Exploratory procedures employed by visually impaired and blind children during joint book reading

Bara Florence

Abstract

Illustrations in storybooks not only provide a source of interest in children but support language development and literacy skills. A better understanding of how to communicate stories through tactile illustrations is a central issue for practitioners and researchers who work with visually impaired children. Recognizing tactile illustrations implies precisely perceiving the shapes and being able to associate meaning to theses representations. This study focused on the way tactile pictures were haptically explored by visually impaired and blind children during joint book reading. The aim was to determine how the task and the type of illustrations promote the haptic exploration. Children seemed to be more active and used more often the contours following procedure when they have to find the meaning of the pictures than when the meaning was given to them through reading. The 3D illustrations led to the use of more different exploratory procedures than the 2D illustrations.

Key words: visually impaired, blind, children, tactile book, exploratory procedures, joint reading

Increasing language level, acquiring vocabulary and understanding stories orally told are important components of child development in the literacy domain. Picture books reading is a common way to develop these abilities in young children both at school and at home, and has been shown to be an important activity to promote children's language and literacy skills (Abbott & Berninger, 1993; Bus, Van Ijzendoorn, & Pellegrini, 1995; Collins, 2010; Mol, Bus, & De Jong, 2009; Sénéchal, 2006). Picture books reading at home has been linked to children‘s development of language (DeBaryshe, 1993; Payne, Whitehurst, & Angell, 1994; Snow & Goldfield, 1983), print concepts, and emergent reading (Snow & Ninio, 1986; Sulzby & Teale, 1991). Most books published for young children are illustrated. It is widely assumed that such illustrations increase children's motivation and attention, promote their creativity, serve as mental scaffolds (making the story more concentrated, more concrete, more coherent and comprehensible), clarify the text content and serve to organize verbal information (Levin & Mayer, 1993; Peeck, 1993). According to Fang (1996) pictures in storybooks serve to help to establish the setting, develop the characters and the plot, provide a different viewpoint, contribute to the text coherence and reinforce the text. In complementing the text, pictures can help the children to perceive, understand and remember the stories (David, 1998; Rubman & Waters, 2000). Exposure to information both verbally and visually results in the construction of separate verbal and pictorial representations that are connected in memory (dual coding hypothesis proposed by (Paivio, 1986), which leads to the establishment of stronger, more elaborated and more organized memory traces (Digdon, Pressley, & Levin, 1985; I. Levin & Mayer, 1993; Peeck, 1993; Pressley, Pigott, & Bryant, 1982). Levin (1981) described five functions of pictures in books: decorational (little relationship with the text), representational (illustrate the text content), organizational (provide a framework for the text content), interpretational (clarify the text content), and transformational (include mnemonic components). A majority of the illustrations are representational in that they literally depict or overlap part or all of the text content, with the basic purpose of making the story concrete (Carney & Levin, 2002).

