Research in Developmental Disabilities 34 (2013) 2173–2184

Contents lists available at SciVerse ScienceDirect

Research in Developmental Disabilities

When the body is time: Spatial and temporal deixis in children with visual impairments and sighted children

Rositsa Iossifova [a], Fernando Marmolejo-Ramos [b,*]

[a] SLT Centre "Romel", South-East European Centre for Semiotic Studies, New Bulgarian University, Sofia, Bulgaria
[b] School of Education, Faculty of the Professions, University of Adelaide, Australia

ARTICLE INFO

Article history:
Received 12 December 2012
Received in revised form 19 March 2013
Accepted 25 March 2013
Available online 1 May 2013

Keywords:
Embodiment
Metaphoric mapping
Space
Time
Cognitive development
Deixis

ABSTRACT

While there is mounting evidence explaining how concrete concepts are processed, the evidence demonstrating how abstract concepts are processed is rather scant. Most research illustrating how concrete and abstract concepts are processed has been obtained from adult populations. Consequently, not much is known about how these concepts are processed by children, especially those with sensorimotor impairments. This paper reports a study in which groups of children who were either visual-motor impaired (VMG), blind (BG), or sighted (CG) were requested to perform deictic gestures for temporal and spatial concepts. The results showed that: (i) spatial pointing was performed faster than temporal pointing across all groups of children; (ii) such difference in pointing times occurred also within groups; and (iii) the slowest pointing times were those of the blind children followed by the VMG and the CG children, respectively. Additionally, while CG children correctly performed the pointing tasks, VMG and, particularly, BG children relied on a form of deixis known as autotopological (or personal) deixis. The results thus suggest that deprivation or lack of sensorimotor experience with the environment affects the processing of abstract concepts and that a compensatory mechanism may be to rely on the body as a reference frame.

1. Introduction

The metaphorical means used to make concepts relating to "time" more understandable are primarily space-related. The grounding metaphors of "*moving ego*" and "*moving time*" based on direct sensorimotor experiences of *motion* (walking) and on representations of time as physical objects that can *move* are common in many languages (Boroditsky, 2000; Gentner, 2001; Graf, 2011; Moore, 2006; Núñez, Motz, & Teuscher, 2006; Özçalışkan, 2005; Sinha, Sinha, Zinken, & Sampaio, 2011).

The word "time" in ancient Bulgarian translates as 'врѣмѧ' (*vrěmę*) and refers to the verb 'врьтѣти' or 'тврьштѫ', which means to "turn" or to "go round". This "cyclical" understanding of time has been shown to be different from that utilised in current Bulgarian language. Specifically, "time" appears to be understood in terms of its relationship to material objects located in space that can be pointed at or described regarding their physical properties (e.g., objects' size and consistency) and movability (e.g., some objects can run, fly, or crawl) (Iossifova, 2008). For example, Iossifova (2008) found that, during a free verbal association experiment, adult Bulgarians linked the word "time" with words such as "pass", "fly", "trail", "run", "many", "less", "have", "have not", "frame", "hand", and "sun", among others.

* Corresponding author. Tel.: +61 8 8313 3021.
E-mail addresses: logoped@techno-link.com (R. Iossifova), fernando.marmolejoramos@adelaide.edu.au (F. Marmolejo-Ramos).
URL: http://www.nbu.bg/index.php?l=444, http://sites.google.com/site/fernandomarmolejoramos/

0891-4222/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ridd.2013.03.030

These findings thus suggest that the concepts of time and space can entail the activation of sensorimotor representations. This idea is in line with proposals found in theories of conceptual metaphor and grounded knowledge (Barsalou, 2008; Casasanto, Fotakopoulou, & Boroditsky, 2010; Casasanto & Henetz, 2012; Gibbs, 1996; Isbell & Roncalla Fernández, 1977; Lakoff & Johnson, 1999; Lakoff & Núñez, 2000; McNeill, 1992; Özçalışkan, 2005, 2007; Scorolli et al., 2011; Shabalina, 2007; Vosniadou, 1987). Most of the claims and findings from these theories are based on data collected from normal adult populations; therefore it is open to question how the concepts of space and time are processed by normal children and children with sensorimotor impairments.

The present paper provides evidence as to how sighted children and children with visual-motor impairments perform deictic pointing when referring to spatial and temporal concepts. Firstly, the deictic pointing in both sighted and visually impaired children will be reviewed in two separate sections. Secondly, the purpose and the methodological details of the present study will be spelled out. Finally, an interpretation of the results and some ideas for future research will be put forward.

1.1. Deictic pointing in children

The dynamics of spatial and temporal concept acquisition has been studied mainly from a linguistic perspective (Clark & Sengul, 1978; Johnston & Slobin, 1979; Weist, 2002, 2009), and the early chronological asymmetry between both domains has been shown to be very complex. For instance, Casasanto et al. (2010) argue that space and time are related asymmetrically in children's minds, based on the finding that children between the ages of 4.5 and 10.9 more accurately judge distance in the presence of temporal interference than the duration of actions in the presence of spatial interference. Özçalışkan (2005) found that by the age of 4.0 English and Turkish-speaking children begin to understand metaphorical motions of time in a story context. By the age of 5.0 children begin to take into account the meaning of both the source domain (motion) and the target domain (time) and produce metaphorical interpretations.

Therefore, it is necessary to understand how children perform metaphoric gestures, especially deictics. The metaphoric gestures play an important role in understanding the source domain and the possible ways children achieve the conceptual-linguistic mapping between the source (space) and the target domain (time) (Casasanto et al., 2010; Gentner, 1977; Gibbs, 1996; Lakoff & Johnson, 1999; McNeill, 1992; McNeill, Cassell, & Levy, 1993; Özçalışkan, 2007; Scorolli et al., 2011).

Normal psychomotor development, i.e., the development of gross and fine motor movements (i.e., ocular, oral, and manual movements), is a prerequisite for the normal structure of body scheme and the egocentric and allocentric (intrinsic, absolute) space. The term "egocentric space" (Asenova, 2009; Barca, Pezzulo, & Castelli, 2010; Brownell, Nichols, Svetlova, Zerwas, & Ramani, 2010; Brownell, Svetlova, & Nichols, 2012; Colby, 1998; Paillard, 1991; Pederson, 2003) defines the body as the central point of reference. In addition, the topology of body refers to certain body parts that can be regarded as possible frames of reference. For instance, in normal psychomotor development, the sensation of gravity and bodily verticalisation plays a key role in acquiring the transversal axes ("up"-"down") (e.g., Elk & Blanke, 2011; Mazeau, 2005; Paillard, 1991; Puche-Navarro & Millan, 2007). Automated walking (approximately appearing at 18 months) becomes a precondition for the mastery of the frontal axes ("front"-"back"). At the age of 6.0–7.0 years the concepts of left and right become properly understood and applied, i.e., the verbalisation of sagittal axes is achieved.

Adult speakers use the egocentric and allocentric frames of reference to locate or indicate objects that are proximal or distal, present or absent, as well as actions or events. That is, different bodily axes serve to define the egocentric frame; specifically, the transversal (the up/down axis), the frontal (the front/back axis), and the sagittal (the left/right axis) frames are used to give concreteness about direction by which objects, actions or events can be seen. For instance, Casasanto and Jasmin (2012) found that during spontaneous speech relating to time, English speakers produced more systematically deliberate gestures on the sagittal axis than on the lateral axis (Experiment 1), while during spontaneous co-speech they produced more lateral than sagittal gestures by about 3:1 (Experiment 2). One of the possible explanations for this can be found in the dual role that hands play during spontaneous communication, as they simultaneously perform pointing and beat gestures which support the fluency of speech and serve as metadiscursive markers (Boyer, Di Cristo, & Guaïtella, 2001; Brandhorst & Theune, 2009; Krahmer & Swerts, 2007). Cooperrider and Núñez (2009) found that English speakers perform several types of temporal-related gestures (i.e., placing, pointing, duration-marking, bridging and animating), and that gestures that localise the events use the transversal pattern. According to the authors, one reason for this preference for the transversal pattern is the visibility of hands to the interlocutor.

The predominance of one or several temporal axes seems to be dependent on cultural representations that include direction of writing, language, variability of context, and mode of speaking (spontaneous speech or deliberate reaction) (Boroditsky, Fuhrman, & McCormick, 2010; Calbris, 1985; Casasanto & Jasmin, 2012; Cooperrider & Núñez, 2009; Montredon, 1998; Moore, 2006; Pederson, 2003; Sinha et al., 2011). Additionally, it is important to stress that age and the presence of pathology might affect the way an individual maps space onto time.

