# C

# Constraint Type Specific Expressivity of Constraint Languages

We evaluated to which extend the most common constraint languages fulfill each of the 81 requirements to formulate constraints and to validate RDF data. We also evaluated to which extend a specific requirement is satisfied by the better performing OWL 2 profile *OWL 2 QL* or if the more expressive OWL 2 sub-language *OWL 2 DL* is needed. In case a constraint type is marked with an asterisk, reasoning may be performed prior to validating data on constraints of that particular type in order to enhance data quality.

In case a constraint language does not directly support a given constraint type, but is yet capable to express that constraint type - either by limitations, workarounds, or extensions - we mark that combination of constraint type and constraint language with the tilde symbol, but consider that constraint type as being supported by that language. For the constraint type *negative literal pattern matching (R-230)*, e.g., there is no dedicated term in the SHACL vocabulary. Nevertheless, this constraint type is expressible with SHACL in terms of a workaround by combining multiple language constructs. By combining the negation constraint (*sh:NotConstraint*) and the property *sh:pattern*, e.g., it can be ensured that an ISSN of a journal does not have be conform to a valid 10- or 13-digit ISBN. The property sh:pattern is used to validate whether all values of a given property match a given regular expression. The values of sh:pattern must be valid pattern arguments for the SPARQL REGEX function:

```
SHACL Shapes Graph:
:JournalShape
    a sh:Shape ;
    sh:constraint [
        a sh:NotConstraint ;
        sh:shape [
            a sh:Shape ;
            sh:property [
                sh:predicate :issn ;
                sh:pattern "(ISBN[-]*(1[03])*[ ]*(: )0,1)*(([0-9Xx][- ]*)
                           13|([0-9Xx][- ]*)10)" ; ] ; ] ] .

Valid journal:
:Journal-Of-Web-Semantics
    :issn "1570-8268" .

Invalid journal:
```

```
18 :International-Journal-Of-Metadata-Semantics-And-Ontologies
19     :issn "978-3-642-35172-3" .
```

**Table C.1.** Constraint Type Specific Expressivity of Constraint Languages (1)

| Constraint Types | DSP | OWL2-DL | OWL2-QL | ReSh | SHACL | ShEx | SPIN |
|---|---|---|---|---|---|---|---|
| *Subsumption | ✗ | ✓ | ✓ | ~ | ✓ | ✓ | ✓ |
| *Class Equivalence | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| *Sub Properties | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| *Property Domains | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| *Property Ranges | ✗ | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ |
| *Inverse Object Properties | ✗ | ✓ | ✓ | ~ | ✓ | ✗ | ✓ |
| *Symmetric Object Properties | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| *Asymmetric Object Properties | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| *Reflexive Object Properties | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| *Irreflexive Object Properties | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| Disjoint Properties | ✗ | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ |
| Disjoint Classes | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| Context-Sp. Property Groups | ✗ | ~ | ~ | ✓ | ✓ | ✓ | ✓ |
| Context-Sp. Inclusive OR of P. | ✗ | ~ | ~ | ✗ | ✓ | ✗ | ✓ |
| Context-Sp. Inclusive OR of P. Groups | ✗ | ~ | ~ | ✗ | ✓ | ✗ | ✓ |
| Recursive Queries | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ~ |
| Individual Inequality | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✓ |
| *Equivalent Properties | ✗ | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ |
| Property Assertions | ✗ | ✓ | ~ | ✗ | ~ | ✗ | ✓ |
| Data Property Facets | ✗ | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ |

