Human and Computer Readings: towards a Collaborative Research

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1. Project summary

The research focus of this SPARK project, entitled *Human and Computer Readings: towards a Collaborative Research* (HCR), is to study the impact of combining scholarly human reading and automated computer reading on collaborative research. The test case will be done on a trilingual biblical manuscript, the Gr.Z.11(=379), early 13th century, written in Latin, Greek, and Arabic (Devreesse, 1955; Moni, 1985; Piemontese, 2002; NN, [Ref1] & [Ref2]). The HCR project will compare human and computer readings in their efficiency, error, and correction capacities by transcribing Gr.Z.11(=379). This multilingual and complex manuscript is an ideal test case for HCR.

Highly skilled in reading texts, Humanist scholars are facing challenges due to the successful developments of automated reading of printed texts and manuscripts by OCR (*Optical Character Recognition*) or by HTR (*Handwritten Text Recognition*), and of the big data research (Bukhari et al. 2017; Puigcerver 2017; Shu-Heng Chen, 2018; Hodel, 2019; Kiessling et al., 2019b). Humanist scholars are currently writing about these changes in books and newspapers as a means of engaging the public (Wolf, 2007 & 2018; Carr, 2011; Lauer, 2019; Duthat 2020). Accordingly, HCR would like to compare human and computer readings in order to highlight the potential and limitations of each method and to find ways to maximize their collaboration for future projects. The HCR results aim to provide a concrete dataset to discuss the added value of each reading practice. HCR is most likely the first project of its kind: comparing the results of highly-skilled human reading practices with results coming from advanced OCR/HTR technologies.

To evaluate the efficiency and error capacity of human reading, two Humanist researchers will be asked to undergo eye-tracking tests on two folios of Gr.Z.11(=379), at the *Lutin Userlab* at the Cité des Sciences in Paris. Eye-tracking will observe the ways they read in three steps. First, they will transcribe f. 229v, in Latin, Greek and Arabic. Their body language will also be observed and compared to evaluate their style of reading (Bouziane et al. 2013; Ballenghein – Baccino, 2019a; Ballenghein et al. 2019b). Second, they will check the transcriptions of the other reader, looking for variants and potential errors. Finally, the eye-tracking test will evaluate them while they are correcting a folio previously transcribed by OCR/HTR. At each step, efficiency, ability to spot errors, accuracy of the transcription, and body language will be evaluated. Their results will be analyzed and compared with the results of the computer reading.

To test the computer reading, an IT researcher will prepare a computer with the OCR/HTR system *Kraken* and the manuscript viewer *eScriptorium*, both in full open source (Stokes et al., 2018; Kiessling et al., 2019bcd). The type of research needed for the project influenced the choice of *Kraken*, due to the particularities of Gr.Z.11(=379), as argued in the state of research. After the computer is set up with the proper systems, *Kraken* will transcribe folios 229r-236r. They will also be transcribed by a Humanist researcher. Results from the eye-tracking tests on human reading and from the OCR/HTR transcription produced by the computer will be compared, analyzed and submitted as an article (deliverable 1). Assuming that *Kraken* will produce good results, it will transcribe other Gr.Z.11(=379) folios. All the resulting material will be made available in open access on the manuscript viewer (deliverable 2). HCR will have a timeline on 12 months (September 2020-August 2021), employing a post-doc at 20%, a DH Scientist at 20% and an IT researcher at 50%. A final workshop will be organized in June 2021 to

discuss the results of HCR, in collaboration with EPHE/PSL colleagues (deliverable 3). HCR will prepare a base for an international collaboration through the use of Switch edu-ID on a Swiss virtual machine, and through data sharing and storage in the Huma-Num open public depository Nakala (deliverable 4).

2. Project Plan

2.1 State of research

The research focus of *Human and Computer Readings: towards a Collaborative Research* (HCR), is to test the impact and efficiency of a collaborative research between the scholarly human reading and automated computer reading. The test will be done on a complex ancient biblical manuscript from the Marciana Library in Venice[1], the trilingual Gr.Z.11(=379), dating back to the early 13th century[2], written in Latin, Greek and Arabic[3]. HCR will compare both readings in their efficiency and error, capacities by transcribing Gr.Z.11(=379).