Within the picture book reading interaction, there are three components: a book, a child and an adult (Martinez & Roser, 1985; van Kleeck, 2003). The benefits of picture books reading depend on the type of illustrations, the children characteristics (age, abilities, learning potential), and the quality of the interaction between the adult and the child during reading (Alder, 1993; Aram, Fine, & Ziv, in press; DeLoache & DeMendoza, 1987; Ninio & Bruner, 1978; Senechal, Cornell, & Broda, 1995) Illustrations enhance preschoolers' memories of auditory prose only under some conditions. Even though a particular illustration has been designed to be cognitively useful, its effectiveness depends on how the learner perceives and processes the picture. Some specific features in book support more learning than other. Considering the type of picture, the benefits on the stories' recalling showed effect size from moderate (representational pictures) to high (transformational pictures) (Levin, Anglin, & Carney, 1987). The ability of children to transfer knowledge from pictures in books to reality depends on the physical similarity between the picture and their real world referent, with greater iconicity leading to better learning (Ganea, Pickard, & DeLoache, 2008; Tare, Chiong, Ganea, & DeLoache, 2010). Carney & Levin (2002) wrote guidelines to create text illustrations: they recommended to select pictures that provide congruent or supporting information to the text, to add pictures only when it is necessary (the more complex is the text, the more helpful the pictures are), to guide children to do something with the pictures (labeling the features of the illustration), and to choose pictures as text supplements rather than as text substitutes. The learner characteristics, as age, working memory resources, reading ability and ability to extract visual information from pictures may constrain the benefits of picture books reading. Picture facilitation effects require that individuals encode and connect in memory both verbal and pictorial information. Storybook pictures may interfere with words reading and extracting meaning from text if not enough working memory resources are available (Mayer & Moreno, 1998). (Tare et al., 2010) showed that children's learning from pictures was impeded by manipulative features, which are intended to increase young children's engagement with books. They suggested that children were distracted by manipulative illustrations that focused their attention toward the sensory stimuli and away from the text content. The children's manipulation might have increased their cognitive load such that they could not process what the adult was telling. Picture books tell stories with a combination of texts and illustrations, providing children with a narrative language and a visual experience (Yu, 2012). Thus the child's visual information processing has also an impact on the extraction and interpretation of meaning. If perceptual processing and memory resources are crucial in picture books reading in sighted children, it is the same in visually impaired and blind children. The tactile skills and manipulative experiences that are essential for blind children development and learning are also the foundation of their emergent literacy (Stratton, 1996). The haptic system that involves active manual exploration is necessary for blind and visually impaired individuals to collect information about the objects in their environment.

Even though some aspects of literacy development naturally fit with the ways blind and visually impaired children learn, others need some adaptations. This need of adaptations was highlighted by Crespo (1990) who showed that some parents did not read stories to their blind children because they thought that their children might be confused by visual references because they could not see the pictures. After participating in making tactile story books, these parents were more positive about reading stories to their children. The purpose of tactile books is to communicate information through touch. Tactile illustrations are scanned with the fingertips and the reader had to interpret and associate meaning to the picture. Most of books are based on an existing printed book and usually a tactile picture is transferred from a visual one, and the printed text is transferred into Braille. The illustrations in tactile books come in a wide variety of materials and can be produced by several different techniques, such as swell paper (lines, dots and surfaces are used to create raised line drawings), thermoform (technique of molding plastic in a matrix), textiles, textures, 3D objects... Tactile pictures that are literally transferred from visual pictures might not fit with the cognitive and haptic abilities of young blind children and bidimensional representations can be very hard to understand (Lewi-Dumont, 1997). To facilitate tactile exploration and interpretation, pictures need to be simplified and some details of the visual picture need to be deleted, leaving only the most important features (Eriksson, 1999). As it is the case with sighted children, tactile pictures (if correctly identified) improve the understanding of the text (Stratton & Wright, 1991), develop creativity and imagination (Meuwes, 1999) and improve the retention and recalling of the story (Pring & Rusted, 1985). Even if tactile pictures are often hardly recognizable by blind children, they could be helpful for their cognitive, language and literacy development (Hatwell, 2001; Lewi-Dumont, 1997; Miller, 1985). Selecting stories that relate to a child's interest and experiences (Stratton & Wright, 1991) and adapting books and reading strategies (Crespo, 1990; Miller, 1985) will increase children's understanding of stories.

The type of illustrations, the child characteristics (age, memory resources, knowledge level) and how the book is read and haptically explored, should constrain the benefits of tactile picture books reading. A main difficulty leads in the cognitive load generated by tactile pictures identification and interpretation. Haptic processing allows to collect sequential and fragmented information that need to be integrated, which places an important load on attention and working memory (Hochberg, 1986; Loomis, Klatzky, & Lederman, 1991). As the haptic system is more sequential than vision and more adapted for processing material properties of objects, such as texture and temperature (Lederman & Klatzky, 1987, 1993), it could be difficult for blind children to access shape information contained in tactile pictures. Even if haptic can process geometric properties of objects (such as shape and size), it cannot be done with the same accuracy than with vision. Taking into account the small haptic perceptual field, it is difficult for blind people to keep in memory raised drawing (Hatwell, 2001). Movement control during exploration interferes with identification, and sequential processing in haptic is slower than parallel processing in vision. The dual task of exploration and identification constrain the identification latencies. If the exploration is guided, it relieves the observer (adults and children) partly from the exploration task and lead to better identification scores (D'Angiulli, Kennedy, & Heller, 1998). This guidance can be made by the experimenter who move the observer hand (Magee & Kennedy, 1980), or can be facilitated by the material used, like an embossed surface that guides the finger more easily along the picture than only a line (Thompson, Chronicle, & Collins, 2003). The verbal guidance could also induce some exploratory procedures in blind children and help them to understand tactile pictures (Theurel et al., 2010)