**Table C.2.** Constraint Type Specific Expressivity of Constraint Languages (2)

| Constraint Types | DSP | OWL2-DL | OWL2-QL | ReSh | SHACL | ShEx | SPIN |
|---|---|---|---|---|---|---|---|
| Literal Pattern Matching | ✗ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |
| Negative Literal Pattern Matching | ✗ | ✓ | ✗ | ✗ | ~ | ✗ | ✓ |
| *Object Property Paths | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| *Intersection | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| *Disjunction | ✗ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |
| *Negation | ✗ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |
| *Existential Quantifications | ✗ | ✓ | ✗ | ~ | ✓ | ~ | ✓ |
| *Universal Quantifications | ✗ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |
| *Minimum Unqualified Cardinality | ✓ | ✓ | ✗ | ~ | ✓ | ✓ | ✓ |
| *Minimum Qualified Cardinality | ✓ | ✓ | ✗ | ~ | ✓ | ✓ | ✓ |
| *Maximum Unqualified Cardinality | ✓ | ✓ | ✗ | ~ | ✓ | ✓ | ✓ |
| *Maximum Qualified Cardinality | ✓ | ✓ | ✗ | ~ | ✓ | ✓ | ✓ |
| *Exact Unqualified Cardinality | ✓ | ✓ | ✗ | ~ | ✓ | ✓ | ✓ |
| *Exact Qualified Cardinality | ✓ | ✓ | ✗ | ~ | ✓ | ✓ | ✓ |
| *Transitive Object Properties | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Context-Sp. Exclusive OR of P. | ✗ | ✓ | ✗ | ✗ | ✗ | ✓ | ✓ |
| Context-Sp. Exclusive OR of P. Groups | ✗ | ~ | ✗ | ✓ | ✗ | ✓ | ✓ |
| Allowed Values | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| Not Allowed Values | ✗ | ✓ | ✗ | ✗ | ~ | ✓ | ✓ |
| Literal Ranges | ✗ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |

**Table C.3.** Constraint Type Specific Expressivity of Constraint Languages (3)

| Constraint Types | DSP | OWL2-DL | OWL2-QL | ReSh | SHACL | ShEx | SPIN |
|---|---|---|---|---|---|---|---|
| Negative Literal Ranges | ✗ | ✓ | ✗ | ✗ | ~ | ✗ | ✓ |
| Required Properties | ✓ | ✓ | ✗ | ✓ | ~ | ✓ | ✓ |
| Optional Properties | ✓ | ✓ | ✗ | ✓ | ~ | ✓ | ✓ |
| Repeatable Properties | ✓ | ✓ | ✗ | ✓ | ~ | ✓ | ✓ |
| Negative Property Constraints | ✗ | ✓ | ✗ | ✗ | ~ | ✓ | ✓ |
| *Individual Equality | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| *Functional Properties | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| *Inverse-Functional Properties | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| *Value Restrictions | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| *Self Restrictions | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| *Primary Key Properties | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| *Class-Specific Property Range | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ |
| *Class-Sp. Reflexive Object P. | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Membership in Controlled Vocabularies | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| IRI Pattern Matching | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ |
| Literal Value Comparison | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ | ✓ |
| Ordering | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Validation Levels | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ |
| String Operations | ✗ | ✗ | ✗ | ✗ | ~ | ✗ | ✓ |
| Context-Specific Valid Classes | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |

**Table C.4.** Constraint Type Specific Expressivity of Constraint Languages (4)

| Constraint Types | DSP | OWL2-DL | OWL2-QL | ReSh | SHACL | ShEx | SPIN |
|---|---|---|---|---|---|---|---|
| Context-Specific Valid Properties | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ |
| *Default Values | ✗ | ✗ | ✗ | ✓ | ✓ | ✗ | ✓ |
| Mathematical Operations | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Language Tag Matching | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Language Tag Cardinality | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Whitespace Handling | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| HTML Handling | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Conditional Properties | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ |
| Recommended Properties | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Handle RDF Collections | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Value is Valid for Datatype | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ |
| Use Sub-Super Relations in Validation | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| *Cardinality Shortcuts | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ |
| Aggregations | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| *Class-Specific Irreflexive Object Properties | ✗ | ✓ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Provenance | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Data Model Consistency | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Structure | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Labeling and Documentation | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ |
| Vocabulary | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| HTTP URI Scheme Violation | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |