

# Formal Specification of Our Extended Vega-Lite by Hyeok Kim

Supplementary Material to a CHI 2022 paper, "Cicero: A Declarative Grammar for Responsive Visualization"

Notations	Examples	Description
" <b>:=</b> ": is defined as a tuple of	$a := b, c, d$	$a$ is defined as a tuple of $b, c$ , and $d$ .
" <b>=</b> ": set as value of	$A=b$	An argument $A$ set as $b$ .
" <b>~</b> ": possible names for ... are ...	$a \sim b, c$	The possible names of $a$ are $b$ and $c$ .
" <b> </b> ": alternate argument	$a   b   c$	Either one of $a, b$ , or $c$ .
" <b>...</b> ": extensible arguments	$a := b   c   \dots$	$a$ can be either $b, c$ , or something else.
" <b>&lt;&gt;</b> ": datatype	$A<String>$	$A$ is a string type argument.
" <b>[]</b> ": a list of	$<String>[]$	A list of string elements.
	$<a, b>[]$	A list of tuples composed of $a$ and $b$ .
" <b>[0..n]</b> ": a list of length 0 to n	$[0..5]$	A length-5 array.
" <b>?</b> ": optional argument	$a?$	$a$ is optional.
	$\dots?$	optional additional arguments

**Notes**  
"**<Number>**" either a number or a string of a number with its unit (e.g., 350, "350px").

## Formal Specification

**ExVLSpec** := Name?, Data, Layout, Layer, Transform?, Interaction?, Title?, NonData?

**Name** := <String> the name of a visualization

**Data** := <JSON> the dataset of a visualization

**Layout** := Width?, Height?, Composition, Row, Column, HAxis?, VAxis?, NColumns?, Projection?

**Width** := <Number>                      **Height** := <Number>

**Composition** := single | repeated | projection | ...

the type of a visualization layout; repeated refers to small multiples

**Row** := <RCItem>[0..2]              **Column** := <RCItem>[0..2] row and column items (as used in a Trellis plot)

**RCItem** := Field<String> | FieldObject

**HAxis** := AxisItem                      **VAxis** := AxisItem the design of an X and Y axis, respectively

**AxisItem**<sup>+</sup> := Domain<Boolean>?, DomainColor<Color>?, DomainDash<Dash>?, DomainWidth<Number>?, DomainOpacity<Opacity>?, Grid<Boolean>?, GridColor<Color>?, GridDash<Dash>?, GridWidth<Number>?, GridOpacity<Opacity>?, Offset<Number>? <https://vega.github.io/vega-lite/docs/axis.html>

**NColumns** := <Integer> the number of columns in a "repeated" composition

**Projection**<sup>+</sup> := ProjectionType, ProjectionScale?, ProjectionTranslate?, ...? the details of a map projection <https://vega.github.io/vega-lite/docs/projection.html>

**FieldObject**<sup>+</sup> := Field<String>, DataType?, Scale?, Sort?, Aggregate?, Bin? | Aggregate=count, Scale? details about a data field encoded to a row/column/channel <https://vega.github.io/vega-lite/docs/encoding.html#field-def>

**DataType** := nominal | ordinal | quantitative | temporal

**Scale**<sup>+</sup> := Domain?, Range?, Scheme?, Reverse<Boolean>?, ...? <https://vega.github.io/vega-lite/docs/scale.html>

**Domain** := <Any>[]                      **Range** := <Any>[]                      **Scheme** := <String> (e.g., "magma")

**Sort**<sup>+</sup> := ascending | descending | SortBy <https://vega.github.io/vega-lite/docs/sort.html>

**SortBy** := SortOrder?, SortField<String>? sort by a certain field

**SortOrder** := ascending | descending | <Any>[] an ascending, descending or custom order

**Aggregate**<sup>+</sup> := count | mean | max | median | ... <https://vega.github.io/vega-lite/docs/aggregate.html>

**Bin**<sup>+</sup> := Maxbins?, BinSteps?, Nice?, ...? <https://vega.github.io/vega-lite/docs/bin.html>

**Layer** := <LayerItem>[]

**LayerItem** := Mark, Text?, Tooltip?, Transform?

**Mark** := MarkType, \$MarkProperty?

**MarkType**<sup>+</sup> := circle | point | bar | rect | ... <https://vega.github.io/vega-lite/docs/mark.html#types>

**\$MarkProperty** ~ color, shape, size, stroke, ... mark properties or such channels

**\$MarkProperty** := Value | FieldObject if "Value" is used, then it is a static property. Otherwise, it is an encoding channel.