The type of manual procedures children employed could determine, at least in part, the accuracy of tactile pictures identification. The haptic strategies used for object exploration might be influenced by task demands, prior knowledge (Alexander, Jonhson, & Schreiber, 2002; Millar, 2005), age and level of vision. How the hands move and how long determine the sensory information that is obtained through haptic exploration and what is perceived (Lederman & Klatzky, 1987). In adult and children, it has been shown that bimanual exploration leads to better performance than unimanual exploration (Ballasteros, Manga, & Reales, 1997; Russier, 1999; Wijntjes, van Lienen, Verstijnen, & Kappers, 2008). Exploration using several fingers rather than just one seems to improve recognition of 2D raised line drawings (Klatzky, Loomis, Lederman, Wake, & Fujita, 1993). Lederman & Klatzky (1987, 1993, 2009) categorized six different exploratory procedures (EPs) and showed how each of these is associated with a specific property and a specific goal. When grouping object by texture, individuals generally performed “lateral motion” (sideways back and forth movements of the fingers), whereas when grouping objects by shape, they often produced “contour following” (tracing the object contours with their fingertips). Even if Bushnell & Boudreau (1991, 1993, 1998) suggested that preschool children might have the capacity to display mature haptic abilities, the EP they used are not always well adapted to the task. Schwarzer, Küfer, & Wilkening (1999) showed that 4 ½ years old children were able to produce EPs as adults when apprehending surface texture information, however, despite being asked to focused on texture when exploring and classifying 3D objects, they also employed procedures such as contours following and enclosure that are specific to shape extraction. Furthermore, children tend to use global strategies (lateral motion) in a shape discrimination task and for perceiving 2D tactile patterns, since this procedure seems to be inappropriate for the encoding of shape information but optimal for the processing of texture information (Hatwell, 2003; Vinter, Fernandes, Orlandi, & Morgan, 2012). Up to around 5 years, children's manual exploration remains partial and incomplete and is unsuitable for the extraction of precise shape information (Piaget & Inhelder, 1963). Exploratory procedures developed gradually with age and when children grow older, they shift to using adult like patterns of exploration such as contours following (Hatwell, 2003). The results of Morrongiello, Humphrey, Timney, Choi, & Rocca (1994) revealed the emergence of a developmental pattern between the ages of 3 and 8 years in object exploration and recognition for sighted children. Older sighted children were able to recognize more objects and more quickly than younger children, and also were more thorough in their exploration patterns. With increasing age, children appear to change their representation of objects from one based predominantly on global shape to one that incorporates both global shape and specific local parts. The nature of the exploratory procedures used by children influence the quality of their perception. The thoroughness of the object exploration by blind children was positively correlated with their recognition scores (Morrongiello *et al.*, 1994). Vinter *et al.*, (2012) showed strong relationships between the exploratory procedures employed by sighted, blind and visually impaired children, when exploring bidimensional tactile patterns and their consequent performance in drawing. The greater the number of strategies was, the more the drawings resembled the model and/or were characterized by salient features and/or were produced using contour lines. The lateral motion procedure, that is not suitable for shape extraction led to poorly recognizable drawings. These authors emphasized the fact that blind children need to be trained in exploratory procedures at an early age and suggested that specific educational program of exploratory activities could be designed for young blind children when they are introduced to illustrated tactile books.

