HELFI: a Hebrew-Greek-Finnish Parallel Bible Corpus with Cross-Lingual Morpheme Alignment

Anssi Yli-Jyrä\textsuperscript{1,3}, Josi Purhonen\textsuperscript{1,2}, Matti Liljeqvist\textsuperscript{3}, Arto Antturi\textsuperscript{3}, Pekka Nieminen\textsuperscript{3}, Kari M. Räntilä\textsuperscript{3}, Valtter Luoto\textsuperscript{3}

\textsuperscript{1}Department of Digital Humanities, University of Helsinki, 00014, Finland
anssi.yli-jyra@helsinki.fi
\textsuperscript{2}Faculty of Theology, University of Helsinki, \textsuperscript{3}Raamatun Tietokirja, Aika[media] Oy

Abstract

Twenty-five years ago, morphologically aligned Hebrew-Finnish and Greek-Finnish bitexts (texts accompanied by a translation) were constructed manually in order to create an analytical concordance (Luoto et al., 1997) for a Finnish Bible translation. The creators of the bitexts recently secured the publisher’s permission to release its fine-grained alignment, but the alignment was still dependent on proprietary, third-party resources such as a copyrighted text edition and proprietary morphological analyses of the source texts. In this paper, we describe a nontrivial editorial process starting from the creation of the original one-purpose database and ending with its reconstruction using only freely available text editions and annotations. This process produced an openly available dataset that contains (i) the source texts and their translations, (ii) the morphological analyses, (iii) the cross-lingual morpheme alignments.

Keywords: parallel texts, word alignment, the Bible, Finnish translation, alignment guidelines, fine annotation

1. Introduction

Parallel editions of Bible translations have existed for 1,800 years, but now there is a steadily growing interest to attach a fine-grained alignment to the numerous translations of the Bible and other parallel texts. The interest brings together linguistics, theology, translation studies and language engineering. Fine-grained manual text alignment produces valuable linked data sets and gold standards for automatic alignment. Tools for producing such manual annotations range from coarse word group aligners (Melamed, 1998b) to ones that align words with confidence levels (Lambert et al., 2005b) and to ones that link various types of subword units (Yli-Jyrä, 1993; Yli-Jyrä, 1995). The obtained gold datasets support the evaluation of alignment algorithms (Mihalcea and Pedersen, 2003; Lambert et al., 2005a; Cysouw et al., 2007) and the development of methods for automated corpus linguistics (Szymanski, 2012).

The aim of this work is to produce an openly shareable, fine-grained alignment for parallel Bibles. Such openly available language resources catalyse research, sharing, linking and tool development.

1.1. The Aim

Scientific Bible editions and copyrighted translations are seldom freely shareable. Moreover, manually validated annotations and fine-grained alignments are expensive to produce and thus not typically freely available for research and product development. The research problem of this paper is to overcome the obstacles to producing an openly shareable, manually aligned fine-grained alignment for a parallel Bible.

1.2. The Approach

The paper describes a recently completed process to produce a fine-grained and open morpheme-alignment between the most important 20th century Finnish Bible translation and the most relevant source texts. The whole process covers the years 1991-2020 and consists of two active phases:

(1) Product Development. The first phase (1991-1997) added a fine-grained alignment on top of a Bible bitext that contained proprietary components because we had no freely available morphology for the Hebrew source text to rely on. The resulting value-added database was then used to produce, in a few months, a commercial handbook product: a comprehensive analytical concordance of the Finnish Bible translation – \textit{Iso Raamatun Sanahakemisto} (IRS) (Luoto et al., 1997). The concordance was editorially envisioned by Valtter Luoto as an addition to the publisher’s long-running series of Bible handbooks (1967–). On the basis of the \textit{work-made-for-hire} rule, the publisher obtained the copyright to the alignment and had the authentic right to decide whether to share the copyrighted alignment with other parties.

(2) Resource Sharing. The second phase (2018-2020) began as the publisher made the decision to release the in-house dataset (the alignment) under the CC-BY 4.0 licence. This opening would have been useless without further work on the database. Any remaining proprietary components in the database have now been substituted with open resources by the first two authors. The work resulted in an open resource that contains two bitexts with a fine-grained bilingual alignment. The quality of the whole is comparable with the proprietary database.

