10	U9_F2	U11_F2	U8_F2	
10	U12_F2	U8_F1	U16_F2	U13_F1	10	U11_F1	U17_F8	10	U10_F1	U12_F8	11	U12_F8	11	U8_F1	U17_F1	U10_F2	
11	U10_F2	U10_F2	U17_F8	U15_F1	11	U12_F5	U14_F5	11	U9_F4	U10_F4	12	U10_F1	12	U11_F1	U9_F2	U15_F3	
12	U14_F5	U12_F1	U8_F3	U17_F1	12	U12_F8	U12_F8	12	U11_F2	U11_F1	13	U9_F2	13	U8_F2	U10_F4	U9_F4	
13	U15_F3	U8_F2	U9_F4	U10_F8	13	U14_F5	U9_F2	13	U13_F3	U9_F4	14	U17_F8	14	U12_F5	U9_F1	U12_F7	
14	U17_F1	U17_F8	U14_F5	U14_F5	14	U17_F8	U8_F2	14	U13_F1	U17_F1	15	U17_F1	15	U16_F3	U14_F1	U16_F2	
15	U12_F5	U12_F8	U12_F8	U12_F7	15	U15_F3	U8_F3	15	U9_F2	U16_F1	16	U8_F2	16	U9_F4	U16_F3	U13_F3	
16	U9_F2	U14_F1	U11_F1	U10_F2	16	U17_F1	U16_F2	16	U8_F3	U8_F3	17	U16_F2	17	U13_F3	U15_F3	U11_F2	
17	U10_F1	U10_F8	U11_F2	U10_F4	17	U12_F1	U11_F1	17	U10_F8	U15_F3	18	U11_F1	18	U17_F1	U13_F1	U12_F5	
18	U12_F1	U11_F2	U9_F2	U11_F2	18	U10_F8	U8_F1	18	U17_F8	U10_F1	19	U14_F1	19	U12_F1	U13_F3	U10_F1	
19	U10_F4	U9_F1	U8_F2	U12_F5	19	U10_F1	U16_F3	19	U9_F1	U16_F3	20	U16_F3	20	U16_F2	U10_F1	U13_F1	
20	U16_F1	U10_F4	U10_F1	U14_F1	20	U14_F1	U17_F1	20	U10_F2	U15_F1	21	U13_F3	21	U14_F5	U16_F2	U15_F1	
21	U16_F2	U9_F2	U12_F1	U9_F4	21	U15_F1	U13_F3	21	U8_F2	U9_F2	22	U8_F1	22	U16_F1	U11_F1	U9_F1	
22	U14_F1	U12_F7	U12_F5	U12_F2	22	U16_F3	U15_F3	22	U16_F3	U10_F8	23	U15_F3	23	U15_F3	U8_F1	U12_F2	
23	U11_F1	U17_F1	U12_F7	U10_F1	23	U8_F3	U9_F1	23	U15_F3	U17_F8	24	U13_F1	24	U15_F1	U15_F1	U14_F5	
24	U9_F4	U12_F2	U10_F4	U9_F2	24	U13_F1	U14_F1	24	U8_F1	U11_F2	25	U9_F3	25	U13_F1	U10_F2	U12_F1	
25	U13_F1	U10_F1	U10_F8	U11_F1	25	U13_F3	U16_F1	25	U15_F1	U8_F2	26	U15_F1	26	U14_F1	U16_F1	U11_F1	
26	U15_F1	U11_F1	U12_F2	U12_F1	26	U16_F1	U13_F1	26	U16_F2	U16_F2	27	U16_F1	27	U9_F1	U8_F2	U14_F1	
27	U9_F1	U9_F4	U10_F2	U9_F1	27	U8_F1	U15_F1	27	U16_F1	U10_F2							