To be able to create and propose pictures that are suited for tactile scanning, there is a need to analyze what is to be shown and how the pictures need to be explored. Considering the importance of exploratory procedures in picture identification, this study focused on the way pictures in tactile books are haptically explored by visually impaired and blind children during joint reading. The aim was to determine how the type of task and the nature of the illustrations promote haptic exploration of tactile illustrated books. In experiment 1, the exploratory procedures used by children when exploring the book illustrations, following two different goals, were analyzed: (1) exploring the picture to infer its meaning and (2) exploring the picture while listening to the text and attempting to link the text content with the illustration. In experiment 2 the exploratory procedures used by children with visual handicap when exploring two kinds of illustrations (2D and 3D illustrations) were compared.

Study 1

The aim of this study was to assess the effect of the goal pursued by children when exploring tactile pictures. The effect of the task on the exploratory procedures employed by children was studied. The exploratory procedures used by children when they explored the pictures for the first time and tried to find their meaning were compared to the exploratory procedures employed when the adult read the text and the child has to link the illustration with the text content.

Method

Participants

The participants of this study were six children, two girls and four boys, aged between 5 years 7 months and 8 years 5 months. Four of them were right-handed and two left-handed. Five were visually impaired and one was totally blind. The main causes of visual impairment were bilateral retinal atrophy, glaucoma and nystagmus. The cause of blindness was prematurity. The children did not present any other known cognitive or psychiatric disabilities. Four of them were attended specialized classroom, and two were in regular classes. None of them was academically retarded. Written consent was obtained from the parents of each child participating in the study. The adults who read the book were the teachers and the educators in charge of the children.

Material

The book “Ali and Leo”, produced by “Les Doigts Qui Rêvent”, a publishing company specialized in books adapted for visually impaired children, was used. The pictures were produced in swell paper. The pictures were not representational in that they do not exactly depict the reality. They consisted in raised line drawings and each picture can be associated with different meanings. This book is assumed to develop imagination and creativity in blind children. One page consisted in the Braille and printed text and the other page consisted in the raised line drawing. No color was added in the pictures.

Procedure

Children worked in pairs with their teacher/educator. Each of them had a book in front of him. Each page of the book was explored in two steps. First of all, the child had to explore the illustration in the manner that he chose and had to guess its meanings. He knew that one picture can represent different meanings. He had to propose some ideas and the adult and the other child could react to the proposals. Then the text was read in a loud voice by the teacher, and the child had to explore the picture at the same time. In this second step he had to find in the picture what can represent the text content. Thus two different goals were pursued by the children, finding the meaning of a raised drawing and associating the prose contained in the book to the illustration. Each reading session was videotaped. In order to preserve children's attentional capacity, only five illustrations were shown. Each session lasted around 20 minutes.

The use of different exploratory procedures, the total exploration time for each procedure as well as whether the exploration was bimanual or unimanual were coded. The following criteria were used to code the exploratory procedures(Davidson, 1972; Lederman & Klatzky, 1987):

Contour following: dynamic edge following using finger movements
Lateral motion: dynamic and repetitive movement of one or more fingers
Static contact: stationary contact with the surface without molding
Enclosure: dynamic molding of the fingers and/or the palm to the shape contours
Pinch: holding edges in a pincer grip between thumb and one or more fingers
No exploration: no hand in contact with the picture
"Surface sweeping with the palm": It is similar to lateral motion but children lay their palm flat on the page and do not use their fingers. This procedure (movement of the palm over the whole page surface) was added because it was often used when the children discovered a new tactile picture.

Results

As the type and the proportion of exploratory procedures used by the six children were similar, we chose to calculate the mean scores in function of the goal. The mean percentage of time employed for each exploratory procedure is reported in figures1 and 2.

When the children have to find the meaning of the pictures, they used most of the time the lateral motion (54%) and the contour following (28%) procedures. They were very active in exploring the picture and they spent only 10% of the time with no hand in contact with the surface of the page. The surface sweeping with the palm is a global procedure only used at the beginning, when the children discovered the illustration. It was systematically used by three children and concerned 6% of the haptic exploration duration. On overall children used more often unimanual exploration (59%) than bimanual exploration (41%).

When they have to link the text read by the adult to the illustration, they are less active and spent almost half of the time (49%) without exploring the picture. This result has to be nuanced because one child tried to follow the text in Braille while the adult was reading the text. Instead of exploring the picture (as it was recommended by the teacher), he was scanning the Braille characters with his finger trying to read by himself. Children used more often unimanual exploration (62%) than bimanual exploration (38%).

