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## Linked open data portals: Functionalities and user experience in semantic catalogues

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### Abstract

**Purpose** - This study seeks to understand the current state of development of Linked Open Data (LOD) bibliographic portals to discuss their functionalities, contributions, value-adds, and user experience.

**Design/methodology/approach** - A set of evaluative aspects grouped into three analysis dimensions was established: Collections, Tools—technologies and standards used—and Web user interface. As the object of the study, four projects of diverse nature and volume were selected to help provide a better understanding of the trends in the solutions provided for the end user when accessing linked data collections.

**Findings** - Publishing linked open data through visual interfaces maximises information enrichment, contextualisation, and discovery, in addition to improving user experience, because of both increased navigation capabilities and interrelationships between data. These more flexible environments have metamorphosised the visualisation of bibliographic information. However, aspects that needed improvement were observed, primarily relating to (a) a more intuitive interaction, (b) possibilities of greater personalisation, (c) enhanced communication with the user to favour user engagement, and (d) experimental spaces of data reuse.

**Research limitations/implications** - Further quantitative and qualitative studies should be conducted to improve these portals, assess their adaptation to the behaviour of the user, and their influence on the use of library collections.

**Originality/value** - This article investigates the potential of semantic technologies in bibliographic data portals, proposes a methodological model for their evaluation, and advances conclusions about the usability and user experience that these platforms provide, compared to classic catalogues.

**Keywords:** Information discovery, Information search and retrieval, Linked Open Data, User experience, User interface, Semantic web.

**Paper type** - Research paper.

## 1. Introduction

In recent years, the cultural heritage community has endeavoured to redefine traditional data models based on semantic data technology. Libraries, archives, museums, and galleries have been embracing projects that focus on the publication of data, metadata, and vocabularies applying the ‘Linked Open Data’ model, a specific concretion of the Semantic Web concept aimed at representing information in a Resource Description Framework (RDF), using Uniform Resource Identifiers (URIs), and adopting the search language in RDF and SPARQL data (Berners-Lee, 2009).

The documents and metadata possessed by these institutions, particularly libraries, show a high level of structuring. In the library field, the significance of linked data was further reinforced in 2004, when the World Wide Web Consortium (W3C) recommended that libraries publish their data using Semantic Web technologies to improve their digital impact and social utility (Hallo *et al.*, 2016).

Among the advantages of the application of this model for memory institutions, as indicated in the final report of the W3C Incubator Group (Library Linked Data Incubator Group, 2011), the following are prominent: the advanced visibility of the collections, reuse of data, improvement in the cataloguing processes, collaboration with other data-generating communities, and the reduced costs for the institutions.

Data published as linked data are designed to be understood by machines and used by applications that need them to generate new resources and services through mass downloads or selective data queries employing SPARQL access points or other technologies. Linked data are about exploiting library data to show their strategic value within the interoperable data web. Equally relevant is the integration of the linked data paradigm with the standardisation initiative [Schema.org](http://Schema.org).<sup>1</sup>

Parallel to the standards emerging from the Semantic Web, alternatives from the catalogue field have also converged, specifically Resource Description and Access (RDA), based on the conceptual model Functional Requirements for Bibliographic Records - Library Reference Model (FRBR-LRM), that upscales libraries to the linked data scenario. A sizable number of linked data projects use FRBR both as a conceptual reference model and a data model. Bibliographic Framework (BIBFRAME)<sup>2</sup>, a model proposed as the evolution of the MARC 21 format to the Semantic Web and linked open data, deserves special mention, as there is harmonisation between the RDA guidelines and the entities, and between attributes and relationships of its LRM conceptual model and the classes and properties (corresponding to characteristics and relationships) of BIBFRAME. The vocabulary used in BIBFRAME is based on RDF classes and properties for exchanging data on the web. This framework extends the link structure of the web through the use of triplets or RDF sentences and declarations about web resources in the form of subject-predicate-object expressions, each identified through a URI (Kroeger, 2013; Senso and Arroyo Machado, 2018; Taniguchi, 2018; Willer and Dunsire, 2013; Xu *et al.*, 2018).

Numerous platforms implement these semantic technologies in the library field, and the number of projects based on LOD is on the increase. An international survey by OCLC Research in 2018 collected 104 linked data projects or services, despite the fact that the survey itself highlights the great learning curve expected from the staff as the main barrier for the publication of linked data (Smith-Yoshimura, 2018).

Altogether, the transition from experimental prototypes and initiatives to routine implementation will need to go hand in hand with the generation and presentation of linked data integrated into library management programs and discovery tools. For Senso and Arroyo

Machado (2018), the abiding factor in most of these projects that appealed to them was the fact that they were developed by large institutions, in many cases with the help of a third party (company or university). Recently, OCLC announced that, thanks to funding from the Mellon Foundation, it is planning to develop infrastructure to support linked data management initiatives.<sup>3</sup> We agree with Wang and Yang (2018), who argue that it will not be easy to transform the vast amount of data catalogued over forty years into linked data. Library ontologies and vocabularies are complex, and a significant amount of time is necessary to complete the transformation.

According to Cormenzana López and López-Borrull (2018), the benefits of the new cataloguing paradigm will become more evident when BIBFRAME enters the scene playing a leading role such that linked data will become an inherent part of the library management environment, and it will no longer be executed through transformation of information stored in library repositories. Overall, there are significant efforts ongoing to convert and enrich MARC records, with the solid SHARE-VDE<sup>4</sup> project having converted, reconciled, and enriched one hundred million bibliographic and authority records with external sources.

