1 Contemporary enquiries into a long-standing domain: Drawing research

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DRAWING BEHAVIOUR has occupied European psychologists from the turn of the last century (Kerschensteiner, 1905; Luquet, 1927; Ricci, 1887; Rouma, 1913), maintained their interest ever since, and subsequently also attracted some attention from psychologists in other continents such as the United States. The main contribution of the early work was to describe how this typically human behaviour develops, and in particular which stages it follows (Piaget and Inhelder, 1956). Still, perhaps like many other scientists nowadays, Piaget saw drawing only as a figurative, illustrative instrument of representation, as opposed to rational and operational thought devoted to the genuine understanding of reality. Thus, drawing behaviour was not frequently studied in relation to cognitive development. However, a notable exception was the 'Draw-a-person test' designed by Goodenough (Goodenough, 1926; Goodenough and Harris, 1950) which assesses mental age in children via the human figure drawing, and, because it has a high correlation with intelligence tests until adolescence, it is still in use today.

Since the 1970s and 1980s, a refreshed interest in drawing from developmental and cognitive psychologists from an empirical, experimental, statistically underpinned perspective has flourished, as evident in two books by Freeman (Freeman, 1980, see also his current contribution to this book; Freeman and Cox, 1985). Since then a productive scientific research area has opened and progressed, embedding drawing research into mainstream cognitive and developmental psychology, as shown by the many journal articles and books which followed (e.g. Cox, 1986; Golomb, 1973; Goodnow, 1977; Thomas and Silk, 1990; as well as Lange-Küttner and Thomas, 1995). The current book offers an up-to-date and state-of-the-art overview of the main lines of research currently conducted on drawing from a cognitive perspective.

Producing and understanding artificial and technical reflections of reality needs considerable intelligence. Understanding visual reflections requires an awareness of a second-order reality, perceptual discrimination and memory. Furthermore, already when young children begin to scribble with a pen on paper, motor learning also begins to play a role as they set out to represent an object on paper. A fascinating communication network evolves in children's minds in these years where non-verbal intelligence interacts with social skills to communicate meaning. Meaning is conveyed either in symbolic form, where canonical templates lend the picture some unambiguous quality, or in literal form, where the greatest effort is taken to convey the actual optical impression. While, in the former, the viewer shares the knowledge of the functional properties of objects, in the latter the viewer just needs to have seen a scene. It thus appears that the type of picture production in pictorial space changes considerably, making communication easier and more immediate for the viewer. In this way, non-verbal communication is intrinsically social. But to achieve this facilitation effect for somebody else, the rules and requirements for productivity need to be changed, and many children and adults drop out. There are intricate changes in cognitive, motor and psychological functioning necessary which are described and explained in this book, which unites the most original and active researchers in this field.

Two more general points are worth making before introducing the contribution of each of the chapters in turn. We would first like to emphasize the great role attributed by most researchers in drawing behaviour to executive functions, particularly to working memory. Sutton and Rose (1998) were amongst the first authors to point to the important contribution of attentional processes in drawing production, revealing the importance of parallel, simultaneous processing of model and product in the transition from intellectual to visual realism, which even overruled instructional manipulation by the experimenter. Today, there is a large agreement between authors that factors like working memory and inhibition influence drawing production and drawing understanding. This functionalist view is shared by several authors in this book. The second point is related to the impact of the work published by Peter Van Sommers (Van Sommers, 1984, 1989) and the late John Willats (Willats, 1985, 1995), who both single-handedly introduced important concepts into research on drawing, such as conservatism versus flexibility, or drawing systems versus denotation systems.

The book is divided into three parts, each dealing with specific aspects of drawing that make this behaviour so interesting to study for developmental psychologists. The organization of chapters into three sections follows a developmental progression. Chapters in the first part of the book

are concerned with the beginnings and roots of drawing behaviour, understood as a typical symbolic behaviour, and they report mainly from the infancy and preschool period. Chapters in the second part refer essentially to the school period, studying influencing factors and their interactions on drawing behaviour which determine the transition to visual realism. Finally, adulthood and old age are at the centre of the chapters in the third part of the book, tackling the role of expertise, and explaining the impact of diverse conditions such as blindness, dementia or autism on drawing.