For the purposes of the current study, which is developmental but also deals with sensorimotor pathology, it is important to specify (1) the possible space and time referential frames (patterns) that might be used by sighted children, children with strabismus, with amblyopia, and by blind children in early school age; (2) the possible deictic types of pointing, and (3) the possible modalities acting as deictic, i.e., haptic and/or kinetic.

The pointing gesture is a concrete motor act that is most likely accomplished within an egocentric framework (Barca et al., 2010; Moore, 2006). According to Semenovich's model of the ontogeny of spatial cognition (2002), metric and

Table 1
Types of deixis, pointing, and frames of reference.

Deixis type	Pointing type	Characterisation and frame of reference
Personal deixis (PD)	Autotopological pointing	The body topology, i.e., different body parts, is used as the frame of reference It might be typical deictic or haptic
Spatial deixis (SD)	Concrete object or action locational pointing	The egocentric space or the egocentric space with non-ego object, which connects egocentric to the allocentric frames of reference (Coluccia et al., 2007; Grush, 2000), is used as the reference point It is manifested as typical deixis The pointed objects/actions are present
	Abstract object or action locational pointing	The egocentric space or the egocentric space with non-ego object is used as the reference point Manifested as typical deixis The pointed objects/actions are absent (McNeill, Cassell, & Levy, 1993).
	Abstract directional pointing	The allocentric space is used as the frame of reference to indicate direction, i.e., "in front", "behind", etc. Manifested as typical deixis.
Temporal deixis (TD)	Metaphoric temporal pointing	The body topology, the egocentric space or the egocentric space with non-ego object reference point, and/or the allocentric space, are used as the frames of reference. All types of concrete or abstract spatial pointing might theoretically be mapped onto time (e.g., under metaphorical mapping, different referential frames of space might map to referential frames of time).

topological representations of the body take shape before the stage of coordinate representations appear. It has been shown (Iossifova & Marmolejo-Ramos, 2012; Stoyanova, Iossifova, Poppandova, & Netsova, 2010) that a large percentage of children between the ages of 3.0 and 4.0, and children with visual disabilities, point at their body parts in lieu of space directions, i.e., they point at their chest in lieu of "in front" or at their crown in lieu of "up". In this article this type of pointing is termed *autotopological pointing* (or personal deixis) since it is a more correct term than that of "self-reference", which is used in some sources to describe pointing at body parts. The egocentric and the allocentric frames of reference are introduced as parts of a continuum, in which the level of abstraction depends on their proximity to the body (Coluccia, Mammarella, De Beni, Ittyerah, & Cornoldi, 2007; Grush, 2000). Several types of deictic pointing are taken into account depending on the spatial reference used and their concrete, abstract or metaphoric nature. Early pointing, which is widely investigated because of its impact on the emergence of words and the transition from the one-word to two-word stage (Bates & Dick, 2002; Capone & McGregor, 2004; Iverson, Tencer, Lany, & Goldin-Meadow, 2000; Volterra, Caselli, Caprici, & Pizzuto, 2005), is not discussed here because of its multifunctional character and close relation to object manipulations such as reaching, grasping, giving, and showing. Table 1 summarises the types of deixis, pointing and reference frames discussed in this paper.

At the age of three, children acquire the ability to indicate spatial directions in the allocentric empty space (Coquet & Maetz, 1999; Johnston & Slobin, 1979; Stoyanova et al., 2010), i.e., they begin to correctly use *abstract directional pointing*. There are reasons to believe, however, that in the process of conceptualising novel abstract levels such as directions in allocentric space, children refer to a primitive, less abstract level (space), such as the *topology* of the body.

1.2. The case of blind children and children with strabismus or amblyopia

Pointing in blind children has been documented by Iverson et al. (2000). They found that in the stage of word-learning, blind children both point and utilise the same types of gestures as sighted children. Nevertheless blind children rely on gestures to a lesser degree than do sighted children, favouring instead speech and explicit verbal feedback from adults. It is also worth noting that blind children predominantly perform interactions with objects that are within their immediate perceptual field because they lack easy access to distal objects. The findings of Bruce, Mann, Jones, and Gavin (2007) are consistent with those made by Iverson et al. (2000). They found that congenitally deaf blind children express fewer distal gestures than do sighted children, and that they perform contact gestures more frequently than conventional (distal) gestures. Congenitally deaf blind children often push a person's hand, pat their own head, touch or tap on objects, push an object, or reach for an object. Pointing, which might be performed by palm, fist, head, or with the upper part of the body, is often substituted with reaching in order to direct the adults' hand or body. Physical contact and touch seem to be preferred as a way of directing adults' attention. Ruggiero, Ruotolo, and Iachini (2009) found that congenitally blind children tend to rely on the egocentric encoding, which is more efficient in providing information about allocentric invariant relationships between objects in external space. The authors conclude that a lack of vision should affect allocentric but not egocentric frames of references.

Despite the availability of data related to early pointing and the performances of blind children in the egocentered frames of reference, there is no data about how these children use conventional spatial and temporal pointing when referring to the specification of directions (i.e., "in front", "behind") and points in time (i.e., "tomorrow", "yesterday", etc.). Thus, it is important to investigate these abilities not only in blind children but also in children with visual-motor impairments due to strabismus and/or amblyopia.

Koller (2000) defines the ophthalmic disorder strabismus ("squint") as a condition of misaligned eyes in which the eyes are not aimed in the same visual direction, and amblyopia as diminished vision without an obvious physical or structural abnormality present to account for the vision loss. Strabismus, as well as severe amblyopia, is related to problems of binocular vision, which may affect depth perception. These ophthalmic difficulties might impair an understanding of abstract concepts, handwriting, reading, and mathematics (Gompel, Janssen, van Bon, & Schreuder, 2003; Koller, 2000; Mazeau, 2005; Reed, Kraft, & Buncic, 2004).

Problems with abstract knowledge acquisition in children with strabismus and/or amblyopia are insufficiently studied, leaving open the question of how space and time are related in their minds. Research with this group of children is of interest because their visual processing has a negative effect on their construction of body schema, egocentric and allocentric space (Asenova, 2009; Barca et al., 2010; Colby, 1998; Dutton et al., 2004; Hyvärinen, 2000; Iossifova, 2009; Lehky & Sereno, 2011; Mazeau, 2005; Paillard, 1991; Popova, 2003). Also, the motor delay due to blindness, strabismus and amblyopia is less investigated than the "pure" role of visual deprivation on the organisation of conceptual knowledge (Bedny, Caramazza, Pascual-Leone, & Saxe, 2012; Marques, 2010; Noppeney, Friston, & Price, 2003; Puche-Navarro & Millan, 2007). Finally, another important characteristic of children with visual-motor impairments is their inability to automatically and subconsciously activate sensorimotor representations during the processing of concrete concepts.

1.3. The purpose of study

The purpose of the current study is to explore the mastery of pointing in relation to spatial deixis (SD) and temporal deixis (TD) by sighted children (CG), children with visual-motor impairments due to strabismus and/or amblyopia (VMG), and by blind children (BG).

It is expected that the deictic execution time for SD will be faster than the execution time for TD in all three groups because the processing time for abstract concepts (time) is longer than it is for concrete concepts (space) (Sabsevitz, Medler, Seidenberg, & Binder, 2005). It is also anticipated that the execution times for spatial pointing will be longer for children with visual-motor problems and blind children than they are for the sighted children, due to the lack of automatism of gross and fine motor reactions which makes executions (pointing) slow and not fluent. On the basis of this expectation, it is supposed that execution times for temporal pointing will be longer in the VMG and BG than in the CG.

In both the VMG and the BG, differences are expected in the accuracy of the executions because of the participants' visual status and the role that vision and motor systems play in conceptual knowledge. Vision is linked mostly with allocentric frames of reference, so it is assumed that both directional pointing (spatial processing) and temporal pointing (time processing) would be impaired in these groups of children. There are reasons to believe that in the process of conceptualising both directions in the allocentric space and temporal references, VMG children might refer to the topology of the body as a less abstract level of reference, and should exhibit substitutions of SD for personal deixis (PD) more often than the CG children. Because a lack of vision implies that the conceptualisation of spatial and temporal references relies primarily on haptic and auditory modalities, a significant number of substitutions of SD and TD for PD are expected in the BG. Finally, based on previous research (Iossifova, 2012; Iossifova & Marmolejo-Ramos, 2012), accuracy and the prevalence of deictic executions are expected in the CG, i.e., we expect to find correct conventional pointing at spatial-related, and at temporal-related references which have a single codeable direction ("front"-"back" or "left"-"right").

