

# Linked Open Data Service about Historical Finnish Academic People in 1640–1899

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**Abstract.** The Finnish registries “Ylioppilasmatrikkeli” 1640–1852 and 1853–1899 contain detailed biographical data about virtually every academic person in Finland during the respective time periods. This paper presents first results on transforming these registries into a Linked Open Data service using the FAIR principles. The data is based on the student registries of the University of Helsinki, formerly the Royal Academy of Turku, that have been digitized, transliterated, and enriched with additional data about the people from various other registries. Our goal is to transform this largely textual data into Linked Open Data using named entity recognition and linking techniques, and to enrich the data further based on links to internal and external data sources and by reasoning new associations in the data. The data will be published as a Linked Open Data service on top of which a semantic portal “AcademySampo” with tools for searching, browsing, and analyzing the data in biographical and prosopographical research are provided.

**Keywords:** Biographies, Prosopography, Social Networks.

## 1 Biographical Dictionaries on the Web

Biographical dictionaries [20] have been published traditionally as printed book series. In 2004, the Oxford Dictionary of National Biography<sup>3</sup> (ODNB) was published on-line, and many major biographical dictionaries started to open their editions on the Web with search engines for finding and (close) reading biographies of interest.<sup>4</sup>

ODNB and other early adopters of web technology started the paradigm shift in publishing and reading biographical dictionaries on the Web. Related to our work on *BiographySampo – Finnish biographies on the Semantic web* [16] we have proposed that the next paradigm shift is to publish and use biographical dictionaries as Linked Data on the Semantic Web with integrated tooling for Digital Humanities research. [17] This paper presents first results of a new case study where this idea is applied to a new

<sup>3</sup> <https://www.oxforddnb.com>

<sup>4</sup> On-line national biographical collections include, e.g., USA’s American National Biography [1], Germany’s Neue Deutsche Biographie [4], France’s Nouvelle Biographie générale [5], Biography Portal of the Netherlands [2], Dictionary of Swedish National Biography [3], and National Biography of Finland<sup>5</sup> (NBF).

dataset: the Finnish registries “Ylioppilasmatrikkeli” 1640–1899<sup>6</sup> that contain short biographical descriptions of 28 000 students of the University of Helsinki<sup>7</sup>, originally the Royal Academy of Turku<sup>8</sup> in Finland. These registries cover a significant part of the history of Finland and the Finnish university institution, since the University of Helsinki was the only university in the country during the time frame in focus.

This paper presents an overview of research underway<sup>9</sup>, addressing the problem of transforming biographical registers into Linked Data, and enriching their contents using Named Entity Recognition and Linking and by reasoning. The focus of this paper is on the data transformation process; application of the data in Digital Humanities research using a semantic portal “AcademySampo”, a new member in the “Sampo” series of portals [14], will be reported later. We first present the source dataset and the ontology model used for representing the biographical data in a semantic, i.e., machine “understandable” way. After this the underlying knowledge graph is discussed and its publication using the Linked Data Finland platform [18]. In conclusion, related works are discussed and relations of the work in a larger setting are summarized.

## 2 Source Datasets

An example of a registry entry for *Anders Israel Cajander*<sup>10</sup> is depicted in Fig. 1. The description starts with date or year of enrollment, in this case *11.2.1830*. After that there is the full name followed by the place and time of birth. Next there is a Finnish abbreviation *Vht* meaning parents; in the example case the father is *Zachris Johan Cajander* and the mother *Gustava Karolina Neiglick*. After that there are two lists of events: the events mentioned before the em dash (—) are related studies and academic career in the University of Helsinki. For example: *Ylioppilas Helsingissä 11.2.1830*. (A student in Helsinki 11.2.1830). After the em dash there is another list of events during his career; e.g. *Äyräpään tuomiokunnan tuomari 1857* (Judge at the District Court of Äyräpää 1857). A person’s death is marked with the symbol † and burial with ‡; the person in this example died in Wyborg on December 18th, 1901.