Whatever was the task, three EPs were used (lateral motion, contour following and static contact). The lateral motion was the preferred procedure. In both tasks the children used bimanual and unimanual exploration, and used alternatively right hand and left hand when producing unimanual exploration.

On average, children made 0,6 proposals for the meaning of each drawing (between 0 to 6 for each page). The correlations between the duration of each exploratory procedures and the number of proposals were not significant.

Discussion

The type of exploratory procedures and the amount of time employed for each procedure depend on the goal pursued by children. Children seem to be more active when they have to find the meaning of the picture than when the meaning was given to them through the reading text. However this finding needs to be nuanced because the exploration to find meaning was always the first step of the book exploration. When the text was read, they already have some representation of the illustration because they explored and interpreted it before. A procedure of surface sweeping was often use by three children when they discovered the pages. This procedure allows rapid scanning of the page that brings global information about the size, the texture and the global shape of the drawing. This global procedure might guide the specific exploratory procedures (contours following) employed after. Whatever was the task, lateral motion was the preferred procedure, even if it brings global information about shape and is more appropriate for texture features than for geometric features. Contours following, that allows precise extraction of shape, was more used when children have to find meaning of pictures. Static contact was more often used when children listen to the text. It is difficult to know if this procedure is an active procedure used by children to link the content of the text and the drawing or if they laid their hand on the page while only listening and not inferring information by touch. “No exploration” corresponds to no hand in contact with the illustration; however, it is sometimes difficult to separate the absence of exploration and the static contact procedure. Cognitive and attentional resources might have been on overall focused on the story listening and understanding, it is possible that no tactile information was interpreted from the static contact. It could explain why children spend more time using static contact when listening to the story than when exploring the pictures in the aim to find their meaning.

Study 2

This study aimed at assessing the effects of the type of illustration on the exploratory procedures used by children. Two types of illustration, 2D illustrations and 3D illustrations, were compared.

Method

Participants

The participants of this study were four children, three boys and one girl, aged from 5 years 7 months to 8 years 5 months. One was visually impaired and three were blind, with reduced residual visual capacity, and no perception of shapes. Three were right-handed and one left-handed. The main causes of blindness were congenital cataract, congenital retinal detachment, albinism, nystagmus, and optic atrophy. None of the children presented any other known cognitive or psychiatric disabilities. They were attended regular classrooms, but were supported by specialized teacher and educators. The adults who read the story were the educators in charge of the children.

Material

Two books that tell almost the same story “Goldilocks and the tree bears” but with different illustrations were used. In each book, every double page contain the text on the left page (in Braille and printed) and the illustration on the right page. In one book the illustrations were bidimensional tactile pictures (this book was produced by “Les Doigts Qui Rêvent”). The illustrations were simplified pictures made with different textures. The characters were the three bears (brown bear shape with soft fur) and Goldilocks (little girl, with textile skirt and long blond synthetic hair). Different objects were illustrated, bowls, table, house, threes, chairs and beds. This book contained 13 pages. The other book proposed 3D illustrations (realized by M. Carrier-Panellati, who illustrates books for blind children). The illustrations consisted in 3D objects glued to the page (plates, seats, beds, windows) or free from the pages (the three bears, the little girl, three spoons) that the child can held and manipulate all along the story. This book contained 6 pages. It tells almost the same story than the first book but with some added details about the material features like: “a plastic and a metal spoon”, “a thin and a warm blanket”, “embossed bed and soft bed”, “a smooth and rough chair” in order to focus sometimes the children’s attention on material properties of objects that can be more easily extracted by haptic exploration than geometric ones.

Procedure

The story was read by the educator in charge of the child. The child was seated beside the educator at a table, the book in front of him. The educator read aloud the text, while the child explored the illustration. For two children the story with 2D illustrations was read before the story with 3D illustrations, whereas the stories were read in the reverse order for the two other children. There was at least an interval of two weeks between the two reading sessions. The reading sessions were videotaped and analyzed. Each EP employed was coded for each child. Comparing to experiment 1, one exploratory procedure well adapted for 3D objects exploration was added: “grasping and holding”. The total duration of each exploratory procedures employed by the children during joint reading was assessed for each book.