The first part (Self, symbols and intention) comprises the first five chapters. This section is quite original in a book on drawing behaviour and deals with the relationships between drawing and the self, which leads to a discussion of children's understanding of drawings as genuine symbols that stand for something else. Indeed, in the same way as infants must understand mirror images as reflections or re-presentations of something else (e.g. the self, others, objects alike), also drawings must be conceived of as independent symbolic representations or reflections of something else. In each case, infants must understand the one-to-one relationship between the image (reflected in a mirror or on a paper) and its referent together with their differentiation or separation. A common difficulty emerges in each case: acknowledging that the image constitutes an object in itself, that refers to something else at the same time. However, while mirror images are reflections strongly constrained in the present time and space, and share the same space at the same time with their referents, drawings act as symbols independently of time and space, and make the evocation of absent referents possible. Within the Piagetian theory, mirror images could be construed as fully differentiated perceptual signifiers whose understanding should emerge at the end of the sensorimotor stage, whereas drawings constitute conceptual signifiers where understanding should expand largely beyond two years of age.

From this perspective, it is most interesting and appropriate to start our journey through drawing development in this book with the chapter by Kim Bard, dedicated to the comparative development of mirror self-recognition in infants and primates, continuing with studies, by Josephine Ross in chapter 3 and Campbell, Duncan, Harrison and Mathewson in chapter 4, on the question of the link between self-recognition and recognition of their own drawing products in young children. To anticipate the result, it turns out that mirror self-recognition behaviour did indeed predict true productivity insofar as a drawing is recognized, as a product of oneself, or as that of somebody else.

In chapter 2, Bard develops a fascinating comparative and developmental approach to the question of mirror self-recognition, and argues

that mirror self-recognition is a product of similar epigenetic processes in hominids, including humans and the great apes, following similar developmental paths across these species. A 'great divide' appears between hominids and the rest of the primate species in this regard. In agreement with the traditional literature on mirror self-recognition, she assumes that success in the mark and mirror test devised by Gallup (1970) indicates fully differentiated self-awareness, allowing children to understand reflections of self (in the mirror) as one's representation of oneself. Bard recalls briefly the main developmental milestones shown in self-awareness as revealed by the mirror situation in human infants, and demonstrates that the pattern of responses to the mirror shown in the chimpanzees follows a similar evolution, from social responses through contingency testing, to self-directed behaviour. However, showing self-directed behaviours does not imply passing successfully the mark test. Only at around 24 months in human infants, and between 28 and 30 months in chimpanzees, does mirror self-recognition truly emerge. Bard suggests that mirror self-recognition has to do with secondary intersubjectivity (the capacity to think mentally about the self and the other as differentiated intentional agents), with empathy and with a capacity to use symbols. We share all these abilities with the great apes. Interestingly, Bard considers that the mark test, passed at around 2 years of age, 'provides a behavioural index of an ability to hold simultaneously two views of the self', the self who is acting and the self in the mirror. We will see later, in chapter 5, that Jolley claims that the understanding of the dual nature of pictures, achieved between 4 and 5 years, similarly relies on a capacity to hold two representations of an entity simultaneously in mind. The similarity of these dual-processing assumptions is a nice illustration of the link that can be drawn between understanding reflections (of self, others or objects) in the mirror and understanding reflections (of self, others or objects) in drawing. The gap of two years between both achievements is probably due to the fact that mirror self-recognition is more immediate and requires less memory.

In chapter 3, Ross weaves the links between the mirror test situation and self-drawing production, claiming that self-drawings, or self-portraits, may reveal the content of self-knowledge, through details and levels of differentiation, and could thus be considered as advanced forms of the mirror test of self-recognition. Consistent with a finding from Gellert (1968), Ross shows that the quality of self-figure drawings is higher than the quality of other figure drawings, implying that self-drawings production is inherently linked to the ability to self-differentiate. However, the beam of relationships linking self-drawings and self-awareness as indexed by mirror recognition appears rather more complex. The quality of

self-drawing relates to self-aware mirror behaviours, which are themselves related to the ability to recognize one's own drawings. Interestingly, Ross reveals that recognition of drawings made by others can increase when children are asked to trace over these drawings before having to recognize them. This highlights the importance of a 'physical' component of self-engagement in the very act of drawing with respect to drawing recognition. Thus, memory of perceived graphic objects improves when information can be in parallel and congruently encoded by the motor system. A similar result was obtained in a study comparing the effect of either a handwriting training or a typing training on letter recognition in preschool children aged 3–5 years (Longcamp, Zerbato-Poudou and Velay, 2005): letter recognition was better following a motor training in which kinaesthetic or proprioceptive information was congruent with visual information. On the other hand, one could say that tracing another person's drawing is like drawing it yourself, and thus it is by definition not another person's drawing anymore, but a 'shared' drawing. This immediate benefit of repetition of other people's work has been rarely discussed in the literature (Wilson and Wilson, 1982); however, it does not need to be seen in a negative way. On the contrary, it explains that recognition both of one's own drawing and of somebody else's appears to rely on perceptual and kinaesthetic/proprioceptive memory, i.e. early sensory components of self-awareness which exist from very early on (e.g. Bahrick and Watson, 1985; Rochat and Morgan, 1995; Schmuckler, 1996).

Chapter 4 focuses directly on the development of the ability of children to recognize their own drawings. Campbell, Duncan, Harrison and Mathewson list further factors that may support this ability, from the idiosyncratic constituents of the drawing (related to what may be called the child's style) to the memory of the drawing episode itself. They report several experiments which demonstrate that recognition of own drawings develops between 4 and 5 years, and is scarce before 4 years of age, contrary to the conclusions drawn from the original experiment of Gross and Hayne (1999). As a matter of fact, these last experiments suggest that the ability to recognize self-drawings, at least within delays of less than 6 months, emerges somewhere between 3 and 4 years. Van Sommers (1984) showed that children as young as 3 or 4 years of age are able to represent idiosyncratic features that ground distinctive styles. In the chapter, it is documented that although these individual styles do indeed exist – and are documented in the chapter with intriguing illustrations of drawing series of the Snodgrass and Vanderwart objects – children's recognition of their own drawings rarely seems to take advantage of these individually based or biased features. The authors conclude that improvement of episodic memory is probably a key factor in the

development of one's drawing recognition. Endorsing the claim made by Ross (chapter 3) that drawing recognition relates to self-awareness, and following Povinelli's theory of self (1995), it could be suggested that the development of one's drawing recognition may rely on the emergence of autobiographical self, i.e. on improvement of episodic autobiographical memory. Povinelli (1995) sustains the view that the self in children around 4 to 5 years can be seen as a genuine representational agent, developing an organized and unified autobiographical self-representation. As noted by Gergely (2006), for an event to be encoded in autobiographical memory, not only the event itself must be represented, but also the fact that memory has been caused by that event, i.e. the event must be encoded as an event one 'personally experienced' among others. Povinelli and Simon (1998) consider that the ability to hold multiple representations of the world in mind simultaneously, and thus the capacity to establish temporal and causal relationships between diverse 'personally experienced' events, would be a key factor in the emergence of autobiographical memory.

Interestingly, the conclusion reached in the following chapter by Jolley is close to the idea of a coherent, autobiographical self as developed by Povinelli and Simon (1998). In chapter 5, Jolley offers an overview of the developmental progression through which children gain conceptual understanding of pictures and their dual nature: pictures are objects in themselves, and simultaneously they stand for some other realities from which they must be conceived of as differentiated. Jolley argues that the conceptual understanding of this dual property of pictures involves being able 'to think about an entity in two ways at the same time' (chapter 5, final page), that is, to hold in mind multiple representations of this entity simultaneously. This would be fully achieved somewhere between 4 and 5 years, an age period similar to the one which sees the emergence of an autobiographical self.

