

Interfacing the Hebrew Bible: past, present and future applications for the BHSa

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Abstract: The open and constantly evolving BHSa database text of the Hebrew Bible (*Biblia Hebraica Stuttgartensia Amstelodamensis*) from the Eep Talstra Centre for Bible and Computer has amazing potential for past, present and future projects in Biblical Hebrew linguistics, language learning and interpretation. The BHSa was used 2004-2009 in the Role Lexical Module <http://lex.qwirx.com/lex/clause.jsp> in order to provide an interface for bidirectional mapping between morpho-syntax and semantics for linguists working within the Role and Reference Grammar model. Since then the BHSa has been used for educational purposes in the corpus-driven learning environment Bible Online Learner offering a persuasive interface for enquiry and practice in and with the BHSa text. Based on these applications for linguistic research and persuasive language learning, we now have a better idea of how the next generation of interfaces for the Hebrew Bible should be designed. We may even envision the direction to take for the next 5 years from now. For translation and education, we will need glosses for many languages, scaffolding with interactive archaeological, textual, grammatical and interpretive data, aural reading and much more.

Keywords: Bible Online Learner, BHSa interface, Role and Reference Grammar, Biblical Hebrew

Interfacing a corpus

The old Latin saying of *nanos gigantum humeris insidentes* – we are dwarfs standing on the shoulders of giants - is more true than ever for contemporary information- and communications technology projects within the new emerging studies of digital humanities. This is certainly also the case for projects focusing on the original languages of the Bible, and especially for the database corpus of the Hebrew Bible which is now often referred to as *Biblia Hebraica Stuttgartensia Amstelodamensis*, or in short BHSa. This database is a result of more than four decades of gigantic pioneer research invested into producing linguistic annotations of the Hebrew Bible with sophisticated research programs. It is now maintained by the Eep Talstra Centre for Bible and Computer in Amsterdam as the only openly available database with advanced research for Hebrew language learning, Bible translation and Biblical education at present.

The Copenhagen 2018 workshop on open Biblical data for research and education felt like the giants come marching in.¹ The workshop provided an opportunity for collaboration among leading devel-

¹ I would like to thank Dr Reinier de Blois of the American Bible Society for inviting me to co-organize the Copenhagen workshop for original-language and digital resources for Bible translation and education <http://fiuc.dk/fiuc-dk-hosts-international-workshop-in-march-2018/> and Every Tribe Every Nation for the funding.

opers of open data and technology for research and education. The BHSA database was at the forefront of several contributions, and it gave us the opportunity to discuss how we can access such databases through interfaces. In a special issue on computer-assisted interactivity for ancient texts, a case was made for “using corpora to train knowledge workers to use new tools for new tasks” (Winther-Nielsen 2017: 2). The vision projected was that all students and scholars of the Hebrew Bible could learn from this particular database and use it for life-long learning in jobs as translators, teachers and preachers.

This dwarf is excited to be still standing on the shoulders of brilliant programmers, ready to jump onto the shoulders of new giants in the cradle. I will illustrate how this new kind of digital interactivity emerges from the way we construct our interfaces for research and education, and how we may be able to improve user experience for researchers and learners in the future. My homage for the past, present and future giants creating interfaces for the BHSA corpus will fall into three steps:

1. The opening case is the Role Lexical Module 2004-2009 (RLM: <http://lex.qwirx.com/lex/clause.jsp>) as an example of an interface for linguistic research.
2. The main case is how learners can interface with the grammar of the texts for language learning through Bible Online Learner since 2009 (Bible OL: <https://bibleol.3bmoodle.dk/>).
3. The last part will discuss what future interfaces should achieve in order to inspire the needs for linguistic research and global learning.

In short, I encourage young emerging giants to lean their shoulders for programming of more effective and user-friendly corpus-adapted interfaces in years to come. I use my own experience with a past and a present project using the BHSA in order to illustrate the promising potential for Biblical Hebrew linguistics, language learning, translation, interpretation and even cultural-historical studies.