When analyzing the videos the contents of the text were connected to the exploratory movements initiated at the same time. In the book with 3D illustrations, 53 words or sentences in the text could be linked with specific exploratory movement. In the book with 2D illustrations the text and the picture could be linked 35 times. For example: the story tells “once upon a time there were three bears” and the child is expected to touch the three bears represented by 3D bears or by 2D bear shapes. If the story tells “a small bed”, the child is expected to touch the small bed. For each story, the number of exploratory movements directly linked with the story content (e.g.: the story told about a big bear and at the same time, the child haptically explored the big bear…), the number of exploratory movements not directly linked with the text (e.g: exploration of different elements of the page before the beginning of the reading, or exploration of the trees whereas the story told about the house) and the number of exploratory movements forgotten (the child did not explore the small bowl whereas the story told about a small bowl) were determined.

Results

The mean durations of each exploratory procedure in function of the type of illustration are reported in figures 3 and 4.

On overall, more EPs were employed when children explored 3D illustrations than 2D illustrations. When they explored the book with 3D illustrations, children employed six different EPs (grasp and hold, lateral motion, contours following, static contact, enclosure, pressure and pinch), whereas when they explored the book with 2D illustrations, they only used three different EPs. Among these EPs, the grasp and hold procedure is specific to 3D patterns and can’t be used for 2D patterns. However, pinch, enclosure, static contact, lateral motion and pressure could have been used for 2D patterns. The grasp and hold procedure was the preferred one when exploring 3D illustrations (55%) whereas the lateral motion procedure was the most often employed when children explored 2D patterns (71%). When they explored the book with 3D illustrations, children spent less time without exploring (3%) than when they explored the book with bidimensional illustrations (13%). Whatever was the type of illustrations children used more often bimanual exploration, 70% of the time for 3D illustrations and 66% of the time for 2D illustrations, than unimanual exploration.

For each book, the percentage of exploratory movements directly linked with the text content, the percentage of exploratory movement not directly linked with the text and the percentage of exploratory movement forgotten was calculated. These percentages are presented in table 1.

Discussion

The type of illustration determines the exploratory procedures used by children. When three-dimensional illustrations were used, children employed more EPs than when bidimensional illustrations were used. Whereas for 3D illustrations the grasp and hold procedure was mainly used, for 2D illustrations, the lateral motion was the preferred procedure. The grasp and hold procedure is a very complete procedure in that it allows a lot of redundant and different information about objects very quickly (Klatsky, 1990). It can be noticed that sometimes this procedure was associated with another procedure, performed at the same time with the free hand. For example the child held the little girl in his right hand and performed lateral motion movement on the bed with his left hand. Whatever was the type of illustration, half or more of the EPs were directly linked to the text content. However, when 3D illustrations were proposed, children made on average more exploratory movements directly linked to the text content and less EP with no link with the story. Sometimes, the text content guided the EP that was used and sometimes, the type of illustration guided the EP used. For example, the pressure procedure was employed when the text told about a soft mattress. When the text told about a rough seat, it provoked the lateral motion procedure in most cases. The use of 3D objects provoked in most cases the grasp and hold procedure. The pinch procedure was often used with Goldilocks' hair, the bed edges, the blankets and the window.