After the life time description there is a possible field for relatives. In the example case his spouse is mentioned first as *Pso: 1841 Fredrika Emelie Schildt* where *Pso* is a Finnish abbreviation for *puoliso* (spouse). There are three relatives who also have an entry in the register, e.g. two brothers *Veli: Gustaf Adolf Cajander* and *Veli: Zakarias Cajander*, and a brother-in-law *Lanko: Berndt Vilhelm Kristoffer Schildt*. The author of the 1640–1852 dataset Yrjö Kotivuori has manually added links from the description texts to the relatives also found in the register, like the three relatives in the example case. Finally, at the end of the description there is a list of reference material used for collecting information about the person.

<sup>6</sup> The registry contains two parts: the database covering the years 1640–1852 is available in Finnish and Swedish at <https://ylioppilasmatrikkeli.helsinki.fi>, and the registry of 1853–1899 is at <https://ylioppilasmatrikkeli.helsinki.fi/1853-1899>

<sup>7</sup> [https://en.wikipedia.org/wiki/University\\_of\\_Helsinki](https://en.wikipedia.org/wiki/University_of_Helsinki)

<sup>8</sup> [https://en.wikipedia.org/wiki/Royal\\_Academy\\_of\\_Turku](https://en.wikipedia.org/wiki/Royal_Academy_of_Turku)

<sup>9</sup> Project description page (in Finnish) <https://seco.cs.aalto.fi/projects/yo-matrikkelit/>

<sup>10</sup> <https://ylioppilasmatrikkeli.helsinki.fi/henkilo.php?id=14689>

When designing the ontology model we wanted it to provide answers to possible research questions made by historians, such as: “Are there marriages between second cousins?”, “Are there families that are closely connected by marriages?”, and “What is the distance between the place of birth and the most long-term place of living, and what are the mean and the standard deviation of this measure?”.

11.2.1830 **Anders Israel Cajander 14689**. \* Leppävirralla 24.2.1811. Vht: Savon alisen kihlakunnan kruununvouti *Zachris Johan Cajander* (†1862) ja *Gustava Karolina Neiglick*. Kuopion triviaalikoulun oppilas 4.2.1822 – 22.6.1826 (betyg). Viipurin lukion oppilas 17.9.1827 – 1.7.1829. Ylioppilas Helsingissä 11.2.1830 (arvosana approbatur cum laude äänimäärällä 14). Viipurilaisen osakunnan jäsen 12.2.1830 *12/2 1830 \ Anders Israel Cajander \ 24/2 1811 \ KronoFogden Zachr. Joh. Cajander i Randasalmi \ Leppävirta \ [med betyg] fr. Gymn. i Wiborg \ Uttog betyg d. 12/10 1833 för att ingå vid Rättegångsverken*. Merkitty oikeustieteellisen tiedekunnan nimikirjaan 9.10.1832. Savokarjalaisen osakunnan perustajajäsen 1833 *Anders Israël Cajander*. Tuomarintutkinto 10.12.1833. Vaasan hovioikeuden auskultantti 24.12.1833. — Varatuomari 1837. Kihlakunnantuomarin arvonimi 1847. Äyräpään tuomiokunnan tuomari 1857, Jääsken tuomiokunnan 1870, Rannan tuomiokunnan 1877, ero 1891. Hovioikeudenasessorin arvonimi 1868. Laamannin arvonimi 1870. Valtiopäivämies 1872. †Viipurissa 18.12.1901.

Pso: 1841 *Fredrika Emelie Schildt* (†1892).

Veli: Räisälän kappalainen *Gustaf Adolf Cajander 15376* (yo 1835, †1882).

Veli: kirjailija *Zakarias Cajander 16147* (yo 1843, †1895).

Lanko: lääninmetsänhoitajan apulainen *Berndt Vilhelm Kristoffer Schildt 14968* (yo 1832, †1892).