1.3. The Methodology

In essence, our high-level methodology is a replicable tactic to cope with the delayed availability of open resources. It breaks the production of open annotation resources into the following steps:

1. Scaffold: Set up the proprietary text resources as a scaffold corpus (SC).
2. Addition: Add valuable annotations to the SC and keep its copyright manageable.

3. Switchover: Negotiate an open licence for the copyrighted annotations and replace the proprietary components of SC with open resources.

The Scaffold and Addition goals were addressed first, during the Product Development phase. Section 3 describes the SC and Section 4 outlines the bilingual annotations. The Switchover goal has been addressed recently, during the Resource Sharing phase. In Section 5, we describe how the linked database was detached from proprietary resources and how we implemented its switchover to open resources. Finally, Sections 6 and 7 summarise and evaluate the results, while Section 8 concludes the paper. In the following Section, we describe the background of fine-grained Bible alignment.

2. Fine-Grained Bible Alignment

Fine-grained Bible alignment is defined as a specialised task where the purpose is to indicate how the shared cross-lingual meaning of the Bible is encoded and aligned between the source and the target texts.

2.1. The Bible as a Parallel Text

Parallel texts have existed for a long time, as demonstrated by the Mesha Stele/the Book of Kings (ca 840 BCE), the Behistun Inscription (ca 500 BCE) and the Rosetta Stone (196 BCE).

The Greek New Testament (GNT) with more than 2,250 target languages is the most widely translated text in the world. Many of its target languages have several translations. Besides the languages into which the entire GNT has been translated, some parts of it have been translated into an additional 1,800 languages. The Hebrew Bible (HB, Tanakh), also known as the Old Testament, has been translated into more than 700 languages, with the first translation (Septuagint) dating back to 200 BCE.

The Bible usually refers to the concatenation of the HB and the GNT. It has influential translations such as the Vulgate (in Latin, CE 405) and the King James Bible (CE 1611). Along with other popular texts like Le Petit Prince (360 languages), it is used as a massively parallel corpus to research languages (Christodouloupolos and Steedman, 2015; Jawaid and Zeman, 2010; Tiedemann, 2012; Xia and Yarowsky, 2017; Carlson et al., 2018; Resnik et al., 1998).

2.2. Granularity of Alignment

Parallel texts can be aligned at varying levels of granularity (Tiedemann, 2011) and confidence (Lambert et al., 2005b; Holmqvist and Alrenberg, 2011). The alignment can be carried out either manually by human experts or automatically by algorithms. Manual alignment is time-consuming and expensive but used to produce gold standards for word alignment, while automatic alignment is less accurate but able to handle large amounts of data.

Until recently, the main application of word alignment (Brown et al., 1993; Tiedemann, 2011) has been statistical machine translation. Its other applications include lexicon extraction, back-translation, cross-lingual transfer learning, and lexical annotation of the translation. Linguistically fine-grained alignment uses lemmas and linguistic tags to align texts in greater detail (Yli-Jyrä, 1993; Yli-Jyrä, 1995; Li et al., 2014). The increased linguistic precision is potentially welcomed in computer-assisted language learning (Nerbonne, 2000), automatic interlinear glossing (Bow et al., 2003; Samardžić et al., 2015), language typology (Cysouw and Wälchli, 2007), and contrastive translation studies (Doval and Nieto, 2019).

2.3. Aligned Bibles

The earliest known parallel Bible is that of Origen of Alexandria who compiled the Hexapla (245 CE), a six-column edition of the Hebrew Bible (HB) and its earliest Greek translations. Hundreds of verse-aligned Bible translations are now accessible via Bible.com1 (1,200 translations), STEP Bible2 (453 translations), BibleGateway3 (224 translations), and BibleWebApp4. The division into verses was developed for the HB and the GNT by the mid-16th century. The division is relatively stable (±1 verse offset) across translations and it helps to split long sentences (e.g. the sentence in Eph. 1:3-14).

Strong’s Exhaustive Concordance (Strong, 1890) of an English Bible translation (King James Version) encodes a special kind of manual word alignment. This concordance indicates, for each content word occurrence, the lemma of the corresponding source word with a 4-digit reference number. This number is linked to Strong’s Hebrew-Aramaic and Greek lexicons. There are also other concordances with similar source correspondencies (Young, 1879; Åberg, 1982) and several interlinear and reverse interlinear editions of the Bible, all involving an implicit cross-lingual word alignment.