RLM: a promising project in the past

In the mid 1980ies I heard about two Benedictine monks from C.I.B Maredsous in Belgium having encoded texts of the Hebrew Bible. I also got news on Westminster Theological Seminary scholar Alan Groves using a PC for analysis of the Hebrew, and I learned about the Werkgroep informatica at the Vrije Universiteit in Amsterdam. I joined the latter in 1987 and professor Eep Talstra served as supervisor of my dissertation in which I explored the corpus as a tool for functional linguistic grammar and interpretation (Winther-Nielsen 1995). It became increasingly clear to me that structural patterns could best be described by a powerful and typologically consistent structuralist-functional theory of language like Role and Reference Grammar (RRG), while less formalized connectivity patterns was best explained through an interpretative framework like Rhetorical Structure Theory. Interclausal labelling of clause connections as either linguistic or rhetorical was carried out for the entire book of Joshua (Winther-Nielsen and Talstra 1995). At a later stage it was possible to use the Linguistic Tree Constructor for manual labelling of interclausal connectivity (Winther-Nielsen 2012).

However, in an early unpublished study by Robert Van Valin, the inventor of RRG, computational linguist Elizabeth Guest and me in 2001 we concluded that it is almost impossible to do a full-length RRG analysis of Genesis 2-3 without digital technology. In 2005-2009, Chris Wilson therefore programmed the first tool for analysis of a natural language corpus like the Hebrew Bible, the Role-lexical Module (RLM).² The then current version of the BHSA was used in order to open up the corpus of the Hebrew Bible for fellow RRG linguists. The tool was designed to map from the morpho-

² The RLM has not been updated since 2009, but this version is still available for documentation of the pilot project and its potential at <http://lex.qwirx.com:8080/lex/clause.jsp>. For access, please ask the author for username and password.

syntactic data to semantic structure, stored both as a logical structure in the lexicon (Winther-Nielsen 2008), but also providing a semantic representation of the text (Winther-Nielsen 2009: 43-44). In the process of working with parsing output, it became clear that a parser with some 50 rewrite rules could handle the syntax of most basic natural clauses of Biblical Hebrew, generating a box-like primitive projection of the syntax (2009:38).

Unfortunately, there was no funding for continuation of this project after 2009, and the interest of the RRG community moved in the direction of machine-translation or construction of large-scale ontologies (Winther-Nielsen 2016: 371-373). Furthermore, severe license restrictions imposed on the use of the database by the German Bible Society at that time hindered further research and development. The real breakthrough for development and innovation only came when the SHEBANQ project (<https://shebanq.ancient-data.org/>) in 2014 deposited the BHSA on github as an open source with unrestricted access for research and development (Roorda 2017: 227).

Even if discontinued, the RLM project clearly rendered the shoulder for the next project. An automated transliteration of the Hebrew text can clearly stimulate language learning projects (Winther-Nielsen 2009: 14), providing a written representation of how the Hebrew text is read (Winther-Nielsen, Tøndering and Wilson 2009; Winther-Nielsen 2009: 11-14). With an almost error-free machine-generated representation of the Hebrew text it is possible for students to form and check their own personal reading of the Hebrew script. Dirk Roorda has later developed a different variant for SHEBANQ so that the ETCBC has the feature phono for a phonetic representation of the BHSA. Benner and Covington (2016) has developed an algorithmically generated transliteration in which ambiguous cases are resolved by a human.³ It could be helpful to compare these different phonemic representations of the Hebrew text and explore the ability of transliterations to support oral Hebrew reading skills. New standards and data for oral and written representation could emerge from such a project.

A second important solution in the RLM project was how the analyst can perform a stepwise decomposition of argument realizations for the Hebrew predicates, storing the logical structures of these predications in the lexicon and representing the meaning of Hebrew text (Winther-Nielsen 2008; 2009: 42-46). There is a clear need for user-friendly interfaces offering simple and transparent pseudo-algorithms for vocabulary learning (Winther-Nielsen 2016; 2017b). In my own course development, I am using a stepwise analysis of verb forms, and a systematic stepwise decoding of the Hebrew script could guide readers struggling with the consonants, vowels, reading aids and syllable rules in their early study of Biblical Hebrew.

The RLM application was a powerful linguistic interface for RRG, and other grammatical models could no doubt also benefit from a tool tailored to their model in a similar way. For the agenda of the workshop, such tools can provide important new data on parsing and logical structure that can be used as open data for research and education.

Bible OL: huge potential at present

In 2009, when the RLM-project closed, a new application was emerging, this time using an interface for the BHSA for education rather than for research. The goal was no longer display of parsing and mapping of semantic meaning, but rather to create a language learning environment using the database as an engine to drive practice for acquiring language skills.