2.1.1 Humanist reading at stake

Highly skilled in reading texts, Humanist scholars are facing challenges due to successful developments of automated reading of printed texts or manuscripts by OCR (*Optical Character Recognition*)[4] or by HTR (*Handwritten Text Recognition*)[5], and of the big data research in general[6]. Big data have been presented as the most obvious way to build a bridge between computing approaches and Humanities and Social sciences[7]. In the daily big data research, important projects about automated reading are now depending on algorithms to answer to questions previously analyzed by Humanist scholars, such as the discovery of a genealogical filiation between texts[8]. Unsettled by this way forward, Humanist scholars are analyzing it in books and newspapers, as a way to engage the public. The reading capability is at the core of the debate, with writings like *The Shallows* by Nicholas Carr (2011), or *Proust and the Squid* by Maryanne Wolf (2007). Whereas Gerhard Lauer considers that "Lesen ist immer lesen – egal ob digital oder analog"[9], Wolf claims that "skim reading" has become the new normal and prevents us to grasp complexity[10].

In a key 1971 article[11], the computer programmer Robert Wachal noted the fear already provoked by the "digitalization of the society" among the Humanist scholars. He also asked them if they would be able to raise new research questions, referring to artificial intelligence (AI)[12]. Paying attention to this insightful article, and to the current Humanist concerns, HCR would like to compare human and computer readings, in order to more clearly lay out the potential benefits and limitations of each of them, and to maximize their collaboration for future projects. HCR is most likely the first project of its kind: comparing the results of highly-skilled human reading practices with results coming from advanced OCR/HTR technologies. The three next sections will discuss the state

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[1] The Marciana Library has put online all images of Gr.Z.11(=379) in open access, public domain, with a watermark: http://www.internetculturale.it/it/16/search/detail?instance=magindice&case=&id=oai%3A193.206.197.121%3A18%3AVE0049%3ACSTOR.240.9602&qt=Gr.+Z.+11. Images license is CC BY-NC-SA 3.0 IT, see http://www.internetculturale.it/it/15/termini-d-uso.
[2] Devreesse, 1955, p. 40; complete references in Section 3; "NN" means applicant's name or collective publications, anonymized according to the SNSF rules for SPARK; all hyperlinks have been last checked on 03/07/20.
[3] Zanetti – Bongiovanni, 1740, p. 16; Rinck, 1830, p. 30-42; Mioni, 1985, p. 16-17; Piemontese, 2002; NN [Ref1] & [Ref2].
[4] Bukhari et al., 2017; Walker et al., 2018; the SNSF project *Impresso* : https://impresso-project.ch/app/.
[5] These OCR/HTR tools are discussed in Section 2.1.3: *Aletheia*, *Monk*, *Kraken*, *Pylaia* and *Transkribus*.
[6] Shu-Heng Chen, 2018.
[7] Biemann et al., 2014.
[8] The *Kitab* project wishes for example to answer to this question: "How many books are strongly related to other books?", https://www.slideshare.net/NaomiWells1/digital-humanities-for-arabic-book-history?ref=https://digitalmodernlanguages.wordpress.com/.
[9] Lauer interviewed by Freuler, *NZZ* 6.04.19. Duthat, *NYT* 11.01.20.
[10] Wolf, 2018.
[11] Wachal, 1971; for comments, see Brennen – Kreiss, 2016; NN [Ref4].
[12] Wachal, p. 33 and 31.

of research on the chosen manuscript (2.1.2), the diverse OCR/HTR systems (2.1.3) and eye-tracking to analyze human reading (2.1.4).