Words	With FAC1			With Fac2			With FAC3			With FAC4		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
U8_F1				U8_F2	U16_F2	U9_F2	U8_F3	U16_F3	U15_F3			
U8_F2	U8_F1	U16_F1	U15_F1				U8_F3	U16_F3	U13_F3			
U8_F3	U8_F1	U17_F1	U10_F1	U8_F2	U11_F2	E12_F2						
U9_F1				U9_F2	U11_F2	U16_F2				U9_F4	U10_F4	
U9_F2	U9_F1	U11_F1	U17_F1							U9_F4	U10_F4	
U9_F4	U9_F1	U11_F1	U17_F1	U9_F2	U11_F2	U16_F2						
U10_F1				U10_F2	E12_F2	U8_F2				U10_F4	U9_F4	
U10_F2	U10_F1	U11_F1	E12_F1							U10_F4	U9_F4	
U10_F4	U10_F1	E12_F1	U11_F1	U10_F2	E12_F2	U11_F2						
U10_F8	U10_F1	U8_F1	U11_F1	U10_F2	U11_F2	E12_F2				U10_F4	U9_F4	
U11_F1				U11_F2	E12_F2	U9_F2						
U11_F2	U11_F1	U9_F1	E12_F1									
E12_F1				E12_F2	U11_F2	U9_F2						
E12_F2	E12_F1	U10_F1	U11_F1									
E12_F5	E12_F1	U14_F1	U11_F1	E12_F2	U9_F2	U10_F2						
E12_F7	E12_F1	U10_F1	U17_F1	E12_F2	U10_F2	U11_F2						
E12_F8	E12_F1	U17_F1	U9_F1	E12_F2	U11_F2	U9_F2						
U13_F1							U13_F3	U15_F3	U16_F3			
U13_F3	U13_F1	U16_F1	U15_F1									
U14_F1												
U14_F5	U14_F1	U8_F1	U13_F1									
U15_F1							U15_F3	U13_F3	U16_F3			
U15_F8	U15_F1	U9_F1	U16_F1									
U16_F1				U16_F2	U8_F2	U9_F2	U16_F3	U15_F3	U13_F3			
U16_F2	U16_F1	U15_F1	U9_F1				U13_F3	U16_F3	U15_F3			
U16_F3	U16_F1	U8_F1	U13_F1	U16_F2	U8_F2	U10_F2						
U17_F1												
U17_F8	U8_F1	U17_F1	U16_F1									

Words	With FAC5			With FAC7			With FAC8		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
U8_F1									
U8_F2									
U8_F3									
U9_F1									
U9_F2									
U9_F4									
U10_F1							U10_F8	E12_F8	U17_F8
U10_F2							U10_F8	U17_F8	E12_F8
U10_F4							U10_F8	U17_F8	E12_F8
U10_F8									
U11_F1									
U11_F2									
E12_F1	E12_F5	U14_F5		E12_F7			E12_F8	U10_F8	U17_F8
E12_F2	E12_F5	U14_F5		E12_F7			U10_F8	E12_F8	U17_F8
E12_F5				E12_F7			E12_F8	U10_F8	U17_F8
E12_F7	E12_F5	U14_F5					U10_F8	E12_F8	U17_F8
E12_F8	E12_F5	U14_F5		E12_F7					
U13_F1									
U13_F3									
U14_F1	U14_F5	E12_F5							
U14_F5									
U15_F1									
U15_F3									
U16_F1									
U16_F2									
U16_F3									
U17_F1									
U17_F8							U17_F8	E12_F8	U10_F8