³ See the website <http://www.miklalsoftware.com/transliteration-of-westminster-leningrad-codex/> where it can be downloaded for non-commercial use.

In this project, Dr Ulrik Sandborg-Petersen was the shoulder, programming the first Biblical Hebrew paradigms for drilling grammatical forms back in 2004 (Winther-Nielsen 2011). The great discovery in class was that when students learned Hebrew morphology by selecting grammatical features and training them in a quizzing tool like Paradigms Master Pro (<http://paradigmsmasterpro.com/>), they would learn far deeper and retain their skills for much longer. The step to use a natural language corpus like the BHSA rather than artificially created and often extremely rare forms listed in the standard paradigms seemed promising, because learners will then train the most frequent forms that occur in actual Biblical texts.

Starting in 2008, programmer Claus Tøndering developed the 3ET, short for *Ezer Emdros Exercise Tool*, a PC program for quizzing the texts, but it only sold a handful of copies. However, from studies of persuasive design it seemed obvious that this application had potential for more effective and efficient language learning, if the user experience and the persuasive forces were enhanced. In the European Union life-long learning project EuroPLOT 2010-2013 we developed a theoretical framework for persuasive learning “that change behaviour or attitude, for example, by using fun, simulation, competition, cooperation or peer influence.” (<http://www.eplot.eu/>). The new persuasive design had potential for business as well as for corpus-driven language learning (Behringer et al 2013).

At the core of persuasive technology is the need of any learner to have instant feedback on accuracy of learner skills and ongoing formative assessment of learning outcomes: - Am I doing the right thing? - How well am I doing? Interfacing the corpus through a learning technology redefines the acquisition of language skills. Grammatical features stored in a database are made available in a complete and interactive display of the grammatical and lexical expressions that the learner needs to explore and memorize in an actual text. From 2013a and onwards, the grammar interface was made available online in the application Bible Online Learner (<https://bibleol.3bmoodle.dk/>) shown in figure 1. By clicking on check boxes, learners can observe the values for each feature type displayed at word, phrase and clause level. Cognitive skills obtained through observation of the grammar of the text can then be modulated for practice of skills. The strength of this system lies in limitless exercises generated on the fly according to the design made by facilitators, and learners can then direct their own learning projects. As users of a database application, they are being taught by the Hebrew Bible itself.

Corpus-driven feedback on learning outcome functions as the engine in this learning technology. Performance is tracked and displayed for formative assessment in a graphical performance tracking module. The first PC program offered online statistics that could be downloaded in files (<https://www.ezer.dk/3ETusersguide/PL-2.0.1/en/statistics.php>). The next version was a Learning Journey module developed by Judith Gottschalk, first as an independent database (Gottschalk and Winther-Nielsen 2013), and later as a module integrated into Bible OL and offering grading and detailed inspection of right and wrong answers. This technology was tested both in Madagascar and in Copenhagen (Winther-Nielsen 2017c: 9-12). In the autumn of 2017, Claus Tøndering programmed performance tracking graphics which plot the number of correct answers per minute for individual learners and classes. Performance tracking can persuade learners to advance and improve in competition with their own prior learning outcomes on a daily basis, producing gaming-effects which are fun and motivational.

