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One first? Acquisition of the cardinal and ordinal uses of numbers in preschoolers

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ABSTRACT

We studied the acquisition of the ordinal meaning of number words and examined its development relative to the acquisition of the cardinal meaning. Three groups of 3-, 4-, and 5-year-old children were tested in two tasks requiring the use of number words in both cardinal and ordinal contexts. Understanding of the counting principles was also measured by asking the children to assess the correctness of a cartoon character's counting in both contexts. In general, the children performed cardinal tasks significantly better than ordinal ones. Tasks requiring the production of the number for a given quantity or position were solved more accurately than those testing the ability to select a set of *n* objects or the object in the *n*th position. Different profiles were obtained for the principles; those principles shared by the two contexts were mastered earlier in the cardinal context. Regarding order (ir)relevance, older children adhered to rigid ways of counting, producing better results in the ordinal context and incorrect rejections in the cardinal trials. Altogether, our data indicate that the acquisitions of cardinal and ordinal meanings of numbers are related, and cardinality precedes the development of ordinality.

Introduction

Number words enable humans to overcome limitations of the approximate number system, shared with several animal species, and to develop a precise representation of large quantities. According to

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Fuson (1992), number words are used in seven different contexts. Three of these are mathematical contexts: a *cardinal* context, where the number word refers to how many items are in a set (e.g., "there are three girls"); an *ordinal* context, where the number word refers to the position of an item in an ordered series (e.g., "the fourth player"), and a *measure* context, where the number word refers to the quantity of units that covers a continuous quantity (e.g., "it is four inches long"). Current models on adult numerical cognition focus mainly on cardinality (Campbell, 1994; Campbell & Clark, 1992; Dehaene, 1992; Dehaene & Cohen, 1995; McCloskey, 1992; McCloskey & Macaruso, 1995), and much work has been done on the development of the cardinal meaning of number words (e.g., Le Corre & Carey, 2007; Sarnecka & Lee, 2009; Wynn, 1992). By contrast, very little is known about the development of numbers in the other two contexts. This study aimed to contribute to the understanding of the development of ordinal number meaning by putting it in relationship with the much more studied development of cardinal meaning.

In the literature, the ordinal meaning of number words has often been confused with the *sequence* meaning of numbers or with *order relations* between cardinal numbers. Sequence meaning refers to the simple recitation of number words without referring to any entities (e.g., Fuson, 1988) or to judgments such as when deciding which of two numbers comes first in the counting list (e.g., see Turconi, Campbell, & Seron, 2006, for an adult study). According to Fuson (1992), sequence meaning does not refer to a mathematical context because this is a simple recitation without any reference to external entities and is very close to other non-numerical recitations such as the days of the week and the letters of the alphabet. Ordinal meaning has also been confused with order relations between cardinal numbers such as deciding which one is greater or smaller between two numbers. However, in this case, it is clearly an operation acting on the cardinal meaning of number words (e.g., Brannon & Van de Walle, 2001; Cantlon, Fink, Safford, & Brannon, 2007).

To our knowledge, only two studies have tested the development of the ordinal meaning of number words in children. Miller, Major, Shu, and Zhang (2000) first asked children to recite the cardinal and ordinal number lists (i.e., testing the sequence meaning), then asked them to apply ordinal numbers to objects and identify the position in which they appeared, and finally tested children's understanding of ordinal concepts (i.e., the fact that their meaning is limited to the series of which they are a part and the difference between "one" and "first"). Their data showed that when deciding the position of an object in a sequence, American kindergarten children (mean age = 6.16 years, range = 5.4–7.0) had an error rate of 34.4%. When two sequences were interspersed (black and white objects) and children needed to decide the position within one of the series, the error rate increased to 44%. Performance in both tasks improved in second and fourth grades until reaching nearly 100% accuracy. As for understanding of ordinal concepts by the youngest children, performance was generally poor. Unfortunately, none of the previous tests was performed for cardinality; therefore, the development of cardinality and ordinality could be compared only in the recitation task, where an important delay was observed for the ordinal numbers list.

The other study was conducted by Fischer and Beckey (1990). They submitted 4- and 5-year-olds to two tasks requiring them to generate a set of objects in the cardinal context (take 7 or 12 blocks) and to select the object in the *n*th position in the ordinal context (point to the third car). They found that 91% and 42% of the children fulfilled the request of collecting 7 and 12 blocks, respectively, but only 31% could point to the third car. They also asked children to produce number words in a cardinal context (count a set of objects and say how many there are) and an ordinal context (name the yellow car using an ordinal number word). They observed that 87% of the children could correctly count a collection and say that there were six objects; however, only 25% correctly said "fifth" for the position of the yellow car. Thus, for both kinds of tasks, performance in the cardinal context was better than that in the ordinal context. However, this study used only one or two trials per task, and it did not specifically match the difficulty of the numbers used in each context. Furthermore, both this and the previous study by Miller et al. (2000) used ordinal number words (e.g., "fifth"), which are acquired later in life (Beilin, 1975; Miller et al., 2000) and are scarcely used, even by adults. Therefore, if children needed to provide their answers in ordinal numbers or were given instructions in using them, this might have hampered their performance. Thus, it might be that ordinality was mastered earlier than what current data seem to indicate.