

INTRODUCTION TO EMPIRICAL STUDIES

The experiments reported here aimed to study the role of vision in the elaboration of the numerical representations and skills. To pursue this objective, we investigated how people who have lacked vision since birth or early childhood represent numbers and numerosities. Therefore in all our experiments, a group of congenitally or early blind people and a group of blindfolded sighted participants were submitted to classical basic numerical tasks. Our experimental tasks were chosen, according to their well-known efficiency in allowing straightforward test of the access and use of a semantic numerical representation with the same properties to those usually attributed to sighted participants' numerical representation. We would like to stress that all our studies were based on the examination of robust classical numerical effects found in the literature, and consequently they were also based on the theoretical metaphor of the mental number line these effects have raised. This theoretical background is used throughout our research as it constitutes a predominant view with a large consensus in numerical cognition research (Dehaene, 2003; Zorzi et al., 2006), as the mental number line metaphor appears to be useful to capture the spatial coding of numerical magnitudes (Fias & Fischer, 2005). Nevertheless, we would like to call the reader's attention to the fact that this metaphor is not the only theoretical proposal existing in the literature on how numerical magnitudes are represented. However, the aim of our thesis is not to try to disentangle between the different models made in numerical cognition. Moreover, the experimental paradigms chosen in our studies do not allow clarifying such theoretical issue, which is largely debated in the literature and would, by itself, constitute the subject of another thesis.

As presented in the first chapter, the semantic numerical representation is consensually defined by three properties, following the recurrent observation of three behavioural effects when human adults are submitted to numerical tasks. The distance and the SNARC effects suggested that the semantic numerical representation presents two spatial properties: 1) numbers are represented along a mental continuum; 2) this continuum is oriented from left to right. The first study of our thesis was conducted to investigate the potential role of vision in the development of this spatial framing of the semantic numerical representation in the range of small and large numbers. Therefore, congenitally or early blind and matched blindfolded sighted participants undertook two tasks on small

numbers (comparison task to 5 and parity judgement task) and one task on large numbers (comparison task to 55). Moreover, this study was amongst the few studies in which participants had to process numbers in the auditory modality. Indeed, this sensory modality has been rarely used in numerical cognition research. Consequently, the postulate according to which the semantic numerical representation is modality-independent was also investigated, by looking for the classical distance and SNARC effects with sighted participants when numerals were presented in the auditory modality.

The observation of the size effect in several numerical tasks suggests that the semantic numerical representation has a third property: its obedience to Weber's law. As we have seen in the first chapter, there is a debate in the literature on the conceptualization of Weber's law on the mental number line. However, the two different theoretical models made on this issue are equivalent at a functional level (Dehaene, 1992) and recently they are no more taken apart from each other but rather suggested to coexist (e.g., Verguts et al., 2005). The study of this third property of the semantic numerical representation has lately gathered an increased attention as several studies have shown that the experience individuals have with numbers and numerosities could have an impact on the way they represent their corresponding magnitudes (e.g., Siegler & Opfer, 2003) or access them (e.g., Lipton & Spelke, 2005), resulting in less sensitivity to Weber's law in their numerical processing. Now, as early visual deprivation in blind people necessarily implies a different experience with numbers and numerosities than sighted people, in the second study of our thesis, we investigated whether the absence of vision and its following experience with numbers and numerosities had an impact on the way the semantic numerical representation obeys Weber's law. A group of congenitally or early blind and matched blindfolded sighted participants were submitted to two numerical estimation tasks conducted in the auditory modality and in a wide range of numerosities: 1) a key-press estimation task; and 2) an auditory events estimation task. The examination of the participants' performance allowed us to see whether both groups presented patterns of performance reflecting similar access and use of a semantic numerical representation obeying Weber's law (e.g., Whalen et al., 1999). In addition, the observation in both groups of participants of discrepancy in the way numerical processing obeys Weber's law would support the assumption of the role of experience with numbers and numerosities in

the access or the representation of their corresponding magnitudes, by showing that different experience with numbers and numerosities leads to different patterns of performance. Finally, as our tasks were again conducted in the auditory modality, the question of the amodal nature of the semantic numerical representation was further investigated by looking for the replication of patterns of performance usually observed with sighted participants in the visual modality.

Following the report of our empirical studies, the results will be discussed and integrated in a general conclusion. The implications of our findings will then be examined, as well as the different perspectives of research they raise for the future.