3. Scaffold Corpus

We began by preparing the necessary text resources as a SC, without necessarily intending to share it. This contained the Finnish translation, the Hebrew and Greek sources text and the morphological analyses of all texts in the corpus.

3.1. Translated Text

In 1992, there were two important, widely used Finnish translations for which there was a commercial interest to develop concordances.

1. the “Church Bible” 1933/38, a relatively literal translation that was already in the public domain, and

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1https://www.bible.com/
2https://www.stepbible.org
3https://www.biblegateway.com/
4http://bibletwbbapp.com/
Both translations were linguistically interesting, each in its own way. The proposal followed the principle of dynamic equivalence (Nida and Taber, 2003). However, this principle tends to lead to an inconsistent terminology and less lexical translation correspondencies. As our project’s goal was to use lexemes rather than semantic concepts (Louw and Nida, 1989) as the head words for the concordance, we chose to base our research on the older Finnish translation.

In 1991, it was not possible to get hold of an authoritative electronic copy of the the 1933 (HB) / 1938 (GNT) translation. Annoyingly, the circulated digital forms of this translation were inconsistent, and their comparison revealed some 3,000 copying errors and differences in spelling, inflection or punctuation. Some of these seemed to have originated in some printed form of the translation. The first pre-processing task was to compare the variants and to arrive at a reliable consensus between the sources. The official master copy of the translation has now been located in the National Archives of Finland, but not yet consulted.

3.2. Source Texts

When a modern publisher translates a book, the author can certify the authenticity and integrity of the original text with a digital signature. This technology has not been available earlier to preserve historical sacred texts or genetic information passed down throughout generations. Biblical manuscripts were not inscribed on a collection of stones, and parchments and papyri were not good for preserving the texts for very long periods of time. Long-term preservation of the texts was dependent on repeated manual copying, correction and verification. Due to the nature of the process, Bible translation is usually based a particular codex or a text-critical edition that aims to indicate the most likely original texts.

The 1933 translation of the HB to Finnish was made using Rudolf Kittel’s second edition (1913) of *Biblia Hebraica*. The 1938 translation of the GNT mostly followed a tentative 1913 translation and Eberhard Nestle’s latest GNT text edition (Nestle, 1904) but the committee also had access to Erwin Nestle’s 13th edition (1927) of *Novum Testamentum Graece*. None of these source text editions was available in digital form when our work started. To set up the source texts in these source text editions was available in digital form throughout generations. Biblical manuscripts were not inscribed on a collection of stones, and parchments and papyri were not good for preserving the texts for very long periods of time. Long-term preservation of the texts was dependent on repeated manual copying, correction and verification. Due to the nature of the process, Bible translation is usually based a particular codex or a text-critical edition that aims to indicate the most likely original texts.

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3.3. Morphological Analyses of Texts

All texts in the SC needed a morphological analysis to support fine-grained alignment.

We obtained the morphological analyses for the BHS edition by licensing the first edition of the *Westminster Hebrew Morphology (WHM)* and *Lemma Database*. The analysis in this database had been perfected by scholars under the direction of Professor Alan Groves in the Westminster Theological Seminary, based on a draft morphological analysis done by Richard Whitaker (Claremont, Princeton Seminary). Other morphologies for the HB exist today: the Hebrew Bible: Andersen-Forbes

The morphological analyses for the NA26 were obtained by licensing Paul Miller’s *GNT Database* from the GRAMCORD Institute. Today, many other comparable resources are readily available: the Analytical GNT

The analysis in this database had been perfected by scholars under the direction of Professor Kimmo Koskenniemi at the University of Helsinki. His FINTWOL morphological analyser, governed by Lingsoft Oy, was applied in 1992 by Anssi Yli-Jyrä to produce raw morphological analyses for a majority of the word types in the Finnish translation. A few thousand proper names and rarely used words were handled with a post-processing extension to the word-form analyser. The analyser produced, for each token, a set of possible morphological analyses. These analyses were then disambiguated and verified manually by Pekka Nieminen. This produced a golden morphological annotation and lemmatisation for all words in the Finnish translation. Under the collaboration agreement with the University, this annotation was shared automatically with the research community.