When occur the first signs of an ability to recognize similarity and difference between pictures and the real referents they represent? Whereas newborns have a basic ability to discriminate visually between pictures and their referents, it may take a few months before babies can recognize on some level a similarity between a picture's contents and its referent. Only at about $1\frac{1}{2}$ years is there clear evidence that infants can recognize familiar subject matter in pictures and behave towards pictures in a way that indicates they would understand that pictures are different from their real referents. However, Jolley shows that there is still a long way to go before children capture a complete understanding of the dual nature of pictures. He reports findings of DeLoache and others from two different tasks, a search task for a real item in space, using a picture as a guide, and the 'false picture' task, where children need to point to the

photo of an object taken at a particular point in time. Between 2 and $2^1/_2$ years, children are able to use information from a picture to locate a toy hidden in a room, while it is only between 4 and 5 years that children's responses in 'false picture' tasks show an understanding that a change made to an object does not modify the picture taken of this object shortly before the change was made. Although both tasks were taken as measures of understanding the dual nature of pictures, Jolley accounts for the apparently contradictory developmental findings. He argues that while the search task primarily investigates the child's understanding of the representational property of the pictures, the false picture task would be assessing also the child's understanding of the independent existence of pictures. He claims that the delayed success in the false picture task is due to a more general cognitive limitation experienced by young children in being able to think simultaneously in two ways about an entity. Thus, an increase in attentional resources or in the size of working memory might constitute one major general cognitive factor underlying this development. We wonder, however, whether a space-mapping task is easier than a time-mapping task, just because space offers a visible extent, while a time scale is much more difficult to grasp.

The role of executive functions in drawing development is also highlighted in the following chapter by Freeman and Adi-Japha. They give a comprehensive overview of the several steps involved in the production of a drawing and how they relate one to the other. These authors focus on whether an interpretation is afforded by the final product, i.e. whether children form an intention to draw something a priori, or allocate a convenient interpretation post hoc, which suits the graphic object they happened to create. They show how children come to relate initial intentions and subsequent interpretations via a complex process that involves both activating and inhibiting or suppressing drawing rules. Interestingly, these notions of intention and interpretation throw new light on the above discussed question of the dual nature of drawings as symbols. Drawing with the prior intention to depict, for example, recognizable lion makes it easier to confer representational and referential attributes to the drawing, but also makes failure more likely, if the aim was too ambitious. In absence of intention, it is likely that the drawing can be seen literally as a series of lines or marks or as a scribble, i.e. as an object in itself, possessing some incidental, geometrical attributes. Though some observations suggest that children as young as 2 years can form some connections between intention, action and interpretation, these links really start to operate by 3 years, that is, approximatively at the same age when children resolve the DeLoache tasks, or the picture recognition tasks of Campbell *et al.* Thus, the angle under which Freeman and Adi-Japha tackle the question of the

entry of children into representational drawing brings them to delineate the same age period as the previous approaches. This certainly shows that general or domain-general representational capacities underly the different drawing-related behaviours examined so far. However, throughout the chapter, Freeman and Adi-Japha prevent us from adopting a uniquely forward-looking orientation towards each next advance in development, as if only progressive acquisition of new abilities, or new drawing rules, occurred. They repeatedly point to the fact that development is also a story of recursive 'rejections' or suppression of old rules, of inhibition of up-to-now dominant behaviours. Similar to Jolley, also Freeman and Adi-Japha consider that changes in executive processes sustain the development of drawing behaviour. Freeman and Adi-Japha's chapter focuses on the role of inhibition, while Jolley attaches importance to the role of working memory. Note that attention is perhaps a key common function underlying these two functional processes. In chapter 9, in the next part of the book, Morra will in fact discuss an entire array of factors which develop and interact during the development of drawing.

In conclusion, the chapters included in this first section illustrate how progressive cognitive expertise and behavioural mastery is gained by children in drawing from the very beginning until their fourth or fifth year of life. The constitution of a representational and autobiographical self accompanies this development, where a self as producer engages in intentions, graphic actions and interpretations, and exercises or rejects drawing rules, which are progressively assembled or disassembled, partly as a function of the ease with which connections between the produced drawing and the model can be established. The next section examines how drawing develops thereafter.

The second part (Syntax, space systems and projection) has six chapters; chapters 7 and 8 deal essentially with syntax in drawing, while chapters 9 to 12 take an 'internal' perspective on drawing, asking how graphic objects are organized within pictorial space, and what the effects of the transition from 'intellectual' to 'visual' realism are on the early representations.