In this sense, Agenjo-Bullón and Hernández-Carrascal (2019, 2020) suggest that the transition stage of LOD towards productivity is underway. Although the path to overcome MARC 21 has opened, a consensual system that guarantees bibliographic normalisation has not yet been attained. BIBFRAME, thus, will not be the only bibliographic data structure; it will coexist with other data structures such as Schema.org, Europeana Data Model (EDM), and others. Responding to the concern regarding the different linked data conceptual models generating choice in the library field, Zapounidou, Sfakakis, and Papatheodorou (2017) clarify that they compare and seek convergences that guarantee interoperability among four models: FRBR, FRBRoo (object oriented version of FRBR), BIBFRAME, and EDM.

Undoubtedly, the ultimate goal of linked data is to make the links between collections and objects explicit. Van Hooland and Verborgh (2014: 197–203) point out that the challenge in publishing the contents lies in serving different users with the least possible effort; in this regard, depending on the target audience, one or multiple publication formats would be used: HTML, JSON, and RDF, among others. According to Smith-Yoshimura (2018), the most commonly used open data serialisation is RDF/XML, and the predominant access formats are web pages, followed by data dumps, content negotiation, and SPARQL endpoint.

Conversely, regarding search interfaces, in recent decades, there have been significant changes that have transformed the way users interact with systems and the user experience as a whole. However, changes in the design of bibliographic information systems, including library catalogues, have not been as significant as expected. Salaba and Merčun (2018) review the literature on the impact of the FRBR conceptual model in representing bibliographic data as well as in relation to the investigations on bibliographic information visualisation, appreciating some experimental attempts and some actual implementations of FRBR. However, the implementation of the *FRBR-visual* prototype demonstrates how semantic relationships among bibliographic entities could be organised and different expressions of the same work could be presented (Merčun *et al.*, 2016, 2017).

We agree with Wang and Yang (2018) that the OCLC and other national libraries are leading important linked data projects, while most small libraries watch closely for prototypes that demonstrate the benefits of publishing data as linked data. Wang and Yang also point out that ‘many librarians still cannot imagine what the future semantic catalogue will look like and how it will work’. However, despite these difficulties, a determined commitment to linked data and clear progress in its publication can be observed in the library field.

In this context, this study examines the end user solutions that have been adopted by institutions involved in linked open data projects. Among the opportunities and advantages that the adoption of this model implies for the end user, the literature specifically details better experience, contextualisation of information, and a multilingual dimension or advances in rigor and interdisciplinarity in the research activity thanks to the enrichment of information (Cole *et al.*, 2017; Feitosa *et al.*, 2018; Hallo *et al.*, 2016; Konstantinou *et al.*, 2014; Library Linked Data Incubator Group, 2011; Mitchell, 2016; Simon *et al.*, 2013). Among the advantages of linking data that appear in bibliographic records with other datasets, Senso and Arroyo Machado (2018) highlight the fact that linking data favours the development of mashups and facilitates the modelling of objects/entities of interest related to a bibliographic resource, such as people, places, events, and topics.

In their work, Candela *et al.*, (2019) explain that the traditional online access to the Miguel de Cervantes Virtual Library (*Biblioteca Virtual Miguel de Cervantes - BVMC*) offers a human-readable representation of the catalogue, but a restricted information retrieval system due to the limitations of the original catalogue records. The publication of the datasets as LOD supports external use and exploitation of data, opening many possibilities for users to explore and interact with the catalogue in new contexts, thus improving the discovery capability and connections to other collections. They also add that among the BVMC users, there are many academics and researchers, and their appearance in repositories such as Wikidata<sup>5</sup> and Research and Education Space (RES)<sup>6</sup> can help it to reach a greater number of users.

A case study by Bontcheva, *et al.*, (2015) concludes that the semantic enrichment of bibliographic records with LOD knowledge responds to more complex information needs; in addition, these semantic search interfaces serve to satisfy advanced search needs in an intuitive environment that reduces the learning curve. Additionally, the usability study carried out by Rico *et al.*, (2019) focused on datos.bne.es system, concludes that semantic technologies applied to library catalogues provide an enhancement that helps satisfy user's information needs.

Based on this background, our study analyses the characteristics and user experience provided by linked open data platforms that offer web access to bibliographic collections; this study also proposes a methodological model for their evaluation.

The article is organised in four parts; following this introduction to the contextual framework of the study, the Objectives and methodology section is presented, in which the purpose of the research is clarified apart from describing the methodology employed. The results of the comparison of projects and their analysis are presented in section 3 and finally, the conclusions, including the final reflections on the findings, are listed in section 4.

## **2. Objectives and methodology**

This study seeks to understand the current state of development of linked open data bibliographic portals to discuss their functionalities, contributions, value-adds, and user experience.

The specific objectives of the study are as follows:

- To formalise the criteria for analysing the selected initiatives and observe their implementation.
- To examine the distinctive functionalities of the user interfaces in a sample of linked open data portals of different natures and entities.
- To explore the discovery and retrieval capacity of these portals.

- To assess observable information visualisation trends in this type of bibliographic project.
- To advance conclusions about the usability and user experience offered by these platforms.