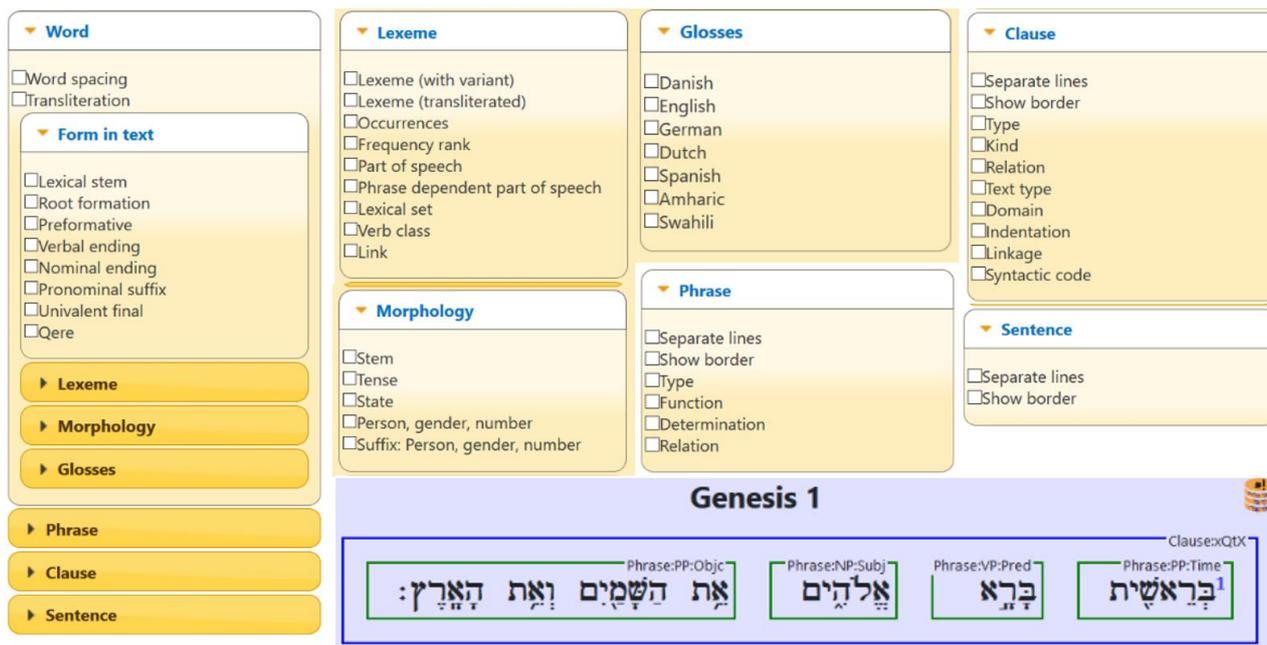


Figure 1. The features in the interface of Bible OL for the Hebrew Bible

This persuasive learning potential is of course only realized if the learning content supports the learning processes. Thanks to learner feedback, learning designers can now construct more efficient learning tasks, test them, measure their effect and then construct even better results for practice. The following points highlights evaluations by learners: learning content must integrate videos, documents and textbooks, and such resources need to be adapted to the features used in the database. Videos need to be short and to the point. It is important to focus on forms of the most frequent vocabulary as used in the texts studied in order to solidify their meanings in memory, enshrined in a textual context. Interfacing vocabulary in a natural language usage is crucial.

For the development of the next generation learning design I am shifting to 60 of the simplest chapters in the Hebrew Bible according to the findings of Bullard (2019). In my current course development I am designing hundreds of micro-tasks that are clearly introduced and well defined in terms of how learning outcome can be validated through the task at hand. Furthermore, the design can now support a transparent and fair summative assessment that provides valid certification for comparison of outcomes among learners. This allows teachers to document learning outcomes to administrations or institutions responsible for accreditation and validation of learner performance in courses.

For more than a decade, since 2009, interfacing the BHS for language learning has evolved into a very persuasive technology for language learning. Bible OL will have great potential to enhance online and blended learning in a much more persuasive, pervasive and productive way. We call for collaboration with partners in many languages to reach global impact.

Next generation BHS-A-applications: Dreams for the future

The most important landmark in the more than 40 years of construction of the BHS-A corpus is without doubt that the database was deposited on github for free accessibility (<https://github.com/ETCBC/shebanq/>). Making decades of advanced research on the Hebrew Bible freely available is a major innovation that is paving the way for many new projects. The goal here is not to discuss all new and interesting projects in the pipeline, but rather to look at the potential for interfacing the BHS-A in the future along the lines discussed for the two cases at hand. Does a research tool of the past like the RLM have a future, and how can an educational technology like Bible OL be developed for over the next 5 to 10 years?

It was unfortunate that the RLM application was discontinued for lack of funding and collaboration at the time, because it had so much potential for creating logical structure and syntactic tree projections. The code is now available at github (<https://github.com/gris/lex>), but a new RLM will no doubt need a complete reprogramming, using the most recent version of the BHS-A, improving transliteration and offering state of the art research. The most promising potential is no doubt to develop a successor to the RLM, or perhaps a complete replacement, in collaboration with the new generation of RRG parsing. The most promising project seems to be the TreeGraSP project directed by professor Dr. Laura Kallmeyer at the University of Düsseldorf (<https://treegrasp.phil.hhu.de/>). Other grammatical models could no doubt also benefit from a tool similar to a new version of the RLM, using the BHS-A text for research.