Viittauksia: HYK ms., Savokarj. osak. matr. #22; HYK ms., Viip. osak. matr. III #2037; HYKA, Album 1817–65 s. 230; HYKA OTA Ba, Oikeustieteellisen tiedekunnan nimikirja 1828–72 s. 19; KA Ansioluettelokokoeelma. — T. Carpelan, Studentmatrikel (1928–30) s. 12; Matrikel öfver ungdomen vid Kuopio Trivialskola [1816–42]. Aarni 10 (1958) #572; H. Hornborg och I. Lundén Cronström, Viborgs gymnasium 1805–1842. Biografisk matrikel. SLS 388 (1961) #311. — K. F. J. Schauman, Finlands jurister (1879) #35; H. J. Boström, Wasa Hofrätts auskultanter 1776–1876. SSV 5 (1921) s. 94–133 #293; H. Holmberg, Suomen tuomiokunnat ja kihlakunnantuomarit (1959) s. 236.

**Fig. 1.** Register entry for *Anders Israel Cajander*.

### 3 Ontology Model for Representing Biographical Data

In addition to basic biographical data, such as people’s names and dates and places of birth and death, the source data provides rich content of information, such as the relatives, student nation, academic degrees, career events, and sources of reference. In our case we selected the data harmonization approach and the event-centric CIDOC CRM [8] ISO standard as the ontological basis, since biographies are based on life events. We used Bio CRM [29], a domain specific extension of CIDOC CRM, applicable to biographical data. It extends CIDOC CRM by introducing role-centric modeling. Bio CRM has been developed and used in our earlier projects on Norssi High School Alumni [15,26] and BiographySampo [17,24] to model roles and occupations as well as the relationships between people.

The ontology schema is depicted in Fig. 2. The people in the register are represented as instances of the class `:Person` and the mentioned relatives using `:Referenced-Person`. The resources of actor classes are enriched with lifetime events and relationships. Events, e.g. birth, baptism, enrollment, death, and burial, are subclasses of

crm:E5\_Event and enriched with linking to corresponding times, places, and titles. The source data provides two kind of binary relationships: family relations (such as *parents, children, spouses, ...*) and domain-specific relations (such as *student, teacher, ...*). Fig. 3 depicts an example of converted RDF in Turtle format.

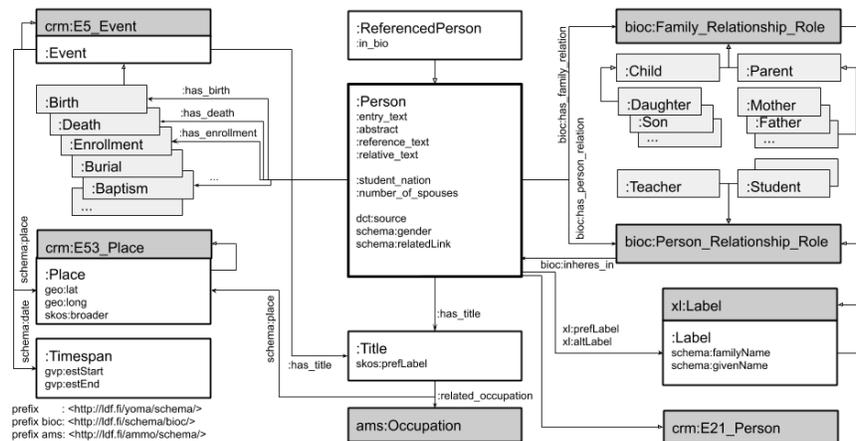


Fig. 2. Ontology schema for representing biographical data.

## 4 Knowledge Graph of Historical Academic Persons

The extracted knowledge graph contains currently 28 000 students and 53 700 other people mentioned in the descriptions. These person resources are further enriched with 175 000 life time events and interlinked by 109 000 family and 3950 academic relations. There are 10 400 distinct occupational titles often referring to a place and an occupation, e.g., *the Bishop of Porvoo* or *Diving Commissioner who lived in Espoo*.

This information was extracted from the person description texts (cf. Fig. 1), which are structured with symbols (like † or ‡) and keywords (like *Vht* for parents or *Pso* for spouse) that aided recognizing the content of each particular text field. To process the data, regular expressions, vocabularies of Finnish names, and a Python script recognizing different expressions of dates and times were used. Vocabularies of Finnish names were also used to infer a person's gender, when it was not otherwise obvious. In particular, the person data is strongly male dominated and the first female student entered the University of Helsinki in the year 1870<sup>11</sup>.