The applied methodology considers research works on evaluation of catalogues and digital libraries that present analysis models, which will be used as a reference to systematise the applied indicators (Alvite-Díez, 2009; Fuhr *et al.*, 2007; Kelly, 2014; Merčun and Žumer, 2008; Muller, 2014; Muñoz-Egido and Hernández-Pérez, 2016; Rodríguez-Yunta, 2014; Xie, 2007, 2008; Xie *et al.*, 2018). Three dimensions of analysis have been established to address the relationships among the three basic components of a collection: user–content (linked to utility), content–system (in connection with performance), and user–system (related to usability).

The evaluative aspects of the three dimensions of analysis can be further subdivided as follows:

- a) Presentation of the collection: specifications and details of the content.
  - Project description.
  - Data volume.
  - License.
  - Terms of use.
  - Evolutionary line.
  - Description in other languages.
  - Publications about the project.
  
- b) Tools: technologies and standards used.
  - Platform.
  - Conceptual model.
  - Data models.
  - Vocabularies.
  - Own ontologies.
  - Embedded data.
  - Data retrieval.
  
- c) Web user interface.
 

40 criteria grouped into six aspects:

  - General aspects.
  - Search.
  - Results page and faceted navigation.
  - Semantic enrichment and extension of discoverability.
  - User interaction and personalisation.
  - Other functionalities.

In the tables corresponding to this dimension, the following indicators have been used to describe the presence and degree of compliance with the criteria:

- ++ (very good)
- + (good)
- +/- (present, but very limited)
- – (not present)

As object of the study, four projects of diverse entity, volume, and technologies were selected to help provide a better understanding of the trends in the solutions provided for the end user when accessing linked data collections: Virtual Polygraph Library Ignacio Larramendi (*Biblioteca Virtual de Polígrafos - BVP*),<sup>7</sup> Open Data Catalogue of the Miguel de Cervantes Virtual Library (*Catálogo de Datos Abiertos de la Biblioteca Virtual Miguel de Cervantes - DBVMC*),<sup>8</sup> Bibliographic Data Portal of the National Library of Spain (*Portal de Datos Bibliográficos de la Biblioteca Nacional de España - DBNE*),<sup>9</sup> and DataBnF of the National Library of France (DBNF).<sup>10</sup> The volume of triplets in the referred projects in datahub.io<sup>11</sup> and Linked Open Data Cloud<sup>12</sup> (April 2020) is as follows: BVP: 9540 (only authority data); DBVMC: 13,000,000; DBNE: 58,053,215; and DBNF: 409,712,948.

The BVP was established in 1999 for collecting the work of Spanish, Latin American, Portuguese, and Brazilian thinkers and data are published since 2010 in Semantic web formats (Agenjo-Bullón and Hernández-Carrascal, 2010).

The BVMC was founded in 1999 delivering contents related to Hispanic culture, and in February 2015 the first release of the linked open data website was launched (Candela *et al.*, 2018).

The DBNE took its first steps in 2010; the first set of linked data was created in April 2011 and a representative set in December 2011, the date on which the first version of datos.bne.es was presented (Vila-Suero *et al.*, 2013).

DBNF, the LOD collection of the French National Library, has been available on the web since July 2011 (Simon *et al.*, 2013).

As can be observed, two of the platforms have been developed by large documentary institutions, and the two remaining are considered to be of great interest due to their uniqueness and significance, especially in academic settings.

The exploration of the selected portals was conducted throughout February and March 2020.

### **3. Results**

The results of the study are presented in this section in accordance with the dimensions established in the methodology.

#### **3.1. Presentation of the collections: specifications and details of the contents**

In the first analysis category, essential aspects related to the information provided about the project, volume of the collection, objectives, evolution, terms of use or publications, among others, are investigated.

The BVP presents on its website the unique character of the collection, reorienting the initial digitisation project towards open content and reuse of LOD. The website indicates, at the time of the analysis, the processing of some 900 polygraphs and 1897 polygraph works. The collection is aimed at academia, digital text editors, libraries, website editors in related fields, and aggregators. The web does not contain data rights statements.

The DBVMC warns that this is a version of the Library catalogue on which constant modifications are being made to improve the user experience. In the lower frame of the web page, prominently displayed, there is an epigraph of 'Linked data', which briefly describes the project. The volume of the collection comprises approximately 270,000 records. Regarding the terms of use, the project states that all the available metadata are published free of

restrictions, under the terms of the *Creative Commons CC0 1.0 License*; however, other material are subject to specific rights statements. Five publications about the project are collected from the DBVMC portal, and information about them are available in Spanish and English.

The DBNE is a project developed by the Ontology Engineering Group<sup>13</sup> of the Polytechnic University of Madrid. The purpose of the project is twofold: exploration of bibliographic data away from traditional catalogues and provision of a database available for reuse of data. Data have been obtained from the bibliographic catalogues and from authorities of the BNE; in addition, digitisation data have been collected from the Hispanic Digital Library. The volume stands at 4 million bibliographic resource records and 4 million authority records. The license applied to the data is *CC0*, an open license that is part of the Spanish legislation on the reuse of public sector information.<sup>14</sup> The website dedicates a space to present the evolution of the project. The contents are available in English and French, and literature on the BNE open data project is also presented.

The DBNF, details its objectives within the web page presentation, highlighting the specific interest in increasing the visibility of the data and facilitating its reuse by third parties. The information is available in French, English, and German. Bibliographic information about the project is available, and the issues overcome in each version of the project are detailed in the 'Roadmap'. By June 2016, the volume of the DataBnF project counted with almost complete coverage of good quality data from the catalogues of the French National Library (general catalogue, catalogue of archives and manuscripts, and the *Gallica* digital Library) included about two million authors. Regarding the terms of use, the website indicates that since 2014, descriptive metadata are under an open license subject to the mention of the source and indication of its retrieval date. Major lines of work are outlined for 2019.