Many of the new directions in research will no doubt focus on improving text-modeling and database design. Current research is now moving beyond two-dimensional syntactic trees and diagrams towards modeling of texts as complex, multidimensional networks.⁴ Researchers predict that these networks will be able to present the linguistic features in a far more dynamic relationship, allowing researchers to interact with the data as sophisticated networks. Interfacing the corpus will no doubt take on a completely new meaning in the future.

As for Bible Online Learner, it has already been pointed out in the past that programming of support for learning to read, classify verbs and acquire an active vocabulary could be helpful. However, current research and development seems to indicate that the design of matching instructional content matters more than we imagined. At present, the *My Biblical Hebrew* (<https://mbh.3bmoodle.dk/>) course material is reinventing Biblical Hebrew language learning as study and practice focusing entirely on learning through the interface. This new online course supports 560 hours of work by learners engaged in practice and textual analysis and out of this course emerges fresh data on average learning outcomes in terms of proficiency. The first learner responses also indicate that this online learning style is superior to results obtained in the traditional language learning class, and its use in blended learning environments will be extremely promising. It will also be possible to build specialized courses for PhD students and for translations teams using the BHS-A in ParaText.

The interface at present supports English, Dutch, Spanish, Portuguese and Chinese, and more languages are yet to come. Furthermore, the Dutch project Data-driven E-Learning (DaDEL) 2018-2020 offers an open Dutch version of Bible OL and develops the technology further for improved user experience.⁵ The technology could in the future be used for similar national versions in German,

⁴ This is the agenda for a Lorentz Center workshop on *Processing Ancient Text Corpora* from February 17-21 2020, see <https://www.lorentzcenter.nl/lc/web/2020/1219/info.php3?wsid=1219&venue=Snellius>

⁵ DaDEL is directed by professor Wido van Peursen and coordinated by phd-student Ernst Boogert. For details on this new new and further developed Dutch version see <https://www.pthu.nl/actueel/nieuws/Nieuwspdf/surf-projectaanvraag-open-leermaterialen-2018-database-driven-e-learning-pthu-vu-definitief.pdf>.

French, Spanish, Amharic, Swahili, and even Chinese, to mention some of the most interesting projects. Should this happen, corpus-interfacing through Bible OL and related versions would have great potential for global reach.

An open source application like Bible OL is under constant change, because agile development takes care of feedback and requests for improvement from teachers and students. Continuing as part-time programmer in charge of Bible OL development, lead programmer Claus Tøndering has made several improvements over the last years. Bible OL now supports localization by facilitators developing the technology for different languages. An option for variant interfaces will allow teachers to use their preferred terminology and an adapted vocabulary. Bible OL supports the new data protection legislation of the European Union from May 26 2018, protecting learner data from exploitation outside the project and for commercial means. Bible OL is now being designed for an exam module developed by a team at Andrews University coordinated by Dr Oliver Glanz. Eventually Johannes Gottschalk will develop a more user-friendly interface for DaDEL and the plan is to have this new design implement for Bible OL as well.

Other features are in high demand, but not yet in production. One of the important new steps will be to improve linking to learning resources. Bible OL has been developed to scaffold learning content for the Hebrew text, place names or dictionary entries. We developed and tested the EuroPLOT Resources as a database containing pictures on archaeological sites (<https://resources.3bmooodle.dk/img.php>) in order to provide references in the text through interactive icons pointing to the data (Winther-Nielsen 2013a: 2014: 90-91). Details on the grammar can in the future be associated with entries in the lexicon and thus appear in association with the lexemes used in the text, in effect delivering content tied to the vocabulary. Eventually, we expect individual facilitators to be able to use their own personalized set of references for specific groups of learners, tying hyper-linking to class-administration support. These features are very much in the forefront of the interface developed by the DaDEL team.

