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# Time knowledge acquisition in children aged 6 to 11 years and its relationship with numerical skills

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ABSTRACT

Acquisition of time knowledge (TK; the correct representation and use of time units) is linked to the development of numerical abilities, but this relationship has not been investigated in children. The current study examined the acquisition of TK and its association with numerical skills. A total of 105 children aged 6 to 11 years were interviewed with our Time Knowledge Questionnaire (TKQ), developed for purposes of this study, and the Zareki-R, a battery for the evaluation of number processing and mental calculation. The TKQ assessed conventional time knowledge (temporal orientation, temporal sequences, relationships between time units, and telling the time on a clock), estimation of longer durations related to birthday and life span, and estimation of the duration of the interview. Time knowledge increased with age, especially from 6 to 8 years, and was strongly linked to numerical skills. Regression analyses showed that four numerical components were implicated in TK: academic knowledge of numbers and number facts (e.g., reading Arabic numerals, mental calculation), number line estimation (e.g., correspondence between a number and a distance), contextual estimation (e.g., many/few leaves on a tree, children in a family), and numerical tasks involving verbal working memory (e.g., comparison of numbers presented orally). Numerical correlations with TK varied according to children's age; subtests based on academic knowledge of numbers, working memory, and number line estimation were linked with TK in the

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younger children, but only contextual estimation was associated with TK in the older children.



## Introduction

Many philosophers have explored the relationship between time and number—from Aristotle (384–322 B.C.), who wrote that "time is the number of movement in respect to the before and after" (Physics IV), to more recent thinkers such as Bergson (1889/1967), who claimed that number is related to space but not to our experience of time. The relationship between time and number has been less widely investigated by developmental psychologists.

Dealing with time is an absolute necessity to organize life in society (for work, meals, leisure, etc.) (Fraisse, 1957), and this has led to the creation of conventional unit systems. Children need to develop some knowledge about these systems even if they are starting to have a primitive "sense of time" linked to actions—time to go to bed, duration of a pleasant/unpleasant event, and so forth. Both aspects, the conventional system of time units and the sense of time, have been assimilated to time knowledge (Friedman, 1990a). Time knowledge (TK), precisely defined here as the correct representation and use of the various time units (e.g., seconds, minutes, hours, days, weeks, months, seasons, years), has not been widely studied, nor has its development. Whereas using time units implies a proper representation and use of numbers (e.g., "It is 10 o'clock on the 25th day of the 9th month in the year 2015"), children's development of time knowledge is logically linked to the development of their numerical competencies.

However, up to now, most studies have been devoted to time perception over short durations without using verbal answers involving time units (for a review, see Droit-Volet, 2013). These studies reveal that the ability to judge time precisely in a wide variety of temporal tasks improves during childhood via the development of selective attention and working memory (Droit-Volet & Zelanti, 2013). As far as we know, the relationship between TK and numerical competencies has not been systematically examined in children, probably because of the lack of a tool for TK evaluation. Therefore, our aim was twofold: first, to study TK development during childhood and, second, to investigate the links between TK and children's numerical abilities. For the purposes of this study, we developed a Time Knowledge Questionnaire to evaluate the correct representation and use of the various time units.

### *Evaluation of TK: previous and new components*

Different aspects of TK, such as present-time awareness, using a calendar (Fraisse, 1957; Friedman, 1990a; Godart & Labelle, 1998), and telling the time on a clock (Burny, Valcke, & Desoete, 2009; Cohen, Ricci, Kibby, & Edmonds, 2000; Friedman & Laycock, 1989; Vakali, 1991), have already been investigated in children. Present-time awareness, also called time orientation, is the awareness of the present hour, day, month, year, or season. Awareness of the present day is thought to be acquired at the end of kindergarten at around 6 years, whereas that of the present month, season, or year occurs later in primary school at 7 or 8 years (Friedman, 1990a).

Other aspects of TK, more related to the experience of time, have been less widely envisaged. For example, the representation of time units might depend on implicit learning, such as experience-based knowledge (e.g., "A familiar activity takes *x* minutes/seconds/hours"), which could be clinically relevant. Indeed, children with autistic spectrum disorders have been shown to perform less well than typically developing children when durations were to be compared (e.g., eating a banana, going to a swimming pool) (Janeslätt, Granlund, Kottorp, & Almqvist, 2010).

Children's estimation of time during a long ongoing activity has rarely been studied (e.g., in the case of an interview duration, "For how long have we been here together?"), unlike children's