Fig 9

Fig 10

Rank	U8_F1	U9_F1	U10_F1	U11_F1	U12_F1	U13_F1	U14_F1	U15_F1	U16_F1	U17_F1
1	U16_F1 224	U15_F1 249	U10_F1 247	U12_F1 258	U11_F1 258	U14_F1 256	U13_F1 256	U16_F1 291	U15_F1 291	U12_F1 112
2	U8_F1 170	U11_F1 217	U10_F1 93	U9_F1 217	U14_F1 159	U15_F1 172	U12_F1 159	U9_F1 249	U8_F1 224	U11_F1 108
3	U15_F1 63	U9_F1 105	U11_F1 74	U17_F1 108	U12_F1 159	U16_F1 75	U15_F1 112	U13_F1 172	U13_F1 75	U15_F1 51
4	U14_F1 25	U13_F1 61	U10_F1 75	U10_F1 74	U17_F1 112	U13_F1 79	U14_F1 95	U15_F1 168	U16_F1 71	U10_F1 17
5	U14_F1 9	U15_F1 38	U17_F1 17	U14_F1 18	U13_F1 95	U9_F1 61	U8_F1 25	U14_F1 112	U17_F1 7	U14_F1 8
6	U17_F1 2	U14_F1 7	U12_F1 1	U14_F1 13	U12_F1 36	U14_F1 1	U11_F1 18	U8_F1 63	U15_F1 5	U16_F1 7
7		U8_F1 2		U12_F1 1	U14_F1 23	U15_F1 1	U17_F1 8	U17_F1 51	U9_F1 1	U8_F1 2
8		U16_F1 1			U10_F1 1		U9_F1 7		U14_F1 1	U14_F1 2
9							U16_F1 1			
Facilitators' line										

Rank	U8_F2	U9_F2	U10_F2	U11_F2	U12_F2	U16_F2
1	U16_F2 240	U11_F2 240	U12_F2 277	U9_F2 240	U10_F2 277	U8_F2 240
2	U10_F2 115	U9_F1 185	U10_F1 219	U10_F2 201	U12_F1 239	U10_F2 154
3	U11_F2 47	U10_F2 30	U11_F2 201	U12_F2 121	U11_F2 121	U11_F2 50
4	U17_F1 7	U16_F2 23	U16_F2 154	U16_F2 50	U9_F2 11	U9_F2 23
5	U12_F2 2	U12_F2 11	U10_F1 139	U8_F2 47	U10_F1 4	U16_F1 5
Facilitators' line						
6	U9_F2 1	U8_F2 1	U8_F2 115	U9_F1 14	U8_F2 2	
7		U9_F1 1	U10_F1 93		U14_F1 1	
8			U12_F1 37		U9_F1 1	
9			U9_F2 30			
10			U9_F1 7			

Rank	U10_F8	U12_F8	U17_F8
1	U10_F1 247	U17_F8 206	U10_F8 225
2	U17_F8 225	U10_F8 151	U12_F8 206
Facilitators' line			
3	U10_F2 219	U12_F1 36	U8_F3 39
4	U12_F8 151	U12_F5 19	U8_F2 7
5	U10_F4 66	U16_F3 1	U16_F3 5
6	U8_F3 42		

Rank	U8_F3	U13_F3	U15_F3	U16_F3
1	U16_F1 250	U16_F1 300	U15_F1 168	U13_F1 300
2	U8_F1 170	U15_F1 91	U13_F1 91	U8_F1 250
3	U10_F1 42	U13_F1 73	U16_F1 68	U16_F1 71
Facilitators' line				
4	U17_F1 39	U8_F1 39	U9_F1 38	U15_F1 68
5	U13_F1 39		U16_F1 5	U17_F1 5
6			U13_F1 1	U12_F1 1
7				U16_F1 1

U12_F7
K's line
U12_F2 239
U12_F1 95
U10_F1 75
U12_F1 40
U10_F2 37
U9_F1 2

Rank	U9_F4	U10_F4
1	U9_F2 185	U10_F2 138
Facilitatory line		
2	U9_F1 105	U9_F4 79
3	U10_F4 79	U12_F7 75
4	U11_F2 18	U10_F1 71
5	U10_F2 7	U10_F8 66
6	U12_F7 2	U14_F5 6
7	U12_F2 1	U12_F2 4
8		U12_F5 3

Rank	U12_F5		U14_F5	
1	U14_F5	287	U12_F5	287
Facilitators' line				
2	U12_F1	153	U14_F1	95
3	U12_F7	40	U12_F1	21
4	U12_F8	19	U11_F1	13
5	U10_F4	8	U8_F1	8
6	U11_F1	1	U10_F4	6
7			U17_F1	2
8			U13_F1	1
9			U12_F2	1