2. Method

2.1. Participants

A total of 48 children (28 males) between the ages of 6.11 and 8.1 from schools in Sofia and Blagoevgrad, Bulgaria participated in the study. Sixteen children (M_{age} = 7.34, SD = .44) without visual or motor impairments formed the control group and 16 children (M_{age} = 7.35, SD = .58) with visual-motor impairments due to strabismus or amblyopia formed the visuomotor group. Both groups of children were recruited from normal schools. Sixteen blind children (M_{age} = 7.50, SD = .41), who were blind from birth, were recruited from schools for blind children to form the blind children group. All children were of Bulgarian ethnicity and came from middle and high-socio economical statuses. The children's parents and directors of the schools were contacted in order to obtain their written or oral consent.

Children's cognitive and visuo-motor status was evaluated by one of the researchers who has expertise in the field of paediatric ophthalmology and logopaedics. The Bulgarian neuropsychological evaluation for children from elementary schools (B. N. E., 1985) was used to perform the evaluation and thus categorise the children into the three groups of participants presented in this study.

2.2. Procedure and materials

Two researchers worked with the children during data collection. One of the researchers gave the instructions and scored the accuracy of their executions while the other researcher measured the children's execution time using a digital stopwatch. In this study, execution time was defined as the lapse between the moment the verbal instruction was given to the child and the moment his/her gesture culminated. The phases of a gesture were those proposed by McNeill (2005), i.e., preparation, pre-stroke hold, the stroke itself, post-stroke hold, and retraction (see Fig. 1).

The same procedure reported by Iossifova and Marmolejo-Ramos (2012) was employed here. That is, children were asked to point at space and time locations in relation to their bodies by using their hand or finger, immediately following the verbal instruction. Children had to use a non-verbal deictic gesture to materialise the verbal request given by the researcher.

Children were asked to perform two types of deixis. First, children were asked to perform the SD with the instruction "use your hand/finger and point 'in front of you', 'behind you', 'up', 'down', 'left', and 'right'", in random order. Immediately after they were asked to perform the TD with the instruction "use your hand/finger and point to 'yesterday', 'tomorrow', 'today', 'two days from now', 'one day ago', and 'now'", in random order.

The rationale behind this ordering was that asking someone to gesture via temporal adverbs is not as common a task as asking to gesture via spatial adverbs, thus the SD task was requested first to help children become familiar with the whole experimental session.

The deictic gestures were registered according to two criteria: their accuracy, and the time taken to execute them. Correct deictic gestures were scored as 1, whereas incorrect ones were scored as 0. Despite multiple options of gesturing time, the correct deictic gesture is defined here as a conventional movement which has single codeable directions, e.g., front/back or left/right. Incorrect executions were those in which a verbal answer was given in lieu of the requested gesture, when children pointed to their body parts in lieu of the temporal (PD_TD) or the spatial (PD_SD) deixis requested, when temporal-related gestures had no single codeable direction, or when the execution time was longer than 40 s.

2.3. Design and analysis

The independent variables were the three groups of children and the two types of deixis requested to be performed. The time children took to correctly perform the spatial and temporal deictic gestures was one of the dependent measures. Other dependent measures included the number of correct deictic gestures and the number of PD_TD and PD_SD.

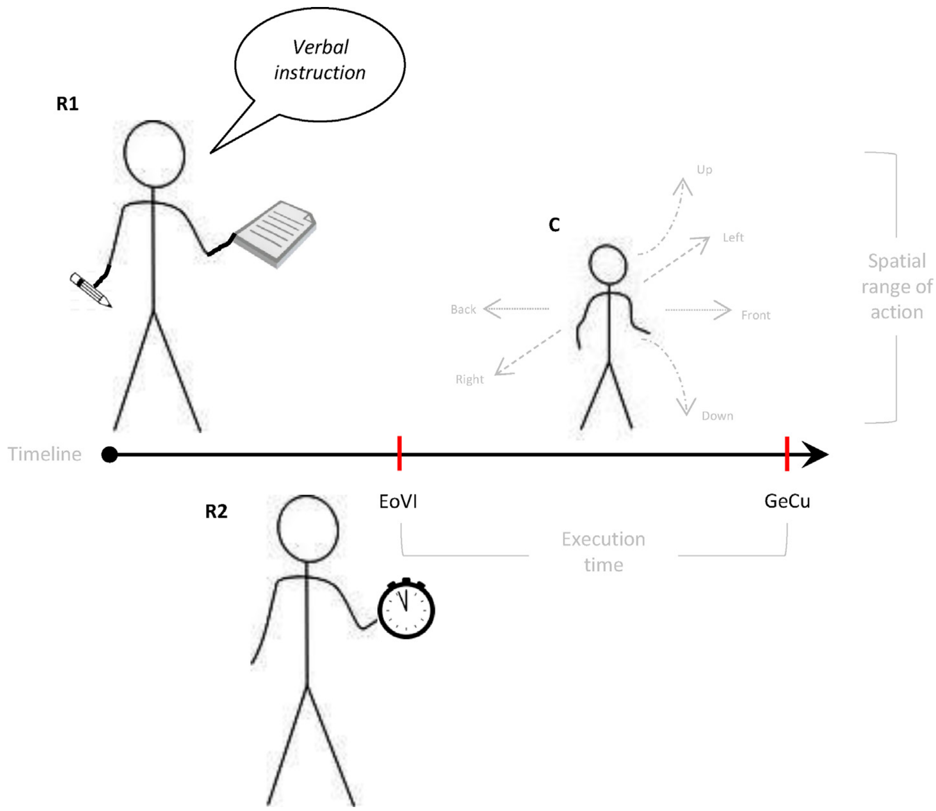

Fig. 1. Illustration of the pointing task. R1, researcher 1 gives verbal instructions and scores the accuracy of executions; R2, researcher 2 times the execution of the action; EoVI, end of the verbal instruction; C, child; GeCu, gesture culmination. The black arrow line represents the timeline of the task for each child.

Deixis execution times were submitted to a 2 (children group: CG and VMG) × 2 (deixis type: PD and TD) ANOVA-type statistic (F_{ATS}) (e.g., Brunner, Dette, & Munk, 1997; Brunner, Domhof, & Langer, 2002; Kapstein, Nass, & Markopoulos, 2010; Noguchi, Gel, Brunner, & Konietschke, 2012; Shah & Madden, 2004) with the first variable entered as a between-subjects factor and the second variable as a within-subjects factor.[1] The execution times of blind children were not included in the analysis since they were, on average, above 40 s due to their difficulty in executing the gesture, high level of hesitations, and motivation problems.

Pair-wise comparisons were done using the Brunner–Munzel (2000) test for two independent samples (W_{BF}) and the two-sample LD-F1 test for stochastic equality (e.g., Brunner et al., 2002, p. 93, equation [7.6]) for two dependent samples (V_{BF}).[2]

Frequency data was analysed using a chi-square test with simulated p-values (based on 2000 replicates) and standardised residuals (sr) were computed to assess the significance of the results observed in specific cells. The simulated p-value (based on 2000 replicates) of the Fisher's exact test (here, p_{FET}) was computed whenever a contingency table had cells with values equal or less than 5. Odds ratios (OR) and their 95% CIs were computed for pair-wise comparisons of interest (see Bland & Altman, 2000, for the computation of ORs and their confidence intervals).

Clustered error bars and mosaic plots (Hartigan & Kleiner, 1984; see also Friendly, 1994) were used to present the results of the deictic execution times and the number of correct and erroneous deictic gestures, respectively.

Eta effect sizes (η) were computed for main and interaction effects and Cramér's V effect sizes (V) were computed for significant associations.[3]

3. Results

3.1. Deictic execution times

A robust average execution time for each child in each condition was obtained by computing the median (e.g., Rosenberg & Gasko, 1983) execution time across the six items in each deixis condition.

The ATS showed a main effect of deixis, $F_{ATS}(1, 26.31) = 89.47$, $p < .001$, $\eta = .87$, and a main effect of participants, $F_{ATS}(1, 25.60) = 25.00$, $p < .001$, $\eta = .70$. The interaction between deixis and participants was not significant, $F_{ATS}(1, 26.31) = 0.56$, $p = .45$, $\eta = .14$. That is, SD were performed faster ($M_{spatial} = 1.72$, $SE = .08$) than TD ($M_{temporal} = 4.83$, $SE = .66$) across groups, $V_{BF}(31) = 8.15$, $p < .001$, and children in the CG group were faster ($M_{CG} = 2.13$, $SE = .48$) to perform both types of deixis than children in the VMG group ($M_{VMG} = 4.41$, $SE = .48$), $W_{BF}(55.58) = 4.83$, $p < .001$ (see Fig. 2).