2.1.2 State of research about Gr. Z. 11(=379)

Gr. Z. 11 (=379) is an early 13th century biblical manuscript in Greek-Latin-Arabic columns[13]. The codex is written on parchment and has 304 folios of ca. 28.7 x 24 cm, but some folios are missing at the beginning and the end of the codex[14]. Listed in the Gregory-Aland list (GA 460), it has not been transcribed in the INTF *New Testament Virtual Manuscript Room*[15], and belongs to the many NT manuscripts that have yet to be transcribed and fully studied. Kurt and Barbara Aland did not place its Greek text in any textual family[16]; for Rinck[17], the Latin column contains the text of the Vulgate, but with pre-Vulgate readings and perhaps influences from the Greek column, whereas the Arabic text was not translated from the Greek column. Gr. Z. 11 (=379) is particularly close to the trilingual Psalter, Mus. Brit. Harl. 5786 (copied in 1153)[18], produced in the context of the court of Roger II of Sicily (1130-1154)[19]. Preliminary inquiry has shown that Gr. Z. 11 (=379) once belonged to the St-Michael Monastery in Troina, Sicily[20]. Datasets have been already produced from 79 folios transcribed and encoded by hand in TEI/XML, available on an open public depository[21]. In summary, Gr. Z. 11 (=379), as multilingual complex biblical manuscript, is an ideal test-case to compare and analyze human and computer reading capabilities.

2.1.3 State of research on Handwritten Text Recognition (HTR) systems

Several HTR, or OCR/HTR, systems exist, notably *Aletheia*, *Kraken, Monk*, *Pylaia* and *Transkribus*[22]. From the perspective of the humanities, OCR and HTR approaches could seem complementary, each adapted to either printed characters or handwritten letters. But from the view of computer sciences, algorithms can be adapted to different kinds of textual digital images, independently on their complexity and heterogeneity: *Kraken* is typically an OCR/HTR system, used in *OpenITI* that recognizes printed Arabic books[23], but is also the core tool of the manuscript project *eSriptorium*[24]. The OCR system *Tesseract* is core to *Aletheia*[25], and the HTR system *Transkribus* relies on AI research[26]; *Pylaia*[27], a second version of *Laia* implemented in 2016 the machine learning system *Torch*[28], is based on handwritten datasets[29].

If all these HTR/OCR systems are all products of AI research, one can discern three main differences between them, first in their ways of giving access to the material. *Monk*'s use cases, which is used by the National Dutch Archives, are currently not available[30]; *Pylaia* (Zurich, CH) does not provide images or web interface, whereas

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[13] See footnotes 1, 2 and 3 above ; Gr. Z. 11 (=379) is the only New Testament manuscript with these three languages.
[14] Canart, 1978, p. 116; the book of Acts only begins at 1.12 and Philemon, put at the end, is almost missing.
[15] https://ntvmr.uni-muenster.de/
[16] Aland and Aland, 1995, p. 138ss.
[17] Rinck, 1830, p. 30-42 (Codex 109).
[18] http://www.bl.uk/manuscripts/FullDisplay.aspx?ref=Harley_MS_5786.
[19] Ambrosetti, 2008, p. 243.
[20] Several notes in the Sicilian dialect, written in Greek script, can be found on folios 2r, 198r, and 252v.
[21] [online datasets 1, 2, 3 & 4]; according to the SNSF anonymization rules, hyperlinks are provided in the complementary documentation.
[22] See Kiessling et al., 2019b, p. 19; https://www.primaresearch.org/tools/Aletheia; https://github.com/mittagessen/kraken; http://monkweb.nl/; https://github.com/jpuigcerver/PyLaia; https://transkribus.eu/Transkribus/.
[23] *OpenITI*, https://iti-corpus.github.io/, refers to an article on Kraken co-signed by Kiessling, Romanov, Miller & Bowen Savant (2017); see recently, but without reference to Kraken, Romanov – Seydi, 2019.
[24] See https://escripta.hypotheses.org; Stokes et al., 2019; Kiessling et al., 2019b; Kiessling, 2019c.
[25] https://www.primaresearch.org/tools/Aletheia/Usecases.
[26] Commenting *Transkribus*, Tobias Hodel references a Xerox webarchive document written by Hervé Dejean (Hodel, 2019, p. 131): https://web.archive.org/web/20170127104937/www.xrce.xerox.com/Blog/Document-Analysis-and-Layout-Using-Sequential-Pattern-Mining-Techniques; Dejean and Meunier, *Neverlabs* (FR), are the creators of contact in the Transkribus documentation: https://github.com/Transkribus/TranskribusDU.
[27] *Pylaia* has notably been tested on the project *Parzival,* https://github.com/jpuigcerver/PyLaia/tree/refactor_kws_egs_master/egs/parzival.
[28] https://github.com/jpuigcerver/Laia.
[29] https://github.com/jpuigcerver/PyLaia/tree/refactor_kws_egs_master/egs/iam-htr.
[30] See the unavailable examples listed in http://monkweb.nl/monk/ExternalLinks/voorbeelden.html.