As stated in this section, the four projects studied aimed at the publication of catalogues as linked data. In addition, all of them are presented as open proposals, subject to continuous improvement, within which the development of innovative visual interfaces for the presentation of bibliographic data is integrated. The BVP has been selected by the W3C Bibliographic Data cluster as a case study, and it has also been chosen by Europeana as an EDM case study. On its part, the DataBnF website highlights receiving the Stanford Prize for Innovation in Research Libraries (SPIRL) in 2013.

Considering the nature and entity of the original collections, the projects of the two national libraries are the closest; in our opinion, the exhaustiveness of the exhibition of the DataBnF project collected on the web stands out. With the exception of the BVP, the data are subject to an open license policy, free of restrictions, and seek to favour reuse.

No portal usage statistics were found, except for an entry in the Larramendi Foundation website on the growth in the number of visits and downloads the previous year.

### **3.2. Tools: technologies and standards used**

In this second dimension, features related to the technologies that support these collections are observed such as platforms used, conceptual models, data models and vocabularies, embedded standards, and data retrieval.

The BVP has been implemented in the DIGIBIB<sup>15</sup> digital management program of the DIGIBÍS company, a tool based on MARC 21, MARCXML, Dublin Core, METS, MODS, ALTO, EDM, and LOD. The fields of the MARC 21 format have also been adapted to the RDA cataloguing rules. For a functional analysis of this collection, FRBR and the

BIBFRAME initiatives were considered (Agenjo-Bullón and Hernández-Carrascal, 2010). The BVP counts as an SRU server (Search/Retrieve via URL).<sup>16</sup>

The DBVMC applies the FRBR model to the existing records in MARC 21, uses the Apache Jena<sup>17</sup> library (Apache License, Version 2.0) to transform the records in the catalogue into RDF. Sesame<sup>18</sup> (currently Eclipse RDF4J) is used as an RDF repository. The contents of the database automatically migrate to RDF triplets by means of RDA to describe the entities as well as their properties and relationships. To improve interoperability, vocabularies such as Dublin Core, FOAF (Friend Of A Friend), OWL-Time ontology, SKOS (Simple Knowledge Organisation System), and DBpedia Ontology have been used. Regarding embedded data, the project uses Schema.org to facilitate the indexing and search; Open Graph Protocol (OGP) has been used to link pages on the main social networks and Glyphicon Halflings has been used to show the icons. The SPARQL<sup>19</sup> query point was created using Sesame as the database engine and as the HTTP/SPARQL server. Consulting examples are incorporated into the web (Candela *et al.*, 2018).

In DBNE, the Marimba tool has been selected for data transformation, which consists of an application that supports the process of RDF generation from MARC 21 records and its subsequent linking, both internally and externally. The data are hosted on a Virtuoso<sup>20</sup> server, which is accessed through a SPARQL terminal with a Linked Data interface built with the free tool, Pubby.<sup>21</sup> FRBR has been used as a conceptual reference model and a data model. In addition to the FRBR and ISBD properties, other vocabularies such as RDA, Dublin Core, SKOS, or BIBO (Bibliographic ontology) have been used as references. For greater vocabulary control, a proprietary BNE ontology, connected to all these vocabularies, has been implemented. MARC 21 authority and bibliographic records have been mapped with the properties of the ontology. DBNE counts as a SPARQL<sup>22</sup> access point, and it is possible to download large files in RDF format.

DBNF uses the open source platform CubicWeb,<sup>23</sup> a semantic application framework available under the LGPL license, based on the use of RQL (similar to SPARQL) and in the Python programming language. CubicWeb merges data, aligns and regroups them in an SQL database, and supports multiple publication possibilities. DBNF employs FRBR and Schema.org; it also follows the OGP for representing data on social networks. Finally, the data are structured in RDF according to various syntaxes. To promote interoperability, in addition to RDFs, it uses SKOS, Dublin Core, FOAF, RDA, and its ontology, bnf-onto. In terms of data retrieval, it provides several options: click on the RDF icon in the footer; add suffixes to the URL depending on the desired format; negotiate the content through an RDF browser; use SPARQL<sup>24</sup>; or make a large download by means of FTP. Examples of SPARQL queries are also included on the DataBnF website.

A predominance of open technologies can be appreciated in this analysis parameter, based on web standards, monitoring of the FRBR reference framework, and bibliographic standards such as RDA. The BVP is unique, as it is built using a proprietary program from the DIGIBÍS company and does not count as a SPARQL query point. In the case of DBNE, the team from the Polytechnic University of Madrid developed an *ad hoc* tool for the RDF generation process from MARC 21 records and its subsequent linking. It should be highlighted that the two national libraries discussed here have developed their own ontologies. Finally, the aim of improving indexing and search in web engines is particularly specified in the use of Schema.org by the DBVMC and the DBNF.



### 3.3. Web user interface

This dimension has been subdivided into six major items for a better understanding of the solutions provided in these portals and their degree of adaptation to the user informational behaviour and search expectations. It addresses the options provided for navigation and explicit search and solutions adopted for the visualisation and categorisation of the results. Their interaction capabilities with the end user are also investigated. Furthermore, particularly explored are the exploitation of semantic relationships and other functionalities specifically related to the publication of linked open data and its reuse.