The dataset contains an ontology of more than 100 types of family relations. Most of the mentions are close relatives like *father* and *brother*, but occasionally there are, e.g., in-law-relations like *stepfather-in-law*, relations marked as potential with a question

<sup>11</sup> Women at the University of Helsinki (in Finnish) <http://www.helsinki.fi/yliopistonhistoria/yliopisto/nostot/naiset.htm>

```

@prefix dct: <http://purl.org/dc/terms/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix schema: <http://schema.org/> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .
@prefix xl: <http://www.w3.org/2008/05/skos-xl#> .

@prefix : <http://ldf.fi/yoma/> .
@prefix bioc: <http://ldf.fi/schema/bioc/> .
@prefix event: <http://ldf.fi/yoma/event/> .
@prefix label: <http://ldf.fi/yoma/label/> .
@prefix rels: <http://ldf.fi/yoma/relations/> .
@prefix s: <http://ldf.fi/yoma/schema/> .
@prefix titles: <http://ldf.fi/yoma/titles/> .

:p14689 a s:Person ;
  bioc:has_family_relation
    rels:r2590153968717837790 ,
    rels:r3067073318077691085 ,
    ... rels:r2556529631795161483 ;
  s:abstract "<strong>Cajander, Anders Israel </strong>,
  laamanni (yo 1830, † 1901)"@fi ;
  s:entry_text "11.2.1830 <strong>Anders Israel
  Cajander</strong> <a href= ...
  ... († 1892).</p>"@fi ;
  s:has_birth event:b14689 ;
  s:has_death event:d14689 ;
  s:has_enrollment event:e1961333836730594986 ;
  s:has_title titles:v7140446880754877544 ;
  s:title_text "laamanni" ;
  s:number_of_spouses 1 ;
  s:reference_text "HYK ms., Savokarj. osak. matr. #22;
  HYK ms., Viip. osak. matr. III #2037;
  ... (1959) s. 236."@fi ;
  s:relative_text "<p>Veli: Räsälän kappalainen <em>
  Gustaf Adolf Cajander</em>
  ... (yo 1832, † 1892).</p>"@fi ;
  dct:source :yo1640_1852 ;
  schema:gender schema:Male ;
  schema:relatedLink
  <://ylioppilasmatrikkeli.helsinki.fi/henkilo.php?id=14689> ;
  skos:prefLabel "Cajander, Anders Israel (1811–1901)"@fi ;
  xl:prefLabel label:l2728541252431989123 .

```

**Fig. 3.** RDF/Turtle data for *Anders Israel Cajander*.

mark *son-in-law*(?), or relations reaching over several generations like *uncle of the great great grandfather*. We extended our earlier ontology [26] to cover at least 99% of the mentioned relationships. The data of the years 1640–1852 contains a dense network of precise relations while in the 1853–1899 data only parents and spouses are mentioned. One of the future aims is to computationally extend the network to cover also the persons of the 1853–1899 dataset. In this work a machine learning approach will be taken and we will use the manually added linkage as training data.

The knowledge graph contains links to 2000 occupations in the ontology of historical occupations AMMO [21] and to 2600 place resources in an ontology of historical places. The place ontology is based on the one used in BiographySampo covering the most of Finnish towns and municipalities and most frequently mentioned places abroad. The

data will be further supplemented with ontologies of student nations, periods of different rectorates, and historical reference documents used as sources of information.