4. Added Annotation

During the Product Development phase, our priority was to produce the most usable and rich analytical concordance that would nicely complement the already published 10-volume comprehensive encyclopedia of the Bible (Gilbrant et al., 1988). The former 3-volume edition (1967–1972) of the encyclopedia contained a monolingual concordance whose production had involved a lot of manual work. This traditional approach to concordancing was challenged by Arto Anturi and Anssi Yli-Jyrä who innovated in 1991-1992

5. https://www.logos.com/product/25444/
6. https://github.com/ETCRC/bbss
7. https://hb.openscriptures.org/
8. https://www.agntsproject.net/
9. http://morphgnt.org/
10. https://www.logos.com/product/179855/
11. https://github.com/byztxt
12. http://biblicalhumanities.org/
a new methodology to carry out the editorial work.\textsuperscript{13} The new plan was to use computers to produce the (i) keyword-in-context lines and (ii) to extract the source lemmas for each Finnish keyword from the bilingually aligned SC. Human experts were still needed to produce a fine-grained bilingual alignment for the SC.

### 4.1. Alignment Guidelines

In 1992, bitext alignment and statistical machine translation were quite novel tasks in natural language processing. Methods for producing bilingual alignments were evaluated for the first time somewhat later in the ARCADE project (Vérinis and Langlais, 2000) but hardly any bitext alignment editors or guidelines were available in the 1990s. In this situation, our team produced a series of internal memos and a graduate school presentation (Yli-Jyrä, 1993) on fine-grained alignment and developed the project’s alignment guidelines. These guidelines contained the following key principles:

- alignments are made between groups of tokens that do not need to be continuous
- tokens motivated only by monolingual considerations are aligned to an \textit{epsilon}.
- translations contain the lexical core and the \textit{aux}-linked phrasal periphery (articles and auxiliaries)
- morphological properties of words can be linked separately, with \textit{extractors}, to function words
- the referential content of a pro-form can be linked (via a \textit{pro-extractor}) with a content word without claiming a lexical translation.

All three languages of the SC are synthetic, but the extractors made it possible to link morphological glosses of their words separately from the lexical content. The use of extractors made the alignment more analytical, although this also introduced new kinds of classification errors to the annotations. For Hebrew, the most consistently used extractors included the following:

\begin{itemize}
  \item \texttt{pers} - person suffix
  \item \texttt{modus} - verb modus
  \item \texttt{tasp} - tempus-aspect
\end{itemize}

Our \textit{aux}-tag and \textit{epsilon} were used very much like the \textit{possible} and \textit{null} confidence levels, developed a decade later by Lambert et al. (2005b).

### 4.2. Alignment Editor

The first editor prototype, \textit{Link}, was bought from IT entrepreneur Sauli Soininen to support Arto Antturi, Kari M. Räntilä and Anssi Yli-Jyrä in their experimentation with the bitext alignment in 1992-1993. Once we had consolidated our alignment guidelines, a more advanced, annotation-aware link editor, \textit{LinkPlus} (Yli-Jyrä, 1995), was developed by Anssi Yli-Jyrä. The editor was implemented in Borland Pascal 7.0 (27th October 1992), and its binaries ran on MS-DOS. Its final 1997 version, constituting 25,000 lines of code, was not just an editor, but an interactive graph database, supporting alternative concordance views to the bitext and provided functions needed to navigate and polish the alignment:

- keyboard-based synchronised bitext navigation
- word alignment across verse/sentence boundaries
- dynamic syntax highlighting for alignment codes
- queries to support validation against guidelines
- concordance view with source language lemmas
- extracting the lines of the printable concordance.

With the \textit{LinkPlus} editor (Yli-Jyrä, 1995), the computer-aided alignment of the whole Bible was carried out in approximately 2.5 man years by theologians Arto Antturi, Kari M. Räntilä, and Matti Liljeqvist. Several review rounds over the alignment were performed.

### 5. Resource Switchover

In 2018, an important step towards the liberation of the aligned Bible was taken by Aikamedia, the publisher and the copyright holder of our concordance: a decision was made to give the in-house alignment data away under the CC-BY 4.0 licence. Right after this decision, the first author started to work on the complete liberation of the aggregated database with his assistant Josi Purhonen. The purpose was to prepare the data for a proper release and to start developing new tools for language learners based on the data.