Fig. 2 shows that there were significant differences between spatial and temporal deixis times within each group as signalled by the non-overlap of CIs within each group ($M_{CG\text{-}space} = 1.36$ and $M_{CG\text{-}time} = 2.90$, $M_{VMG\text{-}space} = 2.07$ and $M_{VMG\text{-}time} = 6.75$).[4]

Fig. 2 also shows that execution times in the SD had lower variance than execution times in the TD in each group ($SD_{CG\text{-}space} = .26$ and $SD_{CG\text{-}time} = 1.80$, $SD_{VMG\text{-}space} = .64$ and $SD_{VMG\text{-}time} = 5.03$). Children in the BG (not shown in the figure) also exhibited a similar pattern with the only difference being that execution times were markedly slower than those of CG and VMG ($M_{BG\text{-}space} = 27.57$, $SD_{BG\text{-}space} = 7.65$ and $M_{BG\text{-}time} = 54.29$, $SD_{BG\text{-}time} = 21.64$).

3.2. Accuracy of spatial and temporal deixis

A Chi-square test suggested that there was a significant association between the group of children and the deixis type, $\chi^2(2, N = 312) = 18.95$, $p < .001$ ($V = 0.246$, $p < .001$).

Standardised residuals (sr) were computed for the specific cells in which the amount of spatial and temporal deixis was significantly higher or lower than that expected ($-1.96 \geq sr \geq 1.96$ represent significant frequencies). That is, the sr values

[1] This analysis was performed in R using the "f1.ld.f1" function available in the "nparLD" package (Noguchi et al., 2012). The output of interest appears under the label "$ANOVA.test" but only the numerator degrees of freedom are provided in that section. Thus, the denominator degrees of freedom were extracted from the output section labelled "$case2x2" (see details in the "nparLD" package).

[2] The two-independent sample test was performed in R using the "brunner.munzel.test" function available in the "lawstat" package. The two-dependent samples test was coded in R.

[3] Statistical packages like SPSS can output partial eta square effect sizes (η_p^2) and, to the best of our knowledge, the only benchmarks available to interpret η_p^2 are those proposed by Kittler, Menard, and Phillips (2007): 0.01 – small, 0.06 – medium, and 0.14 – large. However, this measure of effect size was not used since there is no consensus regarding their interpretation and the only available benchmarks have not been studied in the case of Psychological data. Eta effect size can be interpreted as the well-known Pearson product-moment correlation coefficient (r) and provides a measure of the proportion of variance accounted for in the dependent variable given the effects of the independent variables (see Field, 2005, p. 514, for formula). As η can refer to linear and nonlinear relationships, η can be considered a general case in which r is a special example (Rosenthal & Rosnow, 2008). Thus, the generally accepted regression benchmark for effect size r can be used to interpret η: small – 0.10, medium – 0.30, and large – 0.50 (Cohen, 1992). Cramér's V effect sizes can be interpreted on a range between 0 (no association) and 1 (complete association).

[4] As the present design contained repeated measures (i.e., deixis type), confidence intervals were initially adjusted using the Loftus and Masson method (here, LMm) (1994; Masson & Loftus, 2003) described in Field (2005, pp. 279–285). However, the graphical output, while supporting the significant main effects found, did not permit visualising the difference in variances between the spatial and temporal deixis execution times within each group of participants; therefore unadjusted confidence intervals are reported. Inferences based on the degree of overlap between CIs are not affected in the present results since the purpose of the LMm is to remove the between-subjects variance, which entails shortening the length of the CIs. As Fig. 2 suggests, a non-overlap between CIs within each group already existed, which suggests that applying the LMm would simply enhance such non-overlap.

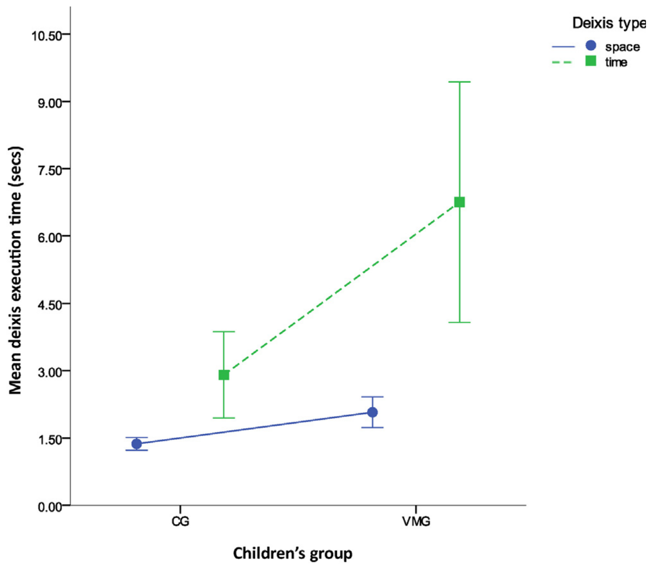

Fig. 2. Mean execution times to spatial (blue circle and solid line) and temporal (green square and dotted line) deixis for the control group (CG) and the group of children with visual-motor impairments (VMG). Error bars represent 95% CIs around the mean. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

signal cases in which children performed more or fewer deictic gestures than expected. The percentages represent the amount of correct deictic gestures occurring within each study group, unless otherwise indicated.

Children in the CG showed percentages of spatial (64.08%) and temporal (35.91%) deixis that were within the expected values for that group (all *sr* = ns). VMG children also exhibited percentages of spatial (66.66%) and temporal (33.33%) deixis that were within the expected values (all *sr* = ns). BG children had a percentage of SD that was not significantly different from that expected (89.13%) but showed a significantly low percentage of TD (10.87%, *sr* = −3.09) (see Fig. 3A).

Finally, while 45.51% of correct spatial and temporal deictic gestures were performed by the children in the CG, 25% and 29.48% of correct deictic gestures were performed by the children with visual-motor impairment and the blind children group, respectively (see Fig. 3A). The *OR* analyses indicated that children in the BG group were 8 times more likely to perform more SDs than TDs, that these children were around 4.5 times more likely to perform more SDs than TDs than CG children, and that these children were around 4 times more likely to perform more SDs than TDs than children in the VMG group (see grey-shaded rows in Table 2).

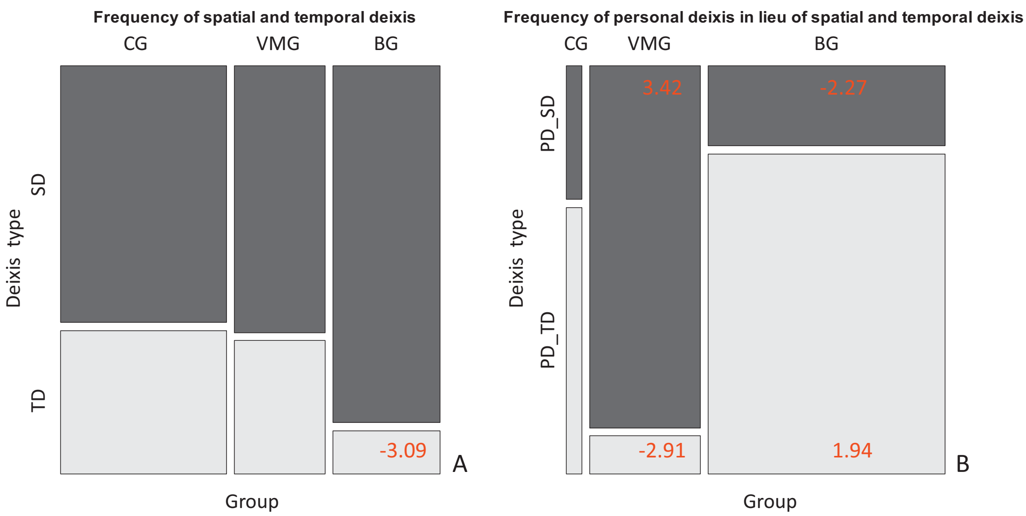

Fig. 3. Mosaic plot of the frequencies of correct spatial and temporal deixis (A) and personal deixis in lieu of spatial and temporal deixis (B). SD, spatial deixis; TD, temporal deixis; PD_SD, personal deixis in lieu of spatial deixis; PD_TD, personal deixis in lieu of temporal deixis; CG, control group; VMG, group of children with visual-motor impairments; BG, group of blind children. The *sr* values signal cases in which children significantly performed more or fewer deictic gestures than expected.