At this stage of work, the data has been manually validated, e.g., by making SPARQL queries or by converting the network into GraphML format [12] with the Python library NetworkX [13] and by rendering it with software tools, such as Gephi [6]. Using the SPARQL queries we tested, e.g., that the years of people's birth, enrollment, and death with ages at each stage were all in a sensible range. This helped us to detect, e.g., occasional false date or time span recognitions of our system. An example of using the

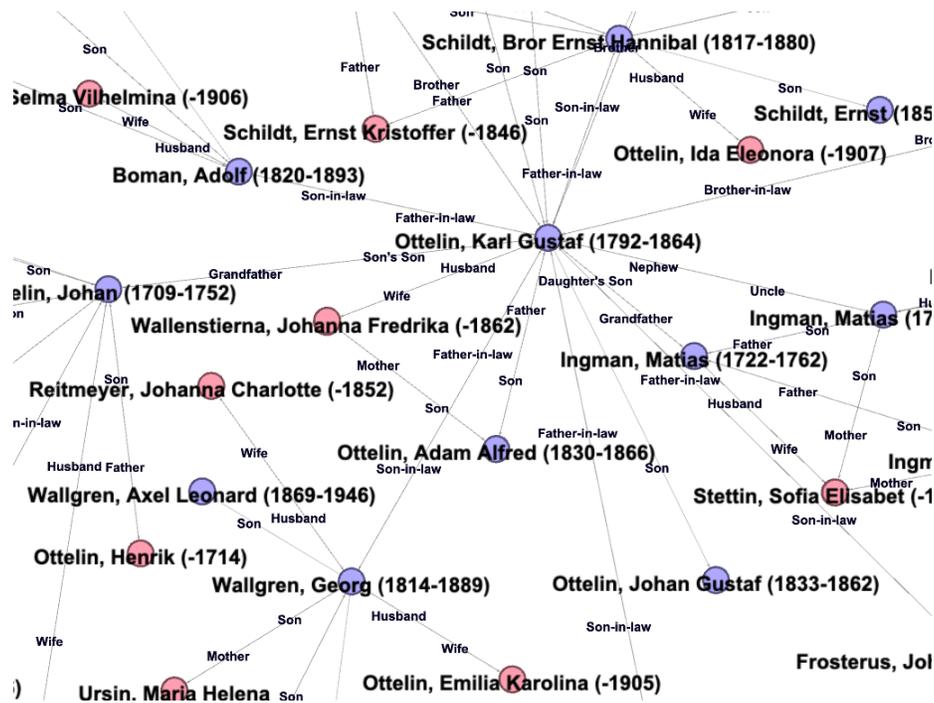


Fig. 4. Family relationships of the example person Karl Gustaf Ottelin.

data service for visualizations is shown in Fig. 4, with the rich network of the family relationships of Karl Gustaf Ottelin (1792–1864). The people with an entry in the student register are marked with bluish and their mentioned relatives with reddish nodes. From the relationship network we also detected a family line of university students reaching over seven generations of fathers and sons.

A test version of the knowledge graph was published using the “7-star” Linked Data Finland model and platform (LDF.fi)<sup>12</sup>. LDF.fi extends Tim Berners-Lee’s famous 5-star model<sup>13</sup> by two additional stars: the 6th star is given, if the dataset is published with the

<sup>12</sup> <http://ldf.fi>

<sup>13</sup> <https://5stardata.info/en/>

schemas it conforms to. The 7th star is given if an analysis of the quality of the data with respect to the schemas is provided, too [18].

## 5 Related Work and Discussion

The Semantic Computing Research Group (SeCo) at Aalto University and University of Helsinki (HELDIG) has made earlier Linked Data publications collecting data about people in the history of Finland and beyond, including the WarSampo actor ontology [25], BiographySampo, U.S. Congress Legislators [27], and Norssit High School Alumni registry [15]. The work of this paper is a continuation of these projects and further a part of a more comprehensive project of assembling an ontology of historical people in Finnish history, an important part of the Linked Open Data Infrastructure for Digital Humanities in Finland<sup>14</sup> [19].

Representing and analyzing biographical data has grown into a new research and application field, reported, e.g., in the Biographical Data in Digital World workshops BD2015 [7], BD2017 [10], and BD2019. In [23], analytic visualizations were created based on U.S. Legislator registry data, and the Six Degrees of Francis Bacon system<sup>15</sup> [30,22] utilizes data of the Oxford Dictionary of National Biography. Extracting Linked Data from texts has been studied in several works, cf. e.g. [11]. In [9], language technology was applied for extracting entities and relations in RDF using Dutch biographies in the BiographyNet, as part of the larger NewsReader project [28].