#### 5.1. Locating Open Resources

The base text of the BHS is essentially a copy of \textit{Codex Leningradensis} (\textit{CL}), which is in the public domain (they differed only in cantillation and punctuation marks). Their similarity allowed us to replace the proprietary WHM analysis of the BHS with the lemma numbers and morphological analyses provided by \textit{Open Scriptures Hebrew Bible} (\textit{OSHB}) project under the CC-BY 4.0 licence. As for the GNT, there are currently a few freely available editions: \textit{Nestle 1904}\textsuperscript{14}, \textit{SBLGNT}\textsuperscript{15}, \textit{Westcott-Hort}\textsuperscript{16}, the Byzantine\textsuperscript{17} editions, and \textit{Textus Receptus}. \textit{Nestle’s 1904} is the closest to the 1938 translation and in the public domain. It has digitised by Diego Renato dos Santos and analysed morphologically by Professor Maurice A. Robinson and Ulrik Sandborg-Petersen.

#### 5.2. Synchronising the Text Editions

The SC was built before the UNICODE standard, using \textit{ad hoc} 8-bit transliterations of the non-Roman scripts. The first step in making the alignment compatible with the open resources was to convert the SC

\footnotesize{\textsuperscript{13}}The advice of Krister Lindén and Lauri Carlson is gratefully acknowledged.

\footnotesize{\textsuperscript{14}}https://github.com/biblicalhumanities/Nestle1904

\footnotescript{15}http://sblgnt.com/download/

\footnotescript{16}https://github.com/byztxt/greektext-westcott-hort

\footnotescript{17}https://github.com/byztxt/byzantine-majority-text
resources to the UTF-8 encoding of UNICODE. During
the process, the minor punctuation differences be-
tween the CL and the BHS involved some extra work.
The Nestle 1904 and NA26 editions of the GNT con-
tain slightly deviant sets of text-critical readings (there
are 700 small differences). Thus some verses or words
are found in one GNT edition but are missing from
another, but most differences between the text-critical
editions were small enough to have no effect on the
alignment. Although Nestle 1904 was closer to what
had been translated in 1938, some translated verses
were missing from both sources. These were copied
from the SC where they had been inserted by the align-
ers.

5.3. Synchronising the Tokenisation
There are significant differences in the way the to-
kens are segmented in different Hebrew morphologies.
Therefore, some manual work was needed to harmonise
the tokenisations. The addressed incompatibilities are
presented schematically in Table 1.

| Layer | Example verse | WHM/SC | OSHB | Type of the problem |
|-------|---------------|--------|------|---------------------|
| 1     | Mal.3:12.4-5b | מְכִּ֖ית יִֽהָֽוּ / מְכִ֖ית יִֽהָֽוּ | מְכִ֖ית יִֽהָֽוּ / מְכִ֖ית יִֽהָֽוּ | WHM in SC (our \(\)) versus OSHB (*\) |
| 2     | Mal.3:12.1a-1b | אֱ/יָשָׁ֖ה / אֱ/יָשָׁ֖ה | אֱ/יָשָׁ֖ה / אֱ/יָשָׁ֖ה | Vav-consecutive prefix: WHM (\(\)) versus OSHB (\(/\)) |
| 2     | Gen.1:5a-5b   | בָּֽשׁ / בָּֽשׁ | בָּֽשׁ / בָּֽשׁ | Article: WHM (\(\)) versus OSHB (\(/\)) |
| 2     | Ezra.2:61.6a-6b| אֶ/ל הָֽוְ / אֶ/ל הָֽוְ | אֶ/ל הָֽוְ / אֶ/ל הָֽוְ | - OSHB inconsistent |
| 2     | Mal.3:2.11a-11b| וְ/אֵ֣שׁוּוְ / וְ/אֵ֣שׁוּוְ | וְ/אֵ֣שׁוּוְ / וְ/אֵ֣שׁוּוְ | Prepositions: WHM (\(\)) versus OSHB (\(/\)) |
| 2     | 2Kgs.5:8.16   | הֲ/לֵמַ֖ו / הֲ/לֵמַ֖ו | הֲ/לֵמַ֖ו / הֲ/לֵמַ֖ו | - WHM inconsistent with preposition ה |
| 2     | Isa.22:18.4a-4b| יָ/ד הָֽוְ / יָ/ד הָֽוְ | יָ/ד הָֽוְ / יָ/ד הָֽוְ | - OSHB inconsistent with preposition י |
| 2     | 2Chr.26:8.8a-8b| הַמְּלֹ֖ו / הַמְּלֹ֖ו | הַמְּלֹ֖ו / הַמְּלֹ֖ו | - OSHB inconsistent with ה + the infin. cstr. of בָּֽשׁ |
| 2     | Eccl.4:10.8a-8b| הַקּוֹצ / הַקּוֹצ | הַקּוֹצ / הַקּוֹצ | Suffixes: WHM (\(\), no split) versus OSHB (\(/\)) |
| 2     | Mal.3:12.2    | קְוֵ/תֵל / קְוֵ/תֵל | קְוֵ/תֵל / קְוֵ/תֵל | Suffixes: WHM (\(\)) versus OSHB (\(/\)) |

6. Results
The research reported in the paper resulted in an open aligned Hebrew-Greek-Finnish Bible and shared
knowledge of the methodology applied in preparing it.