General discussion

Illustrations in storybooks not only provide a source of interest in children but support literacy development. Picture books are learning and informational resources that can promote children's knowledge about the surrounding world. Picture books reading support language and cognitive development and is a first entry in literacy development (Adams, 1990; Bus et al., 1995; Collins, 2010; Mol et al., 2009; Sénéchal, 2006). Considering the impact of picture books on literacy development, it is crucial that children with a visual handicap can access to this way of conveying information. Literacy environment is accessible for visually impaired children through touch. Thus how to communicate ideas and stories through touch is a central issue for practitioners and researchers interested in this field. Tactile illustrations are the link between the child's concrete, tactile experiences of the world (what he can hold and explore with his hands) and a symbolic representation of that experience. Recognizing tactile illustrations implies precisely perceiving the shapes and being able to associate meaning to theses representations. Whereas vision and audition are recognized for providing highly precise spatial and temporal information respectively, the haptic system is especially effective at processing the material characteristics of surfaces and objects. Thus this is challenging to find ways to help blind individuals to perceive precise shape of object representing in illustrated tactile books. Haptic perception of object depends on the nature of contact (which exploratory procedures) and the duration of exploration, that means how and how long the picture is explored (Klatzky et al., 1993). The exploratory procedures are strongly linked with the extraction of certain properties of objects. For example, static contact (placing a large skin surface against an object without motion) is associated with queries about warmth or coolness, pressure is associated with hardness, unsupported holding with weight… For shape, the enclosure procedure makes it possible to extract global shape information while the contours following procedure is suitable for precise extraction of shapes. The various EPs have different costs in terms of their execution time and their interference with other exploration patterns occurring at the same time (Klatzky et al., 1993; Lederman & Klatzky, 1987). They have also benefits in that some EP can provide incidental information about objects properties for which they are not optimal. An EP is optimal when it provides the most precise discrimination along a given dimension. Static contact is quick to execute, provides incidental information about texture, volume, shape and temperature, and can co-occurs with unsupported holding and enclosure (Klatzky et al., 1993; Lederman & Klatzky, 2009). The type of exploratory procedures determines performance in recognizing, matching objects on shape, and drawing (Kalagher & Jones, 2011; Vinter et al., 2012). As shown by Vinter *et al*. (2012) the diversity of procedures used and the number of appropriate procedures for global and local shape encoding determines the quality of drawings. Observing and describing which EPs are used by children when they explored a tactile illustrated book might bring information about how to construct an efficient illustration, recognizable and easily explored by visually impaired and blind children, and how to teach them to explore tactile pictures.

In the present studies, the EPs were influenced by the goal pursued by children, the type of illustrations used and the content of the text. The EPs employed when the child has to imagine the meaning of what he was touching and the EPs when he has to associate the drawing with the text content were compared. On overall the children were more active, spending more time exploring the illustrations when they have to find meaning than when they have to associate the text content with the drawing. However, the task of associating the drawing with the text content always happened after the task of searching meaning. It was expected that the children would have quickly scanned the page to find some elements memorized before that they could have linked to the text content. Instead of that, they spent half of the time only listening at the story without initiating any exploratory movement. Children who already knew the drawing might have been less involved in this task and might have used all their attentional resources to listen to the proposals and to link these proposals to their own proposals formulated the step before. When they discovered a new illustration half of them tend to use a procedure that was called “surface sweeping with the palm”, which consists of quickly and globally scan the whole surface of the page with the palm lay flat on the illustration, moving in lateral or circular motion. This global procedure initiated at the beginning of the exploration might bring global information about the size, the texture and the global shape of the illustration. (Klatzky & Lederman, 1995)showed that a brief “haptic glance” lasting about 200 ms was sometimes sufficient for haptic identification of familiar objects with highly diagnostic geometric or material features. The duration of manual exploration has been shown to influence haptic processing in terms of the distinction between featural and global processing of object structure. After this global procedure of surface sweeping with the palm, they alternated between global procedures like lateral motion and specific ones like contours following. In both tasks lateral motion was largely employed since this procedure is not the most appropriate for encoding the shape but is optimal for the processing of texture information (Lederman & Klatzky, 1987). The common use of this procedure was highlighted in previous studies (Theurel et al., 2010; Vinter et al., 2012). Young children tend to often use the lateral motion procedure when they have to explore bidimensional drawings in the aim to memorize it or to infer their meaning even if this is not optimal for encoding precise shape. However, lateral motion used in combination with the contour following procedure makes it possible to avoid the confusion between foreground and background because it enables children to explore the filled internal region (Kennedy & Domander, 1984). Concerning the exploration of these illustrations in swell paper children chose more often to use unimanual exploration than bimanual exploration, even though bimanual activity is assumed to enlarge the tactile field and to help reducing the costs in terms of memory and information integration processes (Ballasteros et al., 1997; Craig, 1985; Wijntjes et al., 2008).