**Text** := TextType, TextField, Values?, Anchor?, Orient?, TextItems?, Tick?, TextVisibility? ...?  
**TextType** := on-mark | on-axis | legend mark labels, axis labels, and legends, respectively  
**TextField** := FieldName<String> the reference field of the text item (i.e., text element for each value of the "TextField")  
**Values** := <Any>[] a subset of elements of the TextField to show the labels  
**Anchor, Orient** := start | end | middle | right-start | right-end | ...  
Anchor: the reference position to the corresponding mark/axis element; Orient: the reference position to the text element itself  
**TextItems** := <TextItem>[] each line of the text element  
**TextItems** := Format?, FontColor<Color>?, Width?, ...?  
**Tick** := <Boolean> | TickColor<Color>?, TickWidth?, ...?  
the design of the line segment between the text element and referred visual element.  
**TextVisibility** := External<Boolean>?, Numbering<Boolean>?, Position<top|bottom|left|right>?  
internalization/externalization of mark-labels; If Numbering = true, then reference numbers are shown on corresponding marks.

**Tooltip** := TooltipVisibility, TooltipFields  
**TooltipVisibility** := on-mark | fixed | hidden the position of a tooltip  
**TooltipFields** := <FieldName, Format>[] the information shown in a tooltip

**Transform\*** := <TransformItem>[] global/layer-specific data transformation  
**TransformItem\*** := Filter\* | Aggregate\*, As\* | Bin\*, As\* | Compute\*, As\*, Op\* | ...  
<https://vega.github.io/vega-lite/docs/transform.html>

**Interaction** := <InteractionItem>[] global interactions  
**InteractionItem** := ZoomPan | Context | Filter zoom+pan, brush-based context view, and interactive filter, respectively

**Title** := Width<Number>?, Align?, TitleItems  
**TitleItems** := <Name<String>?, Text<String>, Align?, FontSize<Number>?, FontWeight?, ...?>[]  
the design and content of each title element

**NonData** := NonDataVisibility?, NonDataGlobalStyle?, NonDataItems  
annotations and emphases unbound to data  
**NonDataVisibility** := External<Boolean>?, Numbering<Boolean>?, Position<top|bottom|left|right>?  
**NonDataGlobalStyle** := FontFamily<String>?, FontWeight?, BoxStroke<Color>?,  
BoxStrokeWidth<Number>?, LineHeight<Number>, ...? global style of non-data items

**NonDataItems** := <NonDataType, Name<String>?, X<Number>, Y<Number>, DX<Number>, DY<Number>,  
Width<Number>, Height<Number>, Rotate<Number>, NonDataText, NonDataBox, NonDataMark>[]  
the appearance and contents of nondata items / X, Y: absolute position, DX, DY: relative position  
**NonDataType** := text annotations | mark emphases  
**NonDataText** := <Text<String>, Align?, Overflow?, FontSize<Number>?, FontWeight?, LineHeight<Number>?,  
FontColor<Color>?, Opacity<Number>?>[]  
**NonDataBox** := Padding<Number>?, Fill<Color>?, Stroke<Color>?, StrokeWidth<Number>?, Radius<Number>?  
StrokeStyle?  
**StrokeStyle** := solid | dashed | dotted | ...  
**NonDataMark** := NonDataMarkDef, Fill<Color>?, Opacity<Number>?, Stroke<Color>?,  
StrokeOpacity<Number>?, StrokeWidth<Number>?, Radius<Number>?  
**NonDataMarkDef** := Icon<String> Bootstrap icon names | Image<URI> | Shape  
**Shape** := circle | rect | rule | ...

Detailed documents for the following common value types (available as of Feb. 2022).

<b>Number</b>	<a href="https://developer.mozilla.org/en-US/docs/Web/CSS/length">https://developer.mozilla.org/en-US/docs/Web/CSS/length</a>
<b>Align</b>	<a href="https://developer.mozilla.org/en-US/docs/Web/CSS/text-align">https://developer.mozilla.org/en-US/docs/Web/CSS/text-align</a>
<b>Color</b>	<a href="https://developer.mozilla.org/en-US/docs/Web/CSS/color">https://developer.mozilla.org/en-US/docs/Web/CSS/color</a>
<b>FontWeight</b>	<a href="https://developer.mozilla.org/en-US/docs/Web/CSS/font-weight">https://developer.mozilla.org/en-US/docs/Web/CSS/font-weight</a>
<b>Dash</b>	<a href="https://developer.mozilla.org/en-US/docs/Web/SVG/Attribute/stroke-dasharray">https://developer.mozilla.org/en-US/docs/Web/SVG/Attribute/stroke-dasharray</a>
<b>Opacity</b>	<a href="https://developer.mozilla.org/en-US/docs/Web/CSS/opacity">https://developer.mozilla.org/en-US/docs/Web/CSS/opacity</a>
<b>LineHeight</b>	<a href="https://developer.mozilla.org/en-US/docs/Web/CSS/line-height">https://developer.mozilla.org/en-US/docs/Web/CSS/line-height</a>
<b>Overflow</b>	<a href="https://developer.mozilla.org/en-US/docs/Web/CSS/overflow">https://developer.mozilla.org/en-US/docs/Web/CSS/overflow</a>
<b>Icon</b>	<a href="https://getbootstrap.com/docs/5.1/content/typography/">https://getbootstrap.com/docs/5.1/content/typography/</a>