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## References

1. American National Biography (2017), <http://www.anb.org/aboutanb.html>.
2. Biography Portal of the Netherlands (2017), <http://www.biografischportaal.nl/en>.
3. Dictionary of Swedish National Biography (2017), <https://sok.riksarkivet.se/Sbl/Start.aspx?lang=en>.
4. Neue Deutsche Biographie (2017), [http://www.ndb.badw-muenchen.de/ndb\\_aufgaben\\_e.htm](http://www.ndb.badw-muenchen.de/ndb_aufgaben_e.htm).
5. Nouvelle Biographie générale (2017), [https://fr.wikipedia.org/wiki/Nouvelle\\_Biographie\\_generale](https://fr.wikipedia.org/wiki/Nouvelle_Biographie_generale).
6. Bastian, M., Heymann, S., Jacomy, M.: Gephi: an open source software for exploring and manipulating networks. In: Third international AAAI conference on weblogs and social media (2009).

<sup>14</sup> <https://seco.cs.aalto.fi/projects/lodi4dh/>

<sup>15</sup> <http://www.sixdegreesoffrancisbacon.com>

7. ter Braake, S., Anstke Fokkens, R.S., Declerck, T., Wandl-Vogt, E. (eds.): *BD2015, Biographical Data in a Digital World 2015*. CEUR Workshop Proceedings, Vol-1399 (2015), <http://ceur-ws.org/Vol-1272/>
8. Doerr, M.: The CIDOC CRM—an ontological approach to semantic interoperability of metadata. *AI Magazine* 24(3), 75–92 (2003).
9. Fokkens, A., ter Braake, S., Ockeloen, N., Vossen, P., Legêne, S., Schreiber, G., de Boer, V.: *BiographyNet: Extracting Relations Between People and Events*. In: *Europa baut auf Biographien*. pp. 193–224. New Academic Press, Wien (2017).
10. Fokkens, A., ter Braake, S., Sluijter, R., Arthur, P., Wandl-Vogt, E. (eds.): *BD2017 Biographical Data in a Digital World 2015*. CEUR Workshop Proceedings, Vol-1399 (2017), <http://ceur-ws.org/Vol-2119/>
11. Gangemi, A., Presutti, V., Recupero, D.R., Nuzzolese, A.G., Draicchio, F., Mongiovì, M.: Semantic web machine reading with FRED. *Semantic Web* 8, 873–893 (2017).
12. GraphML Team: The GraphML File Format, <http://graphml.graphdrawing.org/>, last accessed 2019/09/30.
13. Hagberg, A., Swart, P., S Chult, D.: *Exploring network structure, dynamics, and function using networkx*. Tech. rep., Los Alamos National Lab.(LANL), Los Alamos, NM (United States) (2008).
14. Hyvönen, E.: “Sampo” model and semantic portals for Digital Humanities on the Semantic Web. In: *Proc. of the Digital Humanities in the Nordic Countries (DHN 2020)*. CEUR WS Proceedings (2020), forth-coming.
15. Hyvönen, E., Leskinen, P., Heino, E., Tuominen, J., Sirola, L.: Reassembling and enriching the life stories in printed biographical registers: Norssi high school alumni on the semantic web. In: *Language, Technology and Knowledge*. pp. 113–119. Springer-Verlag (2017).
16. Hyvönen, E., Leskinen, P., Tamper, M., Rantala, H., Ikkala, E., Tuominen, J., Keravuori, K.: *BiographySampo – publishing and enriching biographies on the semantic web for digital humanities research*. In: *Proceedings of the 16th Extended Semantic Web Conference*. Springer-Verlag (2019).
17. Hyvönen, E., Leskinen, P., Tamper, M., Rantala, H., Ikkala, E., Tuominen, J., Keravuori, K.: *Linked Data – A Paradigm Change for Publishing and Using Biography Collections on the Semantic Web*. In: *Proceedings of the Third Conference on Biographical Data in a Digital World (September 2019)*.
18. Hyvönen, E., Tuominen, J., Alonen, M., Mäkelä, E.: *Linked Data Finland: A 7-star model and platform for publishing and re-using linked datasets*. In: Presutti, V., Blomqvist, E., Troncy, R., Sack, H., Papadakis, I., Tordai, A. (eds.) *The Semantic Web: ESWC 2014 Satellite Events*. ESWC 2014. pp. 226–230. Springer-Verlag (May 2014), [https://doi.org/10.1007/978-3-319-11955-7\\_24](https://doi.org/10.1007/978-3-319-11955-7_24)
19. Hyvönen, E.: *Linked open data infrastructure for digital humanities in finland*. In: *Proc. of the Digital Humanities in the Nordic Countries (DHN 2020)*. CEUR WS Proceedings (2020), forth-coming.
20. Keith, T.: *Changing conceptions of National Biography*. Cambridge University Press (2004).
21. Koho, M., Gasbarra, L., Tuominen, J., Rantala, H., Jokipii, I., Hyvönen, E.: *AMMO Ontology of Finnish Historical Occupations*. In: *Proceedings of the The First International Workshop on Open Data and Ontologies for Cultural Heritage (ODOCH'19)*. vol. 2375, pp. 91–96. CEUR Workshop Proceedings (June 2019), <http://ceur-ws.org/Vol-2375/>, vol 2375.
22. Langmead, A., Otis, J., Warren, C., Weingart, S., Zilinski, L.: *Towards interoperable network ontologies for the digital humanities*. *Int. J. of Humanities and Arts Computing* 10(1), 22–35 (2016).
23. Larson, R.: *Bringing lives to light: Biography in context (2010)*, Final Project Report, University of Berkeley, [http://metadata.berkeley.edu/Biography\\_Final\\_Report.pdf](http://metadata.berkeley.edu/Biography_Final_Report.pdf)