Table 2
Odds ratios (OR) and 95% CIs (LL, lower limit; UL, upper limit) for pair-wise comparisons within and between participants for spatial deixis and temporal deixis (SD and TD) and personal deixis in lieu of spatial and temporal deixis (PD_SD and PD_TD). SD, spatial deixis; TD, temporal deixis; PD_SD, personal deixis in lieu of spatial deixis; PD_TD, personal deixis in lieu of temporal deixis; CG, control group; VMG, group of children with visual-motor impairments; and BG, group of blind children.

Comparisons in the children groups		SD and TD	PD_SD and PD_TD[a]	[LL, OR, UL]
Within groups	Between groups			
CG		SD > TD		[.74, 1.78, 4.29]
VMG		SD > TD		[.83, 2, 4.81]
BG		SD > TD		[3.40, 8.2, 19.72]
	CG vs VMG	SD + TD		[.75, 1.82, 4.37]
	VMG vs CG	(SD > TD)		[.46, 1.12, 2.70]
	CG vs BG	SD + TD		[.64, 1.54, 3.71]
	BG vs CG	(SD > TD)		[1.91, 4.60, 11.07]
	BG vs VMG	SD + TD		[.49, 1.17, 2.83]
	BG vs VMG	(SD > TD)		[1.70, 4.1, 9.86]
CG			PD_TD > PD_SD	[.10, 2, 36.4]
VMG			PD_SD > PD_TD	[.52, 9.5, 172.92]
BG			PD_TD > PD_SD	[.21, 4, 72.80]
	VMG vs CG		PD_TD + PD_SD	[.38, 7, 127.41]
	BG vs CG		PD_TD + PD_SD	[.82, 15, 273.03]
	BG vs CG		(PD_TD > PD_SD)	[.10, 2, 36.40]
	BG vs VMG		PD_TD + PD_SD	[.11, 2.14, 39]

Note: Significant *OR* values (i.e., when LL > 1) are shaded in grey and the interpretation of these results is provided in the main text.
[a] The VMG group showed a pattern opposite to that shown by the CG and BG groups (i.e., "PD_TD > PD_SD") and in which children tended to use more PD_SD than PD_TD (or "PD_SD > PD_TD"). Thus, it was not sensible to estimate *OR*s for the likelihood of performing more PD_SD than PD_TD (or "(PD_SD > PD_TD)") between the VMG and the other two groups.

3.3. *Personal deixis in lieu of spatial and temporal deixis*

A Chi-square test suggested that there was a significant association between the group of children and PD type, $\chi^2(2, N = 69) = 29.28$, $p_{FET} < .001$ ($V = 0.651$, $p < .001$).

Standardised residuals (*sr*) were computed for the specific cells in which the number of PD was significantly higher than that expected ($sr \geq 1.96$ represent significant frequencies). That is, only the cases when children performed non-requested deixis, i.e., pointing to themselves, were considered errors. The percentages represent the amount of personal deictic gestures occurring within each study group, unless otherwise indicated.

Sighted children in the CG showed 66.66% of PD_TD and 33.33% of PD_SD that were close to those expected, i.e., they correctly performed the requested pointing task (all *sr* = ns). VMG children exhibited a significantly higher percentage of PD_SD (90.74%, $sr = 3.42$), and BG children showed a higher percentage of PD_TD (80%, $sr = 1.94$)[5] (see Fig. 3B).

When VMG children were requested to perform a TD and when BG children were requested to perform a SD, significant negative *sr*s were found (−2.91 and −2.27 respectively). These results suggest that these children exhibited an amount of PD that was lower than expected, and made significantly fewer errors than expected. The *sr*s thus indicate that children in these groups did not have significant problems performing the requested deixis.

Finally, while 4.3% of the PD in lieu of spatial and temporal deixis were performed by the children in the CG, 30.4% and 65.2% of PD gestures were performed by the VMG children and the BG children, respectively (see Fig. 3B). Despite some large *OR* values, the analyses did not signal significant ratios for pair-wise comparisons in the case of PD in lieu of SDs and TDs (see results associated to the column "PD_SD and PD_TD" in Table 2).[6]

4. Discussion

It was assumed that children in the VMG and the BG should exhibit differences in their accuracy and execution times because of their visual status and the role that vision and motor systems play in the development of conceptual knowledge.

Asking for SD was an easy and familiar task for children in the CG and children in the VMG who execute these types of gestures in their normal everyday lives (e.g., reacting to instructions of their parents, teachers, friends or asking others to look or point at space). Conversely, asking these children to point via time references provoked momentary surprise. This

[5] Given that this value was very close to the 1.96 benchmark, it is regarded as a result that deserves attention. Other *sr* values in these analyses were not this close to reach significance, thus only this borderline case is worth considering.
[6] The reason for these non-significant results was a rather large standard error for the log-*OR* (which was 1.48). In turn, such a large standard error was due to the small sample size of the contingency table (which was 69) and to some cells having a sample size less than 5. Tentatively, however, the *OR* results seem to suggest that both BG and VMG children are more likely to perform PD in lieu of spatial and temporal deixis than sighted children (*OR*s = 15 and 7, respectively) and that children in the VMG group are highly likely to perform more PD_SD than PD_TD (*OR*s = 9.5).

observation leads to the conclusion that SD is an early, basic and natural activity while the TD seems to be a more complex task that demands more cognitive efforts.

4.1. Deictic execution times

It was expected that the execution time for directional pointing (SD) would be faster than the execution time for metaphoric temporal pointing (TD) in all three groups because the processing time for abstract concepts (temporal reference) is longer than for concrete concepts (space). It was assumed as well, that for the VMG and for the BG the execution time for concrete concepts, relating to space words, would be longer due to a lack of automatisation of gross and fine motor reactions, which makes executions slow and not fluent. On the basis of this expectation it was further assumed that the execution time for abstract concepts relating to time-words would be longer than in the CG.

The results confirmed the hypothesis that both the type of deixis and the type of participants might influence the deictic execution time. The interaction between deixis and participants was not significant. That is, SD were performed faster than TD across groups, and children in the CG were faster to perform both types of deixis than children in the VMG. As expected, there were significant differences between spatial and temporal deixis times within each group.

4.2. Accuracy of the deictic answers

The results showed that sighted children could perform both deictic tasks correctly. In other words, children in this group had achieved the conceptualisation of directions. The children in the VMG could perform spatial and temporal deixis as correctly as the children in the CG. However, the amount of correct temporal and spatial deixis of the VMG children was lower than the amount of deixis normal children exhibit. While blind children might not have problems with performing spatial deictic gestures, they do have difficulties performing TD and, overall, do not perform as much spatial and temporal deixis as sighted children.

The results of PD in lieu of spatial and temporal deixis showed that children in the CG performed temporal and spatial deixis appropriately and that these children did not rely on this deictic approach. Interestingly, children in the VMG relied on autotopological deixis only when a SD was requested. This result could suggest that in the case of the VMG, for whom vision is impaired and the motor system is compromised, information from the allocentric space may be perceived as less reliable than that coming from egocentric and bodily space. The substitutions of SD for autotopological deixis in these children or the blending of bodily and egocentric space has been observed in normal 3.0–4.0 year old children during the same SD task (Stoyanova et al., 2010). Blind children rely entirely on their motor and proprioceptive system when performing both deictic tasks, which in turn can enhance their reliance on both allocentric and egocentric space. However, given the proposal that abstract concepts rely on concrete concepts via metaphorical mapping (in this case, time relying on space), blind children might find it difficult to localise in space an abstract entity for which no other perceptual (e.g., visual) referent exists.

It has been shown that blind people can establish egocentric spatial relationships as appropriately as sighted people; however, blind people have limitations with allocentric space (e.g., Ruggiero et al., 2009). Such results could indicate that since blind people rely heavily on their bodies in order to deal with spatial relations, the use of external landmarks is attenuated. That is, blind people predominantly use their bodies, rather than any sort of external physical landmark, as the frame of reference for the comprehension of concepts. The present results support such claims by showing that while children in the CG exhibited low frequencies of PD in lieu of temporal and spatial deixis, the BG predominantly used the body as the frame of reference for both types of deixis. More importantly, children in the BG resorted more to PD during TD than during SD. This result suggests that blind children mandatorily use the body as the concrete referent for the processing of abstract concepts.