6.1. Aligned Bible Bitexts
The aligned Bible consists of the HB-Finnish subcor-
pus (39 books) and the GNT-Finnish subcorpus (27
books). We formatted the released corpora in a new
column-oriented format in order to facilitate its use (no
conversion to XML format was done at this stage). Ta-
bles 2 and 3 show samples from the HB-Finnish and
the GNT-Finnish bitexts, respectively:

- Column token ID refers to the subtokens of the
  source language.
- Column linked IDs contains links to the source
  language tokens. A number in parentheses stands
  for an aux-link or translation to an epsilon, and a
  bare dash indicates a lack of source support. The
  source-side extractors attach to token IDs.
- Column lemma indicates the lemma, the corre-
  sponding OSHB’s enhanced Strong number, and
  the number of the lexicon entry in the Finnish
  Analytical Bible Concordance (Luoto et al., eds.,
  1997–1999, volumes 1-4). The epsilon-linked and
  aux-tokens are in parentheses, and a bare dash in-
  dicates that there is no Finnish translation. The
  extractors in the target language side appear in
  the lemma column.
- Column morphology presents the morphologi-
  cal analysis of the token using the de facto stan-
  dard Leipzig glossing rules (Comrie et al., 2008;
  Lehmann, 1982) but without morpheme bound-
  aries inside subtokens.
- Column token shows the tokens as they appear
  in the text.
- Column transliteration shows the source token
  in a roman-script form according to the academic
  transliteration standards of the SBL (Collins et
  al., 2014).
### Table 2: The Hebrew-Finnish Alignment of Psalm 1:1

| verse | token ID | linked IDs | lemma | morphology       | word form | transliteration |
|-------|----------|------------|-------|------------------|-----------|-----------------|
| ps001:001 | 1        | -/835/803  | N.MASC.PL.ABS | אַ֥שְֽׁרֵי- | ʾa šĕ rê- |
| ps001:001 | 2a       | -/d/-      | ART    | ġa | ġa |
| ps001:001 | 2b       | -/376/368  | N.MASC.SG.ABS | שָנָ֥ה | šanah |
| ps001:001 | 3        | -/834a/799 | REL     | ʾašer | ʾašer |
| ps001:001 | 4        | -/3808/3600 | NEG | לא | lō |
| ps001:001 | 5        | -/1980/1878 | Qal.3MS.PERF | הָלַח | hālak |
| ps001:001 | 6a       | -/b/9082   | PREP    | 2 | ba |
| ps001:001 | 6b       | -/6098/5817 | N.FEM.SG.CSTR | הֶעָ֟עַט | še′at |
| ps001:001 | 7        | -/7563/7256 | ADJ.MASC.PL.ABS | יְבִֽשׁוּר | še′at |
| ps001:001 | autuas |            | POS.SG.NOM | Autuas | Autuas |
| ps001:001 | 2a       | se         | DEM.SG.NOM | se | se |
| ps001:001 | 2b       | mies       | SG.NOM | mies | mies |
| ps001:001 | 3        | (,)        | PUNC    |  |  |
| ps001:001 | 4        | ei         | NEG.3S | ei | ei |
| ps001:001 | 5        | vaeltaa    | ACT.PRES.NEG | vaella | vaella |
| ps001:001 | 6        | jumalaton  | PL.GEN | jumalattomain | jumalattomain |
| ps001:001 | 6b       | neuvo      | SG.INE | neuvo | neuvo |
| ps001:001 | 6a       | %case      | LOC     |  |  |