Aletheia (Manchester, UK), *Transkribus* (Innsbruck, AT) and *Kraken* (Paris, FR) each offer videos or images that are all equally convincing[31]. The *Kraken* team emphasises that *Transkribus* and *Monk* are not in open source and that the full version of *Aletheia* is restricted for commercial use[32]. A part of *Monk*, these OCR/HTR systems have all their resources on github, with Appache 2.0 license or MIT license[33]; but *Transkribus* that has recently limited its license by a BSD3-clause[34]. The business model of the READ-Coop association, leading now *Transkribus*, is still in construction[35]. But even if the service could remain free for individual researchers, *Transkribus* global intent is to reach Humanist scholars without access to direct IT collaboration[36].

The HTR *Pylaia* and *Kraken* systems are conceived to be used by Humanist scholars in direct collaboration with IT specialists, a second important difference. *Pylaia* presents an "alternative model", based on one-dimensional recurrent layers[37]. *Kraken* is "customizable according to the needs of the research project"[38], an important point, because the complexity of Gr. Z 11(=379) requires a flexible HTR system. But preference will be given to *Kraken* rather than to *Pylaia*, because of a third difference: *Pylaia* relies on IAM handwritten datasets[39], composed by English modern samples (LOB corpus)[40], whereas *Kraken* has been trained on ancient manuscript writings, notably on several ancient Arabic handwritten texts[41], the most uncommon language of Gr. Z 11(=379), that preserves also abbreviations in the Greek and Latin parts. *Kraken* is consequently chosen as a totally open source OCR/HTR system, flexible and customizable, and trained on the material required for ancient manuscripts, fitting particularly well with the specificities of Gr. Z 11(=379).

2.1.4 State of research on eye-tracking and reading

At first glance, the most efficient way to compare human and computer reading seems to be to record the time used by each of them, at their top capacity. But such a one-dimensional perception overlooks features that are specific to each reading event. Although AI experiments have commonly focused on achieving anthropomorphic results, artificial cognitive systems can be also oriented to develop radically different properties[42]. This perspective represents a pathway to establish a collaborative human/computer reading in research. In order to evaluate the efficiency and error capacity of the human reading practices, eye-tracking will be applied to two humanist scholars reading folios of Gr. Z. 11(=379). As far as we can tell, eye tracking seems to have never been applied to a 13th century trilingual manuscript. It implies a potential methodological risk, but coherent with the SPARK spirit. The two scholars will be invited at the *Lutin Userlab*, Cité des Sciences in Paris, a French lab that excels in eye-tracking observation[43], used for example since the 80s to describe visitors' experiment in museum context[44]. Eye-tracking is attentive to bodily attitudes that reflect cognitive engagement in reading[45]. Ballenghein et al. have crossed the observation of eye movements and head motion during the reading to discern the level of cognitive

[31] Compare https://www.primaresearch.org/tools/Aletheia, https://blogs.bl.uk/digital-scholarship/manuscripts/, https://escripta.hypotheses.org/escriptorium-video-gallery.
[32] Kiessling et al., 2019b, p. 19.
[33] *Aletheia*, https://github.com/PRImA-Research-Lab/prima-page-viewer/blob/master/LICENSE; *Monk*,https://github.com/Automattic/monk/blob/master/LICENCE.md ; *Pylaia*, https://github.com/jpuigcerver/PyLaia/blob/refactor_kws_egs_master/LICENSE.
[34] https://github.com/Transkribus/TranskribusDU/blob/master/LICENSE; but see also Google HTR research, Ingle et al., 2019.
[35] According to a direct email exchange with Günter Mühlberger, leader of READ-Coop, https://read.transkribus.eu/coop/.
[36] *Transkribus* collaborates with the CITlab of the University of Rostock, https://transkribus.eu/Transkribus/, rubric "Humanist Scholars".
[37] Puigcerver, 2017, p. 1.
[38] Kiessling et al., 2019b, p. 23.
[39] https://github.com/jpuigcerver/PyLaia/tree/refactor_kws_egs_master/egs/iam-htr; compare with the information of the former *FKI* research group, http://www.fki.inf.unibe.ch/databases/iam-handwriting-database.
[40] Ingle et al., p. 21; https://en.wikipedia.org/wiki/Lancaster-Oslo-Bergen_Corpus.
[41] Kiessling et al., 2017; Kiessling et al., 2019a.
[42] Jouen interviewed by Cario, *Libération* 31.05.2018; NN [Ref3].
[43] https://www.lutin-userlab.fr/site/plateforme/#eyetrackinglab
[44] Ranoldi et al., 2018, p. 474 ; Kenderdine, 2015.
[45] Ballenghein – Baccino, 2018.

