0: 'In this article we revisit the concept of abstraction as it is used in visualization and put it on a solid formal footing. While the term abstraction is utilized in many scientific disciplines, arts, as well as everyday life, visualization inherits the notion of data abstraction or class abstraction from computer science, topological abstraction from mathematics, and visual abstraction from arts. All these notions have a lot in common, yet there is a major discrepancy in the terminology and basic understanding about visual abstraction in the context of visualization. We thus root the notion of abstraction in the philosophy of science, clarify the basic terminology, and provide crisp definitions of visual abstraction as a process. Furthermore, we clarify how it relates to similar terms often used interchangeably in the field of visualization. Visual abstraction is characterized by a conceptual space where this process exists, by the purpose it should serve, and by the perceptual and cognitive qualities of the beholder. These characteristics can be used to control the process of visual abstraction to produce effective and informative visual representations. ',

1: 'The term abstraction often lacks a precise definition in many fields. While several fields have defined the term for their own purposes, there is only a vague understanding of its meaning that is shared by all fields. Some scientific disciplines and scholarly fields have adjusted the vaguely understood meaning to fit the needs of the respective discipline or field. In this article we first present our key definitions related to visual abstraction, and we then provide the justification for the definitions. ',

2: 'An abstraction is a process that transforms a source thing into a less concrete sign thing of the source thing. Abstraction uses a concept of point-of-view, which determines which aspects of source thing should be preserved in its sign thing and which should be suppressed. ',

3: 'A data representation is a sign thing that stands in digital form for a referent thing from reality or another sign thing, using data structures or concept things. Similarly, a visual representation is a sign thing that stands for a referent from reality or another sign thing so that it can be visually perceived and cognitively processed by a human observer. ',

4: 'A visualization is a process that transforms data representations of a thing from reality into visual representations. Visualization is a process that is intended to be a meaningful visual abstraction process. The designers of visualization processes must understand the point-of-view component and tasks. Otherwise, they would not reach the full meaningfulness intended. ',

5: 'In computer science, the term abstraction achieves yet another flavor of its meaning. In object-oriented design, the most frequently used programming methodology, it primarily relates to the definition of classes and methods that cannot be instantiated. Typically, classes and methods are hierarchically grouped into increasingly abstract constructs such that implementations of particular functionality can be shared among many different elements. While for most of these classes it is possible to create instances, an abstract class is a construct that itself cannot be instantiated but which organizes the functionality into a comprehensive representation. The class hierarchy as the outcome of such abstraction gives a clear understanding of differences in functionality among various classes as well as what they have in common. It also facilitates further extensibility of existing code to support new cases that were not considered in the initial software design. ',

6: 'The intuitive understanding of abstraction has been reinforced by this brief excursion into various fields and that stand and argue for abstraction. We can observe that the term is not used uniformly and that it is frequently exchanged with other terms. The recurrent pattern is that abstraction relates to formation of some higher-order constructs or representations that are result of a transformation of lower-level entities. The lowest entities are more tangible, while the higher levels of the abstraction hierarchy are further removed from tangibility and become more mental constructs and concepts that, in one way or another, allow humans to recognize certain characteristics clearer than the lower-level representations. The ability to abstract seems to be one of the core properties of humans, present while shaping the entire body of analytical knowledge humankind has formed throughout our history. ',