### Table 3: The Greek-Finnish Alignment of the Epistle to the Hebrews 1:1

| verse | token ID | linked IDs | lemma | morphology       | word form | transliteration |
|-------|----------|------------|-------|------------------|-----------|-----------------|
| hb001:001 | 1        | πολυμερῶς | ADV    | πολυμερῶς | polymerōs |
| hb001:001 | 2        | καί | CNJ    | καί | kai |
| hb001:001 | 3        | πολυτρόπως | ADV | πολυτρόπως | polytropōs |
| hb001:001 | 4        | πάλαι | ADV | πάλαι | palai |
| hb001:001 | 5        | ὁ | ART.NOM.MASC.SG | ὁ | ho |
| hb001:001 | 6        | θεός | NOM.MASC.SG | θεός | theos |
| hb001:001 | 7        | λαλέω | AOR.ACT.PCP | λαλήσας | lalēsas |
| hb001:001 | 6        | monesti | ADV | monesti | monesti |
| hb001:001 | 2        | ja | CNJ | ja | ja |
| hb001:001 | 3        | moni | INDEF.SG.ADE | moni | moni |
| hb001:001 | 3        | tapa | SG.PTV | tapaa | tapaa |
| hb001:001 | 7        | (olla) | ACT.PAST.3S | oli | oli |
| hb001:001 | 7        | puhua | ACT.PCP2.PERF | puhunut | puhunut |

### 6.2. Methodological Innovations

Our overall methodology was a replicable template that involved three steps: Scaffold, Addition, and Switchover. This methodology allowed us to cope with the delayed availability of open resources. Each step involved a lot of unique research methodology. This demonstrates the complexity of working with historical documents that have several text editions some of which are under copyright while other editions are in the public domain.

The project developed an alignment editor with unique capacities. If the editor could be updated and ported to modern GUI-based systems, it would still have certain advantages. The alignment guidelines were ground-breaking because they contained ideas that have surfaced only much later: (1) the linguistic distinction between different kinds of links, (2) the extractors, (3) alignment across verse/sentence boundaries, and (4) alignment of discontinuous constructions.

### 7. Evaluation

#### Applicability

Our parallel aligned corpus has several applications. The proprietary version of the dataset was used to produce a concordance handbook. The free version is already being used in order to produce interlinear and reverse interlinear texts to assist in learning of the Bible and biblical languages. The dataset can also be used to evaluate morphological parsers and aligners and to study translation divergencies.

#### Market Value

The alignment-based methodology for producing a bilingual concordance was effective for producing a two-volume handbook in a reasonable amount of time (total 2,000 pages, 300,000 entries). The current work will be a predecessor for further aligned parallel Bibles.

#### Alignment Methodology

The LinkPlus editor was
one of the pioneering efforts to speed up manual bitext alignment. Since then, several alignment editors have been developed:

- the PLUG editor (Merkel, 1999) was one of the earliest alignment editors,
- the I*Link editor (Ahrenberg et al., 2002; Ahrenberg et al., 2003) was interactive but restricted to continuous segments,
- the Blinker editor (Melamed, 1998b; Melamed, 1998a) aligned at the level of word groups,
- LinES (Ahrenberg, 2007) was designed for extracting 1-1 correspondencies, and
- the Alpaco_sp editor (Lambert et al., 2005b) supported confidence labels.

Although LinkPlus was text-based and used file formats that are not used today, it would still be one of the most advanced tools if made available for graphical operating systems.

Confidence levels. It is arguable that the LinkPlus editor supported three confidence levels (epsilon, aux, and core links) in links as proposed later (null, possible, sure) by Lambert et al. (2005b). Holmqvist and Ahrenberg (2011) argues that such graded links are particularly suited for use in gold standards.

Granularity. We are not aware of similar granularity at the level of morphemes for any bitext alignment effort, except in interlinear morphological glossing or in alignment of semantic annotations (Saphra and Lopez, 2015).

Further research. In further research, it would be interesting to compare our guidelines with the most recent linguistically designed word alignment guidelines (Li et al., 2008; Li et al., 2014). Another challenge for future research would be to evaluate the inter-annotator agreement under our alignment guidelines. Especially gloss extractors are subject to further validation and correction.

8. Conclusion
We have described here an effort to produce an aligned parallel Bible and to convert the produced alignment dataset into a free resource. The free dataset contains two bitexts: the Finnish 1933 translation of the HB according Codex Leningradensis and the Finnish 1938 translation based on Nestle 1904. The HELFI alignment is released under the CC-BY 4.0 licence on GitHub18, while other components of the HELFI Corpus19 are only redistributed under their existing licenses.

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