engagement: they have reached positive conclusions from the observation of forty-four readers[46]. Before such AI experiments, psychology had already postulated that qualitative analysis could counterbalance impressions of surface level or shallowness in reading[47]. Global bodily movements have been then observed by videos to develop "a vision-based approach for human behaviour recognition"[48]. Paying attention to the synchronization of eye movement and head motion remains a new technology[49], but this recent knowledge developed at the *Lutin Userlab* is an adequate basis for describing what happens during the scholarly reading.

This state of research has demonstrated that HCR starts from an important preoccupation in Humanities: the future of the scholarly reading in light of big research data. The ancient manuscript selected for the experiment requires a high level of Humanist skill, and it has never been fully transcribed and studied. The chosen OCR/HTR system to evaluate computer reading, *Kraken*, has been selected as ideal for a test on Gr. Z. 11(=379), and it is in full open source. Finally, AI analysis combining eye-tracking and head motion in reading is a very new methodology that will be applied for the first time to the human reading of an ancient manuscript.

2.2 Goals, methodology, approach, and expected and possible risks

The goals are to collect data from eye-tracking on human readings and from HTR computer reading on Gr. Z. 11(=379). These reading events will be compared to determine the efficiency of both readings, as well as their error capacities. The applicant postulates that humans and computer will not make the same mistakes and that each reading will create differences in transcription. These observations should allow to highlight the complementarity of each reading. The deliverables will be an article submitted to an international journal (D1), and a website presenting transcriptions of Gr. Z. 11(=379) folios (D2), as well as a summative workshop (D3), and the data curation and storage (D4). The team, supervised by the applicant, will be composed, for 12 months, by two Humanist researchers at 20%, and for 11 months, by a computer scientist at 50%.