#### *General features*

The design of the four portals is consistent, aesthetically pleasing, and similar in terms of the selected colours and fonts. They are clean and fast loading websites. Nevertheless, deficiencies have been observed in the multi-device adaptation of the two national libraries' portals examined; in the case of the DBNF, there was difficulty in reading the home page.

BVP informs the user on the nature of the collection and also guide the user through the search possibilities. The collection can be consulted as a set and also in greater detail, through the thematic or author libraries comprising it.

DBVMC presents an attractive home page that invites the user to discover the LOD catalogue. Both the upper bar and the lower frame include a link that explains the scope of this catalogue. The interface is available in Spanish and English.

In turn, DBNE indicates its interface as beta. It describes the LOD project and invites the user to consult the 'Help' for instructions and search tips. The website highlights that the graphic design has been developed by Amélie Viallet.

DataBnF presents the project within the context of the Semantic Web and the development of open data. The interface presents a box to the right of the search box displaying information about the latest updates to the data model. Likewise, two links are prominently displayed: information about the project and access to download the data.

In the opening paragraph of the DBNE website, the target audience stands out, with library end users and researchers on the one hand and developers of projects related to the Semantic Web on the other. The BNF highlights that this portal aims 'to share the benefits of the work of libraries with citizens by identifying and reporting on the collections they own, including digital collections'. There are no explicit mentions about the target audience for the collections in the rest of the portals.

Regarding help systems, VBP offers help on the retrieval of the language used, typical of classic OPACs. In the DBVMC and in the DBNF, no available help systems were observed in the end user interface; the existing help is directed to SPARQL queries, while DBNE has an extensive Help Guide available in PDF, but only in Spanish.

**Table I. General features**

	BVP	DBVMC	DBNE	DBNF
Consistent and responsive general design	++	++	+	+
Information on the nature and context of the collection	+	+	++	++
Targeted user community	-	-	+	+
Access to help/FAQs	+	-	+	-
Contact mechanisms	+	+	++	++
Interface languages	-	-	-	++

It would be desirable to have some supporting material on the use of the systems, with practical examples and guidance on the criteria for automatic ordering of results, proposed filters, etc. At the time of writing this work, only DBNE provides a help guide.

Regarding the possibility of contacting the platforms, on the BVP, the contact link leads to a general page of the Larramendi Foundation. The contact link in the DBVMC website redirects the user to the Library's general email account. DBNE and DBNF provide specific email accounts for contact, respectively.

Only the DataBnF portal interface is available in multiple languages: French, English, and German.

### ***Search***

BVP, DBNE, and DBNF have an interface that comprises a single search box, however, in the DBVMC, the user has to provide more details using the associated dropdown arrows and then launch a search that is delimited by 'Entity', 'Manifestation', or 'Person', terminology that can be confusing for a non-expert user. In the case of DBNE, in addition, there is an option in the upper portion to access the Advanced Search or delimit the search by four main categories with its own search box: People, Entities, Works, and Topics.

BVP maintains a classic OPAC interface that presents a simple search, which is perhaps confusing given that in it, the text, 'Search for works', appears overwritten and that it also displays an advanced search interface that directs the user to the search by field. The BVP includes the possibility of navigating microsites and specialised informative spaces. Further, browsing alphabetical indexes of polygraphs and polygraphists can be performed.

In its current version, the DBVMC prompts the user to conduct searches by grouping the contents into the following: (1) 'Author pages', (2) 'Works pages'; (3) 'Language pages'; and (4) 'Date pages', wherein all works published on a particular date are shown apart from the authors who were born or had died on that date.

Datos BNE allows browsing by People, Works, and Topics categories. Its 'Advanced Search' interface is designed to launch expert searches by 'Editions', 'People', and 'Entities', although at the moment, it only works for some authors.

DataBnF proposes browsing through the most consulted Authors, Works, and Topics. The interface presents a world map on the home page, which can be navigated to discover the resources on a specific place. Likewise, it is possible to browse the following indexes: Authors, Works, Topics, Places, Dates, Shows, and Periodicals.

**Table II. Search**

	BVP	DBVMC	DBNE	DBNF
Single search box	+/-	-	++	++
Automatic suggestion of terms	-	-	++	++
Detection/autocorrection of spelling/typographical errors	-	-	-	-
Advanced search system	+/-	+/-	+/-	-
Allows initiation of search by navigation	++	-	++	++
Response time	++	++	++	++
Provides full-text search of digitalised works	-	-	-	-

Regarding the automatic suggestion of terms, the autocomplete option is available in DBNF and DBNE. In addition to suggesting terms, both systems indicate whether the proposed terms are Authors, Entities, Works, and/or Topics.

Error self-correction or the possibility of specifying a full-text search has not been observed in any of the tools.

### ***Results page and faceted navigation***

BVP allows for results to be sorted by author, title, date, or relevance. The system uses various icons to distinguish both resource formats as well as the type of access to them. Equally, it provides options to refine the search from the results page; the automatic categories generated are author, subject, period, language, and section.

Conversely, DBVMC does not provide the user the option of sorting the results. Prior to displaying the search results, the system shows the generated SPARQL statement, an element that can cause confusion to the end user. On the ‘Works’ pages, the user can browse the work, its expression (editions and translations), and manifestation. Regarding the categorisation of the results, this system allows the user to navigate in the categories in which the results are grouped for each specific case: ‘Their works’, ‘Works about the author’, ‘Their translations’, ‘Other roles’, ‘Related authors’, and ‘Contemporary authors’.