The use of the different EPs was also influenced by the text content and the type of illustrations. Two ways of illustrating books, one using bidimensional representations and the other using tridimensional objects, glued or freed from the page, were compared. The use of 3D illustrations led to a high diversity of EPs. Children used different procedures like grasp and hold, lateral motion, pinch, enclosure, pressure and static contact. The grasp and hold procedure, which is specific to 3D objects and which was largely employed, allows to collect different and redundant information about objects. Klatzky (1990) predicted that the most efficient way to process an object’s properties was to grasp and lift it, because it provokes at the same time the exploratory procedures of static contact, unsupported holding and enclosure. This action permits to provide at least global information about material and structural properties. Children need redundancy in their information processing to interpret haptic information (Millar, 1994) and this redundancy can be provoked by the use of different procedures for exploring the same object. When exploring tridimensional illustrations, children alternated between coarse and specific information extraction steps. Exploratory movements were oriented toward the extraction of the whole picture characteristics (surface sweeping with the palm, lateral motion, grasp and hold, enclosure) and toward the extraction of local features (pinch, contour following). The diversity of procedures has been linked with the quality of exploration and interpretation of pictures. Vinter 2012 showed that the large number of procedures used was linked with the quality of drawings produced by children after the exploration step. For bidimensional pictures lateral motion was often used. This procedure is optimal for perceiving the texture of pictures. In some case, it might be suitable to the understanding of the story because each character was produced in different texture. For example the bears were in soft fur whereas the little girl wore a skirt in fabric. Thus the lateral motion procedure permitted to easily distinguish the bears from the girl. For the objects that could only been distinguished by the size (big, medium and small bowls) a global procedure might be sufficient. However, to understand, that it is a house or a tree or a table that is represented, a specific contours following procedure is needed. Thus, children were expected to alternate between global and local procedures for more informational exploration of the picture. Some EPs were specific to particular illustrations. The pinch procedure was observed for the long hair of Goldilocks, and for the exploration of the house windows, the blankets and the door. The type of illustrations and the materials used to make the illustrations may constraint the exploratory procedures employed during joint storybook reading.

The EPs employed by children were also largely constrained by the content of the text. In one of the story the author added material information in the text. The text by emphasis some characteristic of objects features induced the use of exploratory strategies. The description of embossed mattress led to lateral motion or pressure procedures in all children. The descriptions of soft bed led to pressure whereas the description of rough seat led to lateral motion. The blanket described as thin led to pinch. The description of the warm chocolate generally produced static contact even if the bowls were not hot in reality. A child played with this concept and put his hand in contact with the drawing of the bowl and quickly removed it simulating the hot sensation. The warmth of the bowls was represented by a drawing of smoke above the bowls. This representation was difficult to understand for children and needed explanations from the educator. As it was shown by (Theurel et al., 2010), the verbal descriptions delivered by the adult along the reading guide the EPs employed by children. Descriptions of pictures with tactile vocabulary led to the use of specific exploratory procedures directly linked with the qualifier. The verbal interactions during joint book reading improved the quality of the exploration initiated by the child. Adult by reading the text and providing additional information guides the exploratory procedures and could consequently enhance the understanding of the story. Pictures should not be considered as separate entity and are strongly linked to the text content. Information containing in the picture has to be congruent with and to correspond to the information brought by the text. Both picture and text are interrelated and guide the exploratory movements.

Despite the fact that picture books reading is an important part of literacy development, tactile books are less present in the environment of children with visual handicap than in the environment of sighted children. When picture books are available, it is not easy for blind children to understand and interpret the tactile pictures that are often hardly recognizable. The understanding of the pictures depends in part of the quality of the haptic exploratory procedures used. Determining which of the EPs are beneficial or detrimental to the extraction of shape information contained in tactile pictures might help to define how illustrated books can be elaborate, which type of illustrations can be chosen and how the adult can read the book and guide the children's exploration. Children need to be taught how to explore the pictures and which EPs are optimal in which context, to support their understanding of illustrations and stories.

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