2.2.1 Eye-tracking methodology

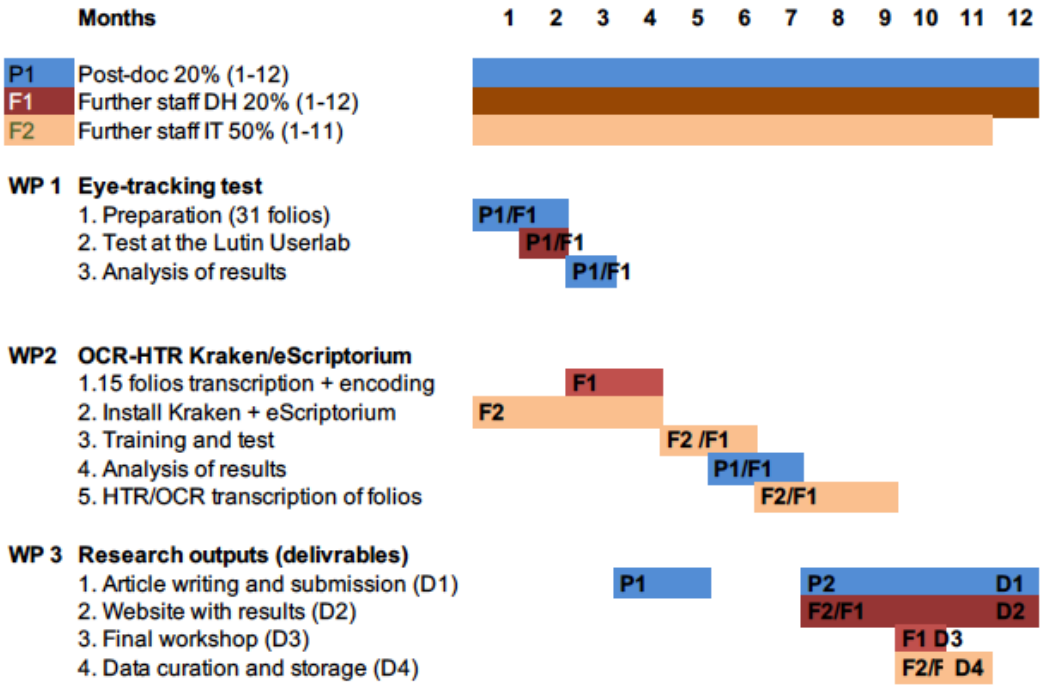
Eye-tracking movements crossed with head motion will be observed in three steps. First, the two researchers will transcribe f. 229v, for the Latin and Greek columns assisted by standard editions, for the Arabic column unaided. Both scholars have substantial experience in manuscript transcription, but different backgrounds. At the second step, their ways of reading will be observed when they check each other's transcriptions of f. 229v, comparing their variants or detecting potential errors (the experiment can be reconducted on f. 230r, if necessary); finally, they will be observed when correcting a folio already transcribed by HTR. Each time, efficiency and error capacity will be observed, by measuring time, accuracy, and error making, crossed with eye-tracking and head motion of scholars. The expected risk in this new experiment is that we may not achieve meaningful results or, alternatively, we may not be able to interpret the results. This risk is limited by the positive results previously achieved on the reading of standard printed texts by the *Lutin Userlab* team.

2.2.2. HTR Kraken transcription and eScriptorium visualisation

The IT collaborator will install *eScriptorium* and *Kraken* on a Switch VM at HCR institution. The standard goal to train *Kraken* is around 100 folios handwritten transcribed and encoded, plus 10 folios to do a first comparative test. As explained in 2.1.2, a dataset of 79 folios handwritten transcribed and encoded are already available, and 31 more have to be prepared. After the machine training and test, *Kraken* will transcribe f. 229r-

[46] Ballenghein – Baccino, 2019a, p. 1.
[47] Graham – Golan, 1991, p. 187.
[48] Bouziane et al., 2013.
[49] Ballenghein et al., 2019b.

236r[50]. One researcher will also transcribe these folios by hand in order to compare human and computer readings. *Kraken* error reports will be analyzed, as well as human mistakes, and efficiency will be compared (time and accuracy). In the light of the good results already produced by this OCR-HTR system, the risk that *Kraken* will be unable to really transcribe Gr. Z. 11(=379) is relatively low. In case of an emergency, this part of experiment can be achieved on *Transkribus*, a programme currently still free to use for some hundreds of folios per researcher. The Gantt chart below indicates the steps of the project in 12 months.



2.3 Description of the potential impact of the project

If successful, the experiment has the potential to fundamentally reorient the debate about scholarly human reading *vs* computer reading. The outcome would be of importance for all fields in Humanities and for the future development of OCR-HTR systems, which could only benefit from a better description of the qualities and capacities of each reading capacity. Other benefits are expected from HCR: SPARK strongly encourages research and funds diversification, a model that has proven to be a fruitful way towards excellence[51]. From this perspective, HCR will open a VM that is able to welcome future projects on manuscripts, creating vectors for international collaboration on a Swiss machine through the use of Swiss edu-ID, a possibility confirmed by SWITCHengines in the preparation of HCR[52]. Moreover, the Huma-Num open depository Nakala[53] will welcome all the research data of the project on an account open also to *Lutin Userlab* and EPHE/PSL colleagues. HCR hopes to demonstrate the added value of Humanist and computer readings and to open a space for further efficient international collaboration in digitized humanities.

[50] Letter of Paul of Tarsus to the Philippians, New Testament.
[51] Mongeon et al., 2016.
[52] https://www.switch.ch/edu-id/; https://www.switch.ch/fr/engines/.
[53] https://www.nakala.fr.

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