24. Leskinen, P., Hyvönen, E.: Extracting genealogical networks of linked data from biographical texts. In: Proceedings of the 16th Extended Semantic Web Conference (ESWC 2019). Springer-Verlag (2019).
25. Leskinen, P., Koho, M., Heino, E., Tamper, M., Ikkala, E., Tuominen, J., Mäkelä, E., Hyvönen, E.: Modeling and using an actor ontology of second world war military units and personnel. In: d'Amato, C., Fernandez, M., Tamma, V., Lecue, F., Cudré-Mauroux, P., Sequeda, J., Lange, C., Heflin, J. (eds.) Proceedings of the 16th International Semantic Web Conference (ISWC 2017). pp. 280–296. Springer-Verlag (October 2017), [https://doi.org/10.1007/978-3-319-68204-4\\_27](https://doi.org/10.1007/978-3-319-68204-4_27)
26. Leskinen, P., Tuominen, J., Heino, E., Hyvönen, E.: An ontology and data infrastructure for publishing and using biographical linked data. In: Proceedings of the Workshop on Humanities in the Semantic Web (WHiSe II). CEUR Workshop Proceedings (October 2017).
27. Miyakita, G., Leskinen, P., Hyvönen, E.: Using linked data for prosopographical research of historical persons: Case U.S. Congress Legislators. In: 7th International Conference, EuroMed 2018, Proc., Part II. pp. 150–162. Springer-Verlag (2018).
28. Rospocher, M., van Erp, M., Vossen, P., Fokkens, A., Aldabe, I., Rigau, G., Soroa, A., Ploeger, T., Bogaard, T.: Building event-centric knowledge graphs from news. *Web Semantics: Science, Services and Agents on the World Wide Web* 37, 132–151 (2016).
29. Tuominen, J., Hyvönen, E., Leskinen, P.: Bio CRM: A data model for representing biographical data for prosopographical research. In: *Biographical Data in a Digital World (BD2017)* (2017), <https://doi.org/10.5281/zenodo.1040712>
30. Warren, C., Shore, D., Otis, J., Wang, L., Finegold, M., Shalizi, C.: Six degrees of Francis Bacon: A statistical method for reconstructing large historical social networks. *Digital Humanities Quarterly* 10(3) (2016).