In relation to the body's representation, it has been shown that sighted adults recognise pairs of words that refer to close body parts (e.g., eyes – mouth) faster than pairs of words that refer to distant body parts (e.g., eyes – feet) (van Elk & Blanke, 2011). The findings presented here suggest that VMG and, particularly, BG children predominantly use their body as the frame of reference in order to understand both concrete and abstract concepts. This posits a future research question: would VMG and BG children show better spatial representations of the body schema than CG children? One could entertain the notion that children with visual impairments might be more aware of the spatiality of their bodies than children in the CG since the lack of visual input might be compensated by enhancing the works of one or two sensorimotor systems (e.g., haptic and kinematic). Another possible explanation for the obtained results could be found in the model of space learning of Semenovich (2002). According to this model, representation of the body topology, i.e., the awareness that the body is composed of different parts is formed before the representation of the body as a coordinate system. That is, spatial directions derive from the axial structure of the body as frame of reference (Landau & Jackendoff, 1993). These ideas thus suggest that the substitution of SD and TD by autotopological deixis can be regarded as a symptom of space learning delay. On the other hand, it could be also conceived that CG children have enhanced overall body knowledge by not being limited to one or two sensorimotor systems. These questions are yet to be explored and would also shed light on how multimodal/multisensory integration might occur in sighted and visually impaired children.

The results thus provide evidence favouring the idea that lack and/or deprivation of sensorimotor experience with the physical environment affects the processing of abstract concepts, and that children with sensorimotor impairments rely heavily on the body as the frame of reference for the comprehension of abstract concepts. Current conceptions of neurocognitive architectures contend that sensorimotor experience is fundamental to concept representation (e.g., Glenberg & Gallese, 2012; Mishra & Marmolejo-Ramos, 2010). For instance, in the model of Mishra and Marmolejo-Ramos (2010), sensorimotor experience is obtained in the informational exchange between the environment and sensory and motor systems. In turn, sensorimotor systems are ingrained in biologically determined neural structures that have specific neural activities. The product of the neural activity is the cognitive activity per se and entails memory, inferential, and simulation processes. Similarly, Glenberg and Gallese (2012) argue that, in the particular case of language, comprehension and the derivation of meaning is achieved via grounding in perceptual, motor, and emotion experiences. Models like these are firmly based on evidence demonstrating that sensorimotor experience impinges on concept formation.

Most research on embodied cognition has relied on results obtained from healthy (e.g., sighted) adult participants using tasks that require some sort of visual processing (e.g., visual priming tasks). In just a few cases other sensory systems and cross-modality paradigms have also been studied in relation to their contribution to embodied processes (e.g., auditory modality = Tajadura-Jiménez, Väljamäe, Asutay, & Västfjäll, 2010; cross modality vision-audition = Zeelenberg & Bocanegra, 2010). Therefore, in the case of people with visual impairments, further investigation is needed to explain the possible compensatory effects of multisensory/multimodal integration on the formation and comprehension of concepts (e.g., how something sounds [e.g., deep sound] might help to identify how it might appear [e.g., big size]). For instance, behavioural evidence suggests that the reduction of visual access to moving objects (e.g., a person walking) enhances reliance on auditory cues (e.g., the person's footsteps) (e.g., Thomas & Shiffrar, 2011). Thus, it is possible that auditory cues can have a great ecological and adaptive value in providing a means of compensating for visual impairments. Furthermore, cell-recording in animals has shown that early sensory experience is fundamental in the achievement of normal multisensory processing and that there is a limited plastic potential to restore this type of processing if no early sensory experience is provided (e.g., Royal, Krueger, Fister, & Wallace, 2010). However, other research in the same field suggests that experience late in life can assist in initiating the development of multisensory integration (e.g., Yu, Rowland, & Stein, 2010). To the best of our knowledge, results of this type concerning humans are not available, let alone in the case of blind children.

Despite evidence supporting the claim that sensorimotor experience is a necessary condition for the acquisition and use of concepts, there remains controversy as to the role of that experience in concept comprehension by blind people. For instance, while behavioural research suggests that the structure and content of conceptual knowledge is dependent on the sensorimotor systems used during knowledge acquisition (Marques, 2010), neuroscientific research shows that brain areas in charge of storing concepts' visual-motion features are activated in both sighted and blind people during semantic judgements (Bedny et al., 2012). The results from brain studies thus suggest that conceptual knowledge seems to be unaffected by the sensory modality used to acquire it. Such a discrepancy hence demands the development of experimental tasks that assist in determining the circumstances under which concept formation and comprehension depends on the graded and selective use of sensorimotor knowledge (e.g., Chatterjee, 2010). More importantly, laboratory task characteristics do determine the results obtained (for an example see Experiments 1 and 2 in van Elk & Blanke's study); consequently, more ecologically valid experimental tasks need to be devised in order to obtain replicable and reliable results.

5. Conclusions

This study gives information about how sighted children, children with visual-motor impairments due to strabismus and/or amblyopia, and blind children from elementary school perform tasks demanding spatial and temporal deixis. It is important to stress that sighted children between the ages of 6.11 and 8.1 perform appropriately both the abstract directional and the metaphoric temporal deixis. It was found that children in the VMG followed trends similar to those in the CG, and approached the task in the same way as younger (3.0–4.0 years old) children, i.e., referred to their own body topology in lieu of the allocentric frame of reference when responding to directional pointing tasks (Stoyanova et al., 2010). The main difference between the VMG and the CG, however, appears in the execution-time results. It is possible that the lack of automatic sensorimotor activation during concrete concept processing compromises motor-action related to processing abstract concepts. In terms of pointing-time, a further tendency was observed in the BG in that these children appeared to rely entirely on their motor and proprioceptive systems to perform tasks demanding directional and temporal deixis.

In summary, in groups of visually impaired children a tendency of ''narrowing'' the space frames was observed. More specifically, the allocentric space was shown to be substituted with egocentric or bodily space, and the egocentric frame was substituted with the child's own bodily space. These findings suggest that there are other ways in which source domains (space) can be mapped onto target domains (time). It was shown that *metaphoric temporal pointing* might use all types of concrete or abstract spatial pointing, such as *autotopological*, *concrete* and *abstract locational* or *abstract directional pointing*. That is, under metaphorical mapping, different referential frames of space might map to referential frames of time. It was found that sighted children use ''conventional'' mapping in that they map the spatial pointing onto the temporal pointing. Children from the visually impaired groups mapped the autotopological pointing onto the spatial or the temporal pointing.

The current study raises the following question: is the body topology a source domain for time, as target domain, only in visually impaired people? This leads to the possibility that extra-communicative (self-touching) gestures need to be re-considered from this perspective. Another question remains unanswered, namely, when do children begin to map spatial onto temporal pointing in both spontaneous speech and upon request? This and other questions call for further research.

Acknowledgements

Rositsa Iossifova thanks Ivanka Assenova for the fruitful discussions about ''autotopological'' deixis, Juliana Stoyanova and Adam Danz for their valuable comments, Ivelina Sokolova for her help in the data collection from the blind children, and Anja Lowit, Chad Habel, Carissa Peck, and Nathaniel de Heer for proofreading the text.

References

Asenova, I. (2009). Невропсихология *[Neuropsychology]*. Blagoevgrad: Sanin N & N.

B. N. E.. (1985). Протокол за невропсихологично изследване *[Protocol of neuropsychological assessment]*. Sofia: Meditsinska akademia.

Barca, L., Pezzulo, G., & Castelli, E. (2010). Egocentric and allocentric spatial references in children with cerebral palsy. In *Proceedings of the 2010 annual meeting of the cognitive science society* (pp. 831–835).

Barsalou, L. (2008). Grounding symbolic operations in the brain's modal systems. In G. R. Semin & E. R. Smith (Eds.), *Embodied grounding: Social, cognitive, affective, and neuroscientific approaches* (pp. 9–42). New York, NY, US: Cambridge University Press.

Bates, E., & Dick, F. (2002). Language, gesture, and the developing brain. *Developmental Psychobiology, 40*(3), 293–310.

Bedny, M., Caramazza, A., Pascual-Leone, A., & Saxe, R. (2012). Typical neural representations of action verbs develop without vision. *Cerebral Cortex, 22*(2), 286–293.

Bland, J. M., & Altman, D. G. (2000). The odds ratio. *British Medical Journal, 320*(7247), 1468.

Boroditsky, L. (2000). Metaphoric structuring: Understanding time through spatial metaphors. *Cognition, 75*(1), 1–28.

