Journal of Applied Logic • • • (• • • •) • • •–• • •

Contents lists available at ScienceDirect

Journal of Applied Logic

www.elsevier.com/locate/jal

The never-ending recursion ☆

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ARTICLE INFO

Article history:
Received 10 May 2016
Accepted 1 February 2017
Available online xxxx

Keywords:
Recursion
Iteration
Cognitive science
Self-involvement

ABSTRACT

This paper is devoted to three main aims: (I) to present the conceptual relations between recursion, on the one hand, and inductive definitions and mathematical induction, on the other; as well as among recursion and self-involvement. In order to receive the original and primary use of recursion in cognitive science, it is important to bear in mind the conceptual relations and distinctions between them. (II) To analyze the interpretation of recursion from two different approaches. The first one, mainly represented by Chomsky, emphasizes the origin of recursion in the formal sciences, and applies it to characterize the mechanical procedure which underlies the language faculty. On this view, recursion is a property of the mind/brain. The second one disregards this conception of recursion and redefines it in terms of either the processing of self-embedded structures (e.g. [20]) or the ability to represent multiple hierarchical levels using the same rule (e.g. [45]); or as follows: recursion refers to the ability to embed structures within structures of the same kind (e.g. [48]). (III) To discuss whether or not this change in the meaning of recursion is more suitable than the original one for empirical research.

1. Introduction

Since the very insightful paper published by [33], a variety of studies have been carried out regarding the notion of recursion. This variety not only concerns the domain of language, as this notion has also been analyzed within the (cognitive) domain of music (see [41,35,60], among others), and Comparative Psychology (see [25,27,56,21]), but as Martins and Fitch [47] have suggested, recursion plays also a crucial role in visuo-spatial processing (see [46,45,50]), phonology (see for instance [69]), or intentional action [71], among other domains.

The current paper does not focus specifically on one domain or another among those mentioned above; rather, it analyzes two different approaches to recursion. The first approach, which may be called '*algorithm-*

☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. On the other hand, I would like to thank an anonymous reviewer for her/his stimulating comments, as well as Professor José Manuel Igoa for his accurate suggestions and comments.

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http://dx.doi.org/10.1016/j.jal.2017.03.003
1570-8683/

Please cite this article in press as: S. Mota, The never-ending recursion, J. Appl. Log. (2017), http://dx.doi.org/10.1016/j.jal.2017.03.003

sensitive', and may be well represented by Chomsky's work, is devoted to the concept of recursion understood as a property of an algorithm. One thing I want to stress from the start is that it is not entirely precise to claim that Chomsky's mechanical procedure is recursive because it calls itself. As I will try to show below, this kind of expression presumes a lot of things that must be explicitly analyzed (for instance the conceptual distinction between 'recursion' and 'self-reference', which is obscured under the very general idea that a procedure is recursive because it calls itself).

The second approach I have in mind is represented by Christiansen and Chater's work, on the one hand, and Martins's work, on the other; and may be labeled '*structure-sensitive*'. Under this approach, the use of recursion as it is understood in the first approach has been abandoned, and recursion has come to be understood as the ability to process recursive (i.e. self-embedded) structures, rather than as a part of some grammar formalism. According to Vicari and Adenzato [71, p. 173], among others, a self-embedded structure is one which is composed of a component (for instance, a constituent or a schema XP) that contains or embeds other component of the same kind (another constituent or schema XP) within itself: an X-within-X of the same kind. In this very sense, Moro refers to recursion as being a combinatory process which is summarized as follows: "a structure of a certain kind (a sentence, for example) that contains structures of the same kind (another sentence)" ([51, p. 62; see examples below]).[1]

On the other hand, Martins [45] proposes a definition of recursion focused on representational abilities; i.e. the ability to represent multiple hierarchical levels using the same rule, which entails the ability to generate new levels beyond those previously encountered. Recently, Martins et al. [48] have referred to recursion in the same terms as above; namely: recursion refers to the ability to embed structures within structures of the same kind. Martins's works will be further analyzed in this paper given that they propose an interesting way to carry out empirical research regarding recursion. My main interest in this regard is to analyze how recursion is used under Martins's paradigm.

Before moving on to these interesting issues, I want to present the prospect of the paper: in the following section 2 I am going to offer a conceptual analysis of the original and primary use of recursion, which requires to distinguish between 'definition by recursion', 'inductive definition', and 'mathematical induction', as well as between 'recursion' and 'self-involvement' (i.e. 'self-reference' for that matter). In doing so, I will show which is my conception of recursion. After this analysis is carried out, I will move on to Section 3, where I shall properly present the two conceptions of recursion referred to above. Section 4 will be devoted to analyzing which of these two approaches is dominant in current empirical research. Finally, I will present some general conclusions.

2. Recursion: its origins

For better or worse, the concept of recursion has its origin in the formal sciences, specifically within a specialized branch of mathematical logic known as computability theory; and it can be traced back to Dedekind's (and Peano's) work (cf. [63, p. 287]). Recursion, in its original and primary (mathematical usage) sense, constitutes a method for defining a function "by specifying each of its values in terms of previously defined values, and possibly using other already defined functions" [22, p. 32]. Odifreddi [55, p. 330] claims that recursion "in its most general numerical form consists in defining the value of a function by using other values of the same function". Wittgenstein [73, 36]; [74, §163] stresses that a recursive definition is a fundamental rule of the system that shows how to proceed (as such, it cannot be asserted or denied), and claims that a recursive definition is a rule to construct other substitution (i.e., replacement) rules or,

[1] According to Moro [51, p. 72], an important discovery in syntactic theory is that "the whole sentence has a phrase structure of the same kind as the phrases it is made of". It is in this sense that recursion is conceptualized as a universal or global property of structures: "the schema XP (where X is any head) repeats itself within the very same XP schema" [51, p. 75]. This is not the primary meaning of recursion, and it is conflated with self-embedding. Recursion does not logically imply structures (an XP) *within* structures (other XPs) of the same kind (see below).

Please cite this article in press as: S. Mota, The never-ending recursion, J. Appl. Log. (2017), http://dx.doi.org/10.1016/j.jal.2017.03.003