In DBNE, the typography highlights the requested term in the results, and the category to which it belongs is indicated with a distinctive icon on the right: Works, Entities, People, and Editions. The collection’s help section clarifies that in the search results, some authors or works of special relevance are prominently featured. In the case of particularly significant works, other works by the same author and works related to it (grouped under the ‘Suggestions’ label) are automatically displayed, and the user can choose to display only digitised editions, if any, or select the results in chronological order. In the case of the authors’ pages, following the biographical information, the results appear graphically grouped into three blocks: ‘Author of’; ‘Topic on’, and ‘Participate in’.

DBNF does not offer the user the option of ordering the results. In this portal, the results are automatically grouped into the following categories: Authors, Organisations, Works, Topics, and Periodicals. When the selection is an Author, the system groups the resulting information into Works’, ‘Documents about’, ‘Related to’, and ‘See also’. All authors have an initial biographical space, where, among others, possible variants of their name, languages in which they have written, field to which their works belong, and so on appear.

**Table III. Results page and faceted navigation**

	BVP	DBVMC	DBNE	DBNF
Ordering the results by relevance	+/-	-	++	-
Visible search box	++	++	++	++
Possibility of selecting different systems for ordering the results	++	-	++	-
Navigation facets grouped into recognisable and intuitive categories	++	+/-	++	++
Possibility of returning to the initial navigation page	++	++	++	++
The visibility of the navigation path	-	-	-	+/-
Item information is relevant without resorting to full display	++	++	++	++
Clear distinction of document typology	++	++	++	++
Contextual help	-	-	-	-

In all the portals, a unique search box is available to the user in the results page to start a new search action. In general, self-explanatory icons are used or the categories grouping the materials that identify the various support documents are shown. No contextualised help has been found in any of the portals to support the user in the event of any doubt to continue interacting with the system from the results page. It would be desirable to improve the

implementation of interactive helps to provide assistance while allowing the user to continue the flow of their task.

### ***Semantic enrichment and extension of the discovery capacity***

This section aims to assess the portals' richness in the exploitation of relationships and links, their alignment with other vocabularies, and the potential of the systems to improve the user's ability to discover new information.

BVP systematically employs VIAF, GeoLinkedData, GeoNames, and Wikidata and establishes links with numerous catalogues. The link to DBpedias has been extended in several languages. All subject headings allow navigation between concepts thanks to the integration of the Subject Headings List for Public Libraries - LEMB) published in SKOS. These SKOS records are linked to other subject lists, such as those of the LCSH (Library of Congress Subject Headings) or RAMEAU. The amplitude of the polygraphs records stands out, that is, from a given author, access is given to (1) a block of biographical/historical data; and (2) a block of 'LOD' links, 'Possible notes', 'Sources consulted', 'Alternative names', and 'Related links'.

When selecting a 'Person' page, DBVMC shows biographical data of the author taken from Wikipedia; it also presents variations of the name and incorporates the author's corresponding links to ISNI, VIAF, and Wikipedia. The discovery of information is based on the relationships that the system groups into 'Related authors' and 'Contemporary authors'.

In DBNE, the data corresponding to certain elements, mainly authors, subjects, and works, are enriched with connections to their equivalent in other data sources: National Library of Germany, National Library of France, SUDOC, Swedish National Library, Library of Congress, DBpedia, Wikipedia, VIAF, and ISNI. At the end of the author's page, equivalent links to the referred data sources and to sources consulted in the BNE for the author's study are shown, if any. The subject and its geographic and type/form registers have links to LEMB, Catalogue of Authorities of the Higher Council for Scientific Research of Spain (CSIC), LCSH, and data from the BnF Authority.

DBNF presents three large groups of links to the following: (1) other external repositories with which the BnF data are aligned (LCSH, Deutsche Nationalbibliothek, ISNI, VIAF, IdRef, Geonames, Agrovoc, and Thesaurus W—the thesaurus for control of French archives authorities); (2) search forms in which the author, subject, or work has been automatically filled out (General Catalogue of the National Library of France, *Catalogue collectif de France*, Europeana, etc.); and (3) Wikipedia data retrieved via DBpedia and Wikidata.

**Table IV. Semantic enrichment and interoperability with other data collections**

	BVP	DBVMC	DBNE	DBNF
Disambiguation	++	++	++	++
Alignment with other vocabularies	++	+/-	++	++
Multilingual search	-	-	++	++
Exploitation of semantic relationships	++	+/-	++	++
Interrelations with other bibliographic collections	++	++	++	++
Images associated with value for the user	+	+	+	+

This section clearly shows the multilingual power of the portals, for example, DataBNF, in aiming for alignment with controlled vocabularies and the ability to discover interrelated information to offer the end user as a result of the links to other data repositories.

### *User interaction and personalisation*

The ability to interact with the users is analysed, evaluating aspects related to personalisation, communication, and socialisation, access to the document, export of bibliographic data, and integration with social tools.

In BVP, users can add comments, highlight controversial data, or complement the information. This system also contemplates the possibility of RSS subscription. BVP provides a persistent link to the records. Likewise, the records can be exported in ISBD, Dublin Core, MARCXML, ISAAR (CPF), etc. The digital versions are available for download in various formats.