Boroditsky, L., Fuhrman, O., & McCormick, K. (2010). Do English and Mandarin speakers think about time differently? *Cognition, 118*(1), 123–129.

Boyer, J., Di Cristo, A., & Guaïtella, I. (2001). Rôle de la voix et des gestes dans la focalisation. In C. Cavé, I. Guaïtella, & S. Santi (Eds.), *Oralité et Gesualité: Communication multimodale, interaction: Actes du colloque ORAGE'01* (pp. 459–463). Paris: L'Harmattan.

Brandhorst, Ch. , & Theune, M. (2009). Beat gestures in direction giving. *The 8th international gesture workshop*.

Brownell, C., Nichols, S., Svetlova, M., Zerwas, S., & Ramani, G. (2010). The head bone's connected to the neck bone: When do toddlers represent their own body topography? *Child Development, 81*(3), 797–810.

Brownell, C., Svetlova, M., & Nichols, S. (2012). Emergence and early development of body image. In V. Slaughter & C. Brownell (Eds.), *Early development of body representations* (pp. 37–58). Cambridge: Cambridge University Press.

Bruce, S., Mann, A., Jones, C., & Gavin, M. (2007). The topography, rate, and function of gestures expressed by children who are congenitally deaf blind. *Journal of Visual Impairment & Blindness, 101*(10), 637–652.

Brunner, E., Dette, H., & Munk, A. (1997). Box-type approximations in nonparametric factorial designs. *Journal of the American Statistical Association, 92*(440), 1494–1502.

Brunner, E., Domhof, S., & Langer, F. (2002). *Nonparametric analysis of longitudinal data in factorial experiments*. NY: Wiley.

Brunner, E., & Munzel, U. (2000). The nonparametric Behrens–Fisher problem: Asymptotic theory and a small-sample approximation. *Biometrical Journal, 42*(1), 17–25.

Calbris, G. (1985). Espace-temps: Expression gestuelle du temps. *Semiotica, 55*(1–2), 43–73.

Capone, N. C., & McGregor, K. (2004). Gesture development: A review for clinical and research practices. *Journal of Speech-Language-Hearing Research, 47*(1), 173–186.

Casasanto, D., Fotakopoulou, O., & Boroditsky, L. (2010). Space and time in the child's mind: Evidence for a cross-dimensional asymmetry. *Cognitive Science, 34*(3), 387–405.

Casasanto, D., & Henetz, T. (2012). Handedness shapes children's abstract concepts. *Cognitive Science, 36*(2), 359–372.

Casasanto, D., & Jasmin, K. (2012). The hands of time: Temporal gestures in English speakers. *Cognitive Linguistics, 23*(4), 643–674.

Chatterjee, A. (2010). Disembodying cognition. *Language and Cognition, 2*(1), 79–116.

Clark, E. V., & Sengul, C. J. (1978). Strategies in the acquisition of deixis. *Journal of Child Language, 5*(3), 457–475.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*(1), 155–159.

Colby, C. (1998). Action-oriented spatial reference frames in cortex. *Neuron, 20*(1), 15–24.

Coluccia, E., Mammarella, I. C., De Beni, R., Ittyerah, M., & Cornoldi, C. (2007). Remembering object position in the absence of vision: Egocentric, allocentric, and egocentric decentred frames of reference. *Perception, 36*(6), 850–864.

Cooperrider, K., & Núñez, R. (2009). Across time, across the body: Transversal temporal gestures. *Gesture, 9*(2), 181–206.

Coquet, F., & Maetz, B. (1999). Le D.P.L.3 (dépistage et prévention du langage à 3 ans): Proposition pour une utilisation en consultation médicale [D.P.L.3 (language screening and prevention in three years old children): Towards a use in medical consultation]. *Le Pédiatre, 35*(173), 130–133.

Dutton, G. N., Saaed, A., Fahad, B., Fraser, R., McDaid, G., McDade, J., et al. (2004). Association of binocular lower visual field impairment, impaired simultaneous perception, disordered visually guided motion and inaccurate saccades in children with cerebral visual dysfunction—A retrospective observational study. *Eye, 18*(1), 27–34.

Elk, M., & Blanke, O. (2011). The relation between body semantics and spatial body representations. *Acta Psychologica, 138*(3), 347–353.

Field, A. (2005). *Discovering statistics using SPSS* (2nd ed.). London: Sage.

Friendly, M. (1994). Mosaic displays for multi-way contingency tables. *Journal of the American Statistical Association, 89*(425), 190–200.

Gentner, D. (1977). Children's performance on spatial analogies task. *Child Development, 48*(3), 1034–1039.

Gentner, D. (2001). Spatial metaphors in temporal reasoning. In M. Gattis (Ed.), *Spatial schemas in abstract thought* (pp. 203–222). Cambridge, MA: MIT Press.

Gibbs, R. (1996). Why many concepts are metaphorical. *Cognition, 61*(3), 309–319.

Glenberg, A. M., & Gallese, V. (2012). Action-based language: A theory of language acquisition, comprehension, and production. *Cortex, 48*(7), 905–922.

Gompel, M., Janssen, N. M., van Bon, W. H. J., & Schreuder, R. (2003). Visual input and orthographic knowledge in word reading of children with low vision. *Journal of Visual Impairment & Blindness, 97*(5), 273–284.

Graf, E. M. (2011). Adolescents' use of spatial TIME metaphors: A matter of cognition or socio communicative practice? *Journal of Pragmatics, 43*(3), 723–734.

Grush, R. (2000). Self, world and space: The meaning and mechanisms of ego- and allocentric spatial representation. *Brain and Mind, 1*(1), 59–92.

Hartigan, J. A., & Kleiner, B. (1984). A mosaic of television ratings. *The American Statistician, 38*(1), 32–35.

Hyvärinen, L. (2000). Understanding paediatric low vision. In C. Stuen, A. Arditi, A. Horowitz, M. A. Lang, B. Rosenthal, & K. Seidman (Eds.), *Vision rehabilitation: Assessment, intervention, and outcomes* (pp. 400–403). Lisse, Netherlands: Swets & Zeitlinger.

Iossifova, R. (2008). Мълчанието. [The silence]. Sofia: LC Romel.

Iossifova, R. (2009). Значение на зрително-моторните дефицити за овладяване на писмената реч [The role of visuo-motor deficits for mastery of written language]. *Practicheska Pediatria, 8*, 5–7.

Iossifova, R. (2012). Вербални и невербални аспекти в развитието на понятията за пространство и време при деца от предучилищна възраст [*Learning of verbal and non-verbal aspects of space and time concepts in preschool children*]. В: Логопедия, IX Национална конференция с международно участие на НСЛБ, 29 март–01 април, 2012 (сб. Под редакцията на Д. Траянова, Н. Йорданова и Я. Дудев). Sofia: BNAL (pp. 97–111). Available at: http://bnal.bg/images/stories/nslb-logopediya-2012-final.pdf.

Iossifova, R., & Marmolejo-Ramos, F. (2012). Spatial and temporal deixis. The role of age and vision in the ontogeny of a child's spatial and temporal cognition. *Journal of Speech and Language Pathology, 2*(2), 75–98.