Another urgent need is to have a kind of “Vocab-o-meter”. As they read and study the texts, learners need to be able to highlight or hide glosses in the texts within a certain range on the fly. When learners are studying and memorizing vocabulary within a certain frequency of occurrence they need to be able to explore them as forms anchored in a linguistic context, before they can train them in exercises. They need to be able to practice reading of the text by hiding all words in focus of learning and occurring within this particular range of frequency. This kind of slider for hiding certain ranges of vocabulary could greatly enhance the ability of learners to internalize vocabulary that has to be learned for the final exam or are in focus in their present stage of learning.

Another major request from learners is to have support for repetition at regular intervals of questions that have been answered correctly earlier. At present, the learner easily gets bored by having to solve tasks that are not sufficiently challenging because the content has already been retained in memory for a long time. Support for this is offered in flash-card solutions like Memrise or Anki, and to have Bible OL calculate the level of retained vocabulary would enhance the effectiveness and pleasure of learning greatly. This kind of adaptive learning or machine learning is an important agenda for the future. It would be especially useful and effective if associative machine learning could calculate ideal performance in terms of practice of skills and provide individual and mean values for use in certification and supervision. Big data are becoming increasingly crucial for business and research, and this may eventually also provide far better open source technology for use in a project like Bible OL.

Other learner requests focus on more mundane problems when typing English names or translation glosses, which is a challenge even for native speakers, let alone then for learners using English as

their second language. It would be desirable to allow for misspellings and for the acceptance of synonyms. Using Bible translations to check correct translations and accept synonyms would be a great help for learners and Bible translators in training. This could also support multiple choices for translation options offered when doing exercises on a smart phone display, which would avoid tedious typing altogether.

One of the issues to discuss for the future is the need to be able to make changes in the BHSa corpus itself when there is a disagreement on choices made by the scholars producing the data. Some choices may not be justifiable or are inconsistently implemented, and this is a challenge for learners who want to trust the data and are not able to understand the reason for seemingly odd choices. It should be possible to add alternative solutions and then compare with the latest version of the BHSa distributed by the ETCBC. There is a dilemma in this, however, because we will lose common ground for reference and we will no longer have a direct tie to SHEBANQ or other applications using the canonical BHSa version.

Many other features will be nice to have in due time, and some are no doubt essential to successful learning. It would be useful if the virtual keyboard could float on the screen and be enlarged. Often exercises will fill much more space than can be shown on the screen, so a responsive exercise design would be useful. For the future we need better support for training analysis of textual structure for exegesis. We also need an aural rendition of the text for listening during the learning process. We need vocabulary lists for many more languages, and they should ideally be tied to translations in those languages – it would be helpful eventually to be able to use work on parallel alignment made by Andi Wu, David Instone-Brewer and others.⁶

Last, but not least, we need much richer data to scaffold the corpus with interactive archaeological, textual, grammatical and interpretive data. Down the road we hope to see virtual and augmented reality added for visualization of the world of the text. We should also be able to interlink to new projects based on the BHSa. A case in point is the Tiberias project which uses the BHSa for a rigorous, consistent and controllable analysis of stylistic features for text-categorization, or authorship attribution, providing “reliable statistical evidence confirming (or refuting) user-provided hypotheses about distinct stylistic threads in the entire corpus of the Hebrew Bible” (Berman 2017: 279).

It is in the nature of open source projects to call for collaboration on developing new technology in dream teams. Yet we also know that new versions and global scaling may call for new funded projects and business-models that will help us create innovative interfaces for Bible translation and interpretation and a suite of different modules localized for many languages.

Conclusions

As designers of interfaces and resources for learning we stand on the shoulders of our programmers. What they are achieving is our basis for creating new content for learning of the Biblical languages, Bible translation, Biblical studies and education at large.

This has been illustrated by two cases of interfacing the BHSa. What we learned from the RLM is the need for display of Hebrew for linguists and the power of algorithms and parsers which must be refined for vocabulary learning and valency research. The steepest learning curve comes from developing the interface for language learning through Bible OL. Even if this technology is only so far used in few teaching environments, we are convinced that it has potential for revolutionizing language

⁶ See the papers in this issue of *HIPHILNovum* 5.2 by Wu (p. 97-101) and Instone-Brewer (p.102-125).

learning, but we need to create new learning environments in many more languages, and we must be able to finance scaling.

The paper has pointed out where there is ample room for improvement and collaboration, if we are to create these new interfaces and the ecologies surrounding the producers of the next education for translation and Biblical studies. Interfacing the BHS in this way could have great impact on global translation and education.

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