DBVMC provides the user with the persistent link of authors and allows, depending on the record, viewing it in the catalogue of the BVMC or in the BVMC thematic portals to read the full text in different textual and/or audio-visual formats or to see concordances. The system leads the user to full documents in PDF or HTML. The work citations can be downloaded in BibTex format on this portal. DBVMC enables sharing on social networks: Facebook, Twitter, Google+, and LinkedIn, and it also maintains a blog of updates on aspects related to the semantic web, digital libraries, and the collection of the BVMC.

On the Editions page of the DBNE, descriptive data of the same are displayed, adapting to the type of material processed. In addition, in the frame on the right, information of interest is offered: Type of material, Subjects, the technique used, etc. The 'Access this work' section offers various actions: Request the document in advance, Request reproduction of funds, Request an interlibrary loan, and View in the traditional catalogue. Finally, information on the copies available in the library is provided. The system allows download of data in MARC 21.

DBNF provides persistent linking of the data and also allows the page to be printed or exported in PDF. It counts as a form that can be filled with possible perceived problems on the page. The portal offers links from the works to the catalogue records and/or to Gallica and indicates if the requested record is available for download. This collection allows author pages to be shared on Facebook, Twitter, and Google+ and sends the link to the email account. Moreover, in the upper right area of the frame, the portal prominently presents a BnF Services section, enabling the following elements: Ask questions to the librarian (through the SINDBAD chat service, or through a specific form), Go to the BnF, and Reproduce a document.

**Table V. User interaction and personalisation**

	BVP	DBVMC	DBNE	DBNF
Persistent links to records	++	++	-	++
Personalised user area	-	-	-	-
Download/print/export	++	+	+	+
Personalised services (access, reproduction, forms, chat, etc.)	+/-	+/-	++	++
Integration with reference management software	-	+/-	-	-
Integration with social tools	-	++	-	++
RSS feeds / Alerts subscription	+	-	-	-
Blogs/Updates	-	+	-	-
Comments / rating labels / information expansion	-	-	-	-

No specific areas in the systems under analysis could be observed for registered users or possible areas dedicated to specific groups of users that could store the history of queries, alerts, etc.

### ***Other functionalities***

In this section, the ability to download data in semantic formats is analysed, as well as the possible development of tools generated from the data publication of the collections considered, that is, the reuse of data within projects generated in the institutions themselves.

In the BVP, records can be exported in Linked Open Data/EDM 5.2.7. In DBVMC, there are buttons for downloading the data in RDF and JSON. The BNE allows for download of data in RDF (Turtle). In DataBnF, data can be downloaded in RDF (xml | nt | n3), JSON-LD, and JSON.

The BVP has a tool called ‘Timeline’,<sup>25</sup> designed to locate polygraphs temporarily and spatially; however, at the time of this analysis, ease of use was lacking.

The access to Lab<sup>26</sup> in the DBVMC occupies a prominent place, where a set of tools, mostly linguistic, is presented. Among other developments and prototypes, the following stand out: (a) ‘Geographical search engine’, which allows searching the general catalogue by location; (b) ‘Diachronic search engine’, which allows searching within a corpus of 86 works of the BVMC for; (c) ‘Analysis and visualisation of data’ about female writers; or (d) a ‘Virtual assistant’, which is capable of returning authors, works, and information on the BVMC social networks by communicating with the open data repository through SPARQL queries.

In the case of the DBNF collection, Atelier<sup>27</sup> is an experimental space to discover the library's data comprising chronological friezes, image galleries, maps, etc. The data could be visualised in different ways as timelines, geographically, or as a map of scientific relationships among works, people, institutions, or movements. In addition, each entry has a link to be viewed in Atelier.

**Table VI. Other functionalities**

	BVP	DBVMC	DBNE	DBNF
Downloads in semantic formats	+/-	+	+	++
Associated experimental spaces	-	++	-	++
Tools aimed at specialised users	+/-	++	-	+/-

Although, as previously stated, all portals have a SPARQL query point (with the exception of the VBP), the option for downloading records in semantic formats has been considered an added value. Regarding experimental spaces, the National Library of Spain counts with BNElab,<sup>28</sup> a space specifically dedicated to the enrichment and reuse of BNE data sets, although this is currently not connected to the Datos BNE portal.

Overall, this dimension dedicated to the web interface has made it possible to analyse the user experience offered by these LOD portals. The analysis of the search, navigation, and the results visualisation solutions contemplated in the selected systems has made it possible to investigate common aspects and unique contributions that allow estimating the values that these portals provide compared to traditional catalogues.

Most of these collections draw attention, mainly due to the experimental and continually developing nature of the interface. At the moment, no automatic correction tools have been observed and the systems of only the two national libraries implement automatic suggestions that are positively valued. With the exception of the BVP, articulated around a classic bibliographic interface, the portals adopt a discovery tool focused on proposing a unique search box available to the user at any point during the process of interaction with the system.

It should be emphasised that search and navigation actions amalgamate, and this is precisely what marks the great difference with respect to traditional catalogues, that is, the data are federated around concepts (Authors, Works, and Topics). The works and authors pages are of particular attention since they undoubtedly represent a clear metamorphosis in the visualisation of bibliographic information. Exploiting subject authorities and the alignment with other controlled vocabularies demonstrate the outstanding benefits of multilingual recovery. Equally worth mentioning is the verbose detail used in many of the collections to indicate the levels of participation of the authors in the works.