Isbell, B. J., & Roncalla Fernández, A. (1977). The ontogenesis of metaphor: Riddle games among Quechua speakers seen as cognitive discovery procedures. *Journal of Latin American Lore, 3*(1), 19–49.
Iverson, J. M., Tencer, H. L., Lany, J., & Goldin-Meadow, S. (2000). The relation between gesture and speech in congenitally blind and sighted language-learners. *Journal of Nonverbal Behavior, 24*(2), 105–130.
Johnston, J. R., & Slobin, D. I. (1979). The development of locative expressions in English, Italian, Serbo-Croatian and Turkish. *Journal of Child Language, 6*(3), 529–545.
Kapstein, M., Nass, C., & Markopoulos, P. (2010). Powerful and consistent analysis of Likert-type rating scales. *CHI 2010 Proceedings of the 28th international conference on human factors in computing systems* (pp. 2391–2394). Atlanta, Georgia: Association for Computing Machinery.
Kittler, J. E., Menard, W., & Phillips, K. A. (2007). Weight concerns in individuals with body dysmorphic disorder. *Eating Behaviors, 8*(1), 115–120.
Koller, H. P. (2000). An ophthalmologist's approach to children with visual perception and learning differences. *American Orthoptic Journal, 49*, 173–177.
Krahmer, E., & Swerts, M. (2007). The effects of visual beats on prosodic prominence: Acoustic analyses, auditory perception and visual perception. *Journal of Memory and Language, 57*(3), 396–414.
Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to Western thought*. New York: Basic Books.
Lakoff, G., & Núñez, R. (2000). *Where the mathematics comes from: How the embodied mind brings mathematics into being*. New York: Basic books.
Landau, B., & Jackendoff, R. (1993). "What" and "where" in spatial language and spatial cognition. *Behavioral and Brain Sciences, 16*, 217–238.
Lehky, S. R., & Sereno, A. B. (2011). Population coding of visual space: Modeling. *Frontiers in Computational Neuroscience, 4*, 155. http://dx.doi.org/10.3389/fncom.2010.00155
Loftus, G. R., & Masson, M. E. J. (1994). Using confidence intervals in within-subject designs. *Psychonomic Bulletin & Review, 1*(4), 476–490.
Marques, J. F. (2010). The effect of visual deprivation on the organization of conceptual knowledge: Testing the grounded cognition hypothesis. *Experimental Psychology, 57*(2), 83–88.
Masson, M. E. J., & Loftus, G. R. (2003). Using confidence intervals for graphically based data interpretation. *Canadian Journal of Experimental Psychology, 57*(3), 203–220.
Mazeau, M. (2005). *Neuropsychologie et troubles des apprentissages: du symptôme à la rééducation*. Paris: Masson.
McNeill, D. (1992). *Hand and mind. What gestures reveal about thought*. Chicago: University of Chicago Press.
McNeill, D. (2005). *Gesture and thought*. Chicago: University of Chicago Press.
McNeill, D., Cassell, J., & Levy, E. T. (1993). Abstract deixis. *Semiotica, 95*(1–2), 5–20.
Mishra, R., & Marmolejo-Ramos, F. (2010). On the mental representations originating during the interaction between language and vision. *Cognitive Processing, 11*(4), 295–305.
Montredon, J. (1998). Comment la gestualité a joué parfois identiquement, parfois differemmement pour figurer a partir de positions et d'oppositions spatiales universelles (droit/gauche, haut/bas, devant/derriere), des axes ou des sites temporels (passée, présent, futur). In S. Santi, I. Guaïtella, C. Cavé, & G. Konopczynski (Eds.), *Oralité et Gesualité: Communication multimodale, interaction: Actes du colloque ORAGE'98* (pp. 147–152). Paris: L'Harmattan.
Moore, K. E. (2006). Space-to-time mapping and temporal concepts. *Cognitive Linguistics, 17*(2), 199–244.
Noguchi, K., Gel, Y. R., Brunner, E., & Konietschke, F. (2012). nparLD: An R software package for the nonparametric analysis of longitudinal data in factorial experiments. *Journal of Statistical Software, 50*(12), 1–23. http://www.jstatsoft.org/v50/i12/.
Noppeney, U., Friston, K., & Price, C. (2003). Effects of visual deprivation on the organization of the semantic system. *Brain, 126*(7), 1620–1627.
Núñez, R. E., Motz, B. A., & Teuscher, U. (2006). Time after time: The psychological reality of the ego- and time-reference-point distinction in metaphorical construals of time. *Metaphor and Symbol, 21*(3), 133–146.
Özçalışkan, Ş. , (2005). On learning to draw the distinction between physical and metaphorical motion: Is metaphor an early emerging cognitive and linguistic capacity? *Journal of Child Language, 32*(2), 291–318.
Özçalışkan, Ş. , (2007). Metaphors we 'move by': Children's developing understanding of metaphorical motion in typologically distinct languages. *Metaphor and Symbol, 22*(2), 147–168.
Paillard, J. (1991). Motor and representational framing of space. In J. Paillard (Ed.), *Brain and space* (pp. 163–182). Oxford: Oxford University Press.
Pederson, E. (2003). How many reference frames? In C. Freksa, W. Brauer, C. Habel, & K. F. Wender (Eds.), *Spatial cognition III, routes and navigation, human memory and learning, spatial representation and spatial learning. Lecture Notes in Computer Science 2685* (pp. 287–304). Springer.
Popova, A. (2003). *Зрителна система на човека*. [The human visual system]. Sofia: St Kliment Ohridski Univ Press.
Puche-Navarro, R., & Millan, R. (2007). Inferential functioning in visual impaired children. *Research in Developmental Disabilities, 28*(3), 249–265.
Reed, M. J., Kraft, S. P., & Buncic, R. (2004). Parents' observations of the academic and nonacademic performance of children with strabismus. *Journal of Visual Impairment and Blindness, 98*(5), 276–288.
Rosenberg, J. L., & Gasko, M. (1983). Comparing location estimators: Trimmed means, medians, and trimean. In D. Hoaglin, F. Mosteller, & J. Tukey (Eds.), *Understanding robust and exploratory data analysis* (pp. 297–336). New York: Wiley.
Rosenthal, R. L., & Rosnow, R. (2008). *Essentials of behavioral research. Methods and data analysis* (3rd ed.). New York: McGraw-Hill.
Royal, D. W., Krueger, J., Fister, M. C., & Wallace, M. T. (2010). Adult plasticity of spatiotemporal receptive fields of multisensory superior colliculus neurons following early visual deprivation. *Restorative Neurology and Neuroscience, 28*(2), 259–270.
Ruggiero, G., Ruotolo, F., & Iachini, T. (2009). The role of vision in egocentric and allocentric spatial frames of reference. *Cognitive Processing, 10*(2), 283–285.
Sabsevitz, D. S., Medler, D. A., Seidenberg, M., & Binder, J. R. (2005). Modulation of the semantic system by word imageability. *NeuroImage, 27*(1), 188–200.
Scorolli, C., Binkofski, F., Buccino, G., Nicoletti, R., Riggio, L., & Borghi, A. M. (2011). Abstract and concrete sentences, embodiment, and language. *Frontiers in Psychology, 2*, 227. http://dx.doi.org/10.3389/fpsyg.2011.00227
Semenovich, A. V. (2002). Нейропсихологическая диагностика и коррекция в детском возрасте. [Neuropsychological diagnosis and correction in childhood]. Moskva: Academia.
Shabalina, O. (2007). Структура и функционирование метафоры в детской речи. Автореферат диссертации [*Structure and functions of metaphor in child speech*]. Doctoral Thesis. Russia: Perm State Pedagogical University.
Shah, D. A., & Madden, L. V. (2004). Nonparametric analysis of ordinal data in designed factorial experiments. *Phytopathology, 94*(1), 33–43.
Sinha, C., Sinha, S., Zinken, J., & Sampaio, W. (2011). When time is not space: The social and linguistic construction of time intervals in an Amazonian culture. *Language and Cognition, 3*(1), 137–169.
Stoyanova, J., Iossifova, R., Poppandova, M., & Netsova, R. (2010). *Диагностика и превенция на езика 3-4*. [Diagnostics and prevention of language 3-4]. Sofia: LC Romel.
Tajadura-Jiménez, A., Väljamäe, A., Asutay, E., & Västfjäll, D. (2010). Embodied auditory perception: The emotional impact of approaching and receding sound sources. *Emotion, 10*(2), 216–229.
Thomas, J., & Shiffrar, M. (2011). Footstep sounds increase sensitivity to point-light walking when visual cues are weak. *Journal of Vision, 11*(11), 693. http://dx.doi.org/10.1167/11.11.693
Volterra, V., Caselli, M. C., Caprici, O., & Pizzuto, E. (2005). Gesture and the emergence and development of language. In M. Tomasello & D. I. Slobin (Eds.), *Beyond nature-nurture. Essays in honour of Elizabeth Bates* (pp. 3–40). NJ: Lawrence Erlbaum Associates.
Vosniadou, S. (1987). Children and metaphors. *Child Development, 58*(3), 870–885.
Weist, R. M. (2002). Temporal and spatial concepts in child language: Conventional and configurational. *Journal of Psycholinguistic Research, 31*(3), 195–210.
Weist, R. M. (2009). Children think and talk about time and space. In P. Łobacz, P. Nowak, & W. Zabrocki (Eds.), *Language, science and culture* (pp. 349–378). Poznań: Wydawnictwo Naukowe UAM.
Yu, L., Rowland, B. A., & Stein, B. E. (2010). Initiating the development of multisensory integration by manipulating sensory experience. *The Journal of Neuroscience, 30*(14), 4904–4913.
Zeelenberg, R., & Bocanegra, B. R. (2010). Auditory emotional cues enhance visual perception. *Cognition, 115*(1), 202–206.