In general, user interaction has been enhanced. No customisation possibilities by the user or session preferences have been observed, and only some systems have integrated the option to select the order of the results; limitations to save or reuse searches, export or save several items together, etc., are appreciable. Export of data to manage bibliographic references is considered only in DBVMC. The communication and feedback mechanisms, such as possibilities of alerts according to the user profile, and possible questionnaires about the collection and/or the service or suggestion forms are not generalised. In the case of the BVP and the BNE, there is no option provided to share pages on social networks.

On the other hand, we consider the spaces dedicated to developments associated with LOD projects to be highly encouraging, especially in BVMC and DataBnF.

Finally, the results of this dimension demonstrate the strength of open data publication as an extraordinary resource for the enrichment of information and its contextualisation. There is emphasis on the breadth of connections to data sources and the integration of controlled vocabularies in almost all the collections under analysis. However, interconnection possibilities are likely to expand tremendously; data from archives, museums, and statistical data can serve as examples for this expansion.

#### **4. Conclusions**

The challenge in publishing bibliographic collections as linked open data lies in the interoperability of these data, which, when addressed, increases the visibility and digital impact of such data beyond the limited catalogue environment. This challenge can be approached using portals based on web interfaces, such as those analysed in this work, which go beyond the traditional catalogue to become new knowledge ecosystems. The qualitative leap goes from a system primarily focused on returning results to an environment that encourages more transversal approaches to knowledge, thanks to the contextualisation and interrelationships facilitated by these new semantic catalogues, that is, environments that contribute to generating new knowledge.

The proposed analysis methodology has allowed for identifying the basic characteristics of a sample of linked open data bibliographic portals, assessing the potential of semantic technologies compared to collections that use a flat description model, as well as investigating the interaction capacities and user experience that they provide.

In general, the projects studied show that publication of linked open data through visual interfaces minimises the search effort and maximises the chances of information discovery; it also improves the user experience, due to both the increased navigation capacity and the interrelationships among data. These portals are aimed at more intuitive environments that enhance the contextualisation and demonstrate great possibilities for research and teaching. Thanks to this network of relationships and the implementation of multilingual recovery, in these portals with aligned controlled vocabularies, the user perceives not only a technologically powerful instrument for accessing bibliographic information but also an

instrument that has been complemented with ‘intelligence’. Consequently, this leads to an unequivocal perception of its value in accessing knowledge, in general, and in its effectiveness as a learning tool, in particular. Innovation also translates into more flexible environments with novel displays of data that allow, among other things, navigating through timelines or geographical locations.

However, despite the obvious innovation involved, the current state of development of the platforms observed lacks, among others, the need for responsive designs, as well as a more efficient display of information based on more attractive and intuitive environments, less overloaded with text, and requiring a more sensible use of the scroll bar. In this sense, the interface solutions of the previously mentioned SHARE-VDE project, which integrates drop-down arrows and context menus, are considered appropriate in reducing feelings that can overwhelm a user.

In our opinion, the ordering of the results, in general, can be improved by implementing more relevant and efficient algorithms. Further, the possibilities for personalisation and feedback are limited. Improvement in these communicative aspects and the development of experimental tools for the exploitation of data subsets, in which some of the collections have made important advances, contribute to the significant enhancement of user engagement, with enormous possibilities for teaching and research, and demonstrate, in parallel, the ability to reuse data and its suitability to respond to more complex information needs.

Finally, it would be desirable to undertake future quantitative and qualitative studies that provide information capable of improving the adequacy of these semantic catalogues and adjust them to the expectations of the users. It is considered essential to study the developments of these portals, assess their adaptation to the behaviour of the user, and their influence on the use of library collections. To guarantee their acceptance, it is essential for these systems to undergo rigorous evaluation processes, adapted to the complexity of the collections and the diversity of its use and users.

## Notes

- [1] <https://schema.org/>
- [2] <https://www.loc.gov/bibframe/docs/bibframe2-model.html>
- [3] <https://www.oclc.org/en/news/releases/2020/20200109-oclc-awarded-mellon-grant-linked-data-management-infrastructure.html>
- [4] <https://www.share-vde.org/>
- [5] <https://www.wikidata.org/>
- [6] <https://bbcarchdev.github.io/res/>
- [7] <http://www.larramendi.es/fundacion/biblioteca-virtual-de-poligrafos/>
- [8] <http://data.cervantesvirtual.com/>
- [9] <http://datos.bne.es/>
- [10] <http://data.bnf.fr/>
- [11] <https://datahub.io/>
- [12] <https://lod-cloud.net/>
- [13] <http://www.oeg-upm.net/>
- [14] Royal decree 1495/2011, October 24<sup>th</sup>, <https://www.boe.es/eli/es/rd/2011/10/24/1495>
- [15] <http://www.digibis.com/software/digibib>
- [16] <http://www.larramendi.es/i18n/sru/sru.cmd>
- [17] <https://jena.apache.org/>
- [18] <http://rdf4j.org/>
- [19] <http://data.cervantesvirtual.com/sparql>
- [20] <https://virtuoso.openlinksw.com/>
- [21] <http://wifo5-03.informatik.uni-mannheim.de/pubby/>
- [22] <http://datos.bne.es/sparql>



- [23] <https://www.cubicweb.org/>  
 [24] <http://data.bnf.fr/sparql>  
 [25] <http://www.larramendi.es/es/timeline/autores.do>  
 [26] <http://data.cervantesvirtual.com/blog/labs/>  
 [27] <http://data.bnf.fr/atelier/>  
 [28] <https://bnelab.bne.es/>

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