Syntax in drawing refers to the way the movements are organized and ordered in a sequence. As pointed out by Braswell and Rosengren in their chapter, the study of the motor aspects of drawing has received less consideration than the study of the final outcome of a drawing episode, at least in children. Note that a move from a product-oriented approach to a process-oriented research approach characterizes not only the drawing domain, but more generally the study of graphic activities, particularly the study of handwriting (e.g. Thomassen and Van Galen, 1992). The interest in graphic syntax was elicited by Goodnow and Levine (1973),

who described several starting and progression rules. This work was further developed by Goodnow's Australian collegue Van Sommers' (1984) very clever and original investigations on drawing carried out in the years thereafter. He carefully demonstrated how perceptual, geometrical, biomechanical and cognitive forces act together in the production of drawing, and proposed heuristic notions, for instance the notion of 'conservatism' in children's drawings, which is now often used to contrast cognitive 'flexibility'.

In their chapter, Braswell and Rosengren review a series of studies demonstrating that biomechanical and cognitive constraints interact with task and cultural constraints during drawing development. With respect to biomechanical constraints, they examine the development of grip configurations as well as its variability, and the influence of handedness on stroke directionality. They show that cognitive constraints linked to planning ability interfere with the application of some syntactical rules, like starting rules when drawing a line, or threading, i.e. connecting shapes with each other. Braswell and Rosengren refer also to the scarce literature that explores how cultural constraints act on syntactical behaviour, in particular how writing systems impact on drawing. For instance, Arab writing systems bias directionality from right to left, while Hebrew writing systems bias it from left to right. Likewise, Braswell and Rosengren explored laterality effects in drawing, i.e. not only where children and adults start to draw, but also how they coordinate their drawing when using both hands, demonstrating entirely different behaviours in adults, who used the hands in a mirror fashion, while young children had both hands carrying out the same movements. Indeed this poses many unanswered questions, such as whether the amount of specialization and expertise, which occurs in adulthood, is matched by different underlying brain processes, such that drawing becomes a truly right-brain activity. Does drawing involve increasingly less verbal labelling with which objects are denoted, as drawing becomes more focused on irregular, view-specific contour of shapes, and thus becomes increasingly and exclusively part of non-verbal intelligence (Edwards, 1992)? It was shown that drawing becomes an increasingly effortful and pressurized activity (Lange-Küttner, 1998), so much so that it can elicit epilepsy (Kho, Van den Bergh, Spetgens and Leijten, 2006; Miller, 2006) and fits of action-induced myoclonus-dystonia (M-D) (Nitschke, Erdmann, Trillenberg, Sprenger, Kock, Sperner *et al.*, 2006) in young people. In the elderly, impairments in drawing spatial position predicted death in a condition of chronic obstructive pulmonary disease (Antonelli, Corsonello, Pedone, Trojano, Acanfora, Spada *et al.*, 2006) and was more common in schizophrenia (Lowery, Giovanni, Harper Mozley, Arnold, Bilker, Gur *et al.*, 2003). It appears

that expert drawers activate more frontal brain activity, related to working memory, while novices activate more the parietal brain area, related to perceptual aspects of spatial position (Solso, 2001). A parieto-frontal network for drawing was indeed also revealed by Ino, Asada, Ito, Kimura and Fukuyama (2003), with a stronger activation on the right side of the brain, but when naming was involved parietal lobes were activated bilaterally (Makuuchi, Kaminaga and Sugishita, 2003; Moritz, Johnson, McMillan, Haughton and Meyerand, 2004). Thus, for expertise, the anterior–posterior brain axis appears to be relevant, while the amount of verbal involvement seems to be reflected in the left–right brain axis. The chapters of Lange-Küttner in the second section and of Lindenberger as well as Patterson in the third section discuss further neuropsychological aspects of drawing.

The central thesis of Vinter, Picard and Fernandes in chapter 8 is that the way reality is parsed into representational units determines the way drawing movements are grouped and ordered in a sequence. More precisely, they argue that changes in drawing behaviour during development result from changes in the *size* of the cognitive units or mental representations used to plan behaviour, and in the capacity to manage *part–whole* relationships. The way an object is conceptualized affects the way it is drawn, not only in its final content, but also in the specific sequencing of the movements used. Therefore, the study of drawing syntax is almost entirely a non-verbal approach to representational development in children. The hypothesis is tested in several experiments carried out by Vinter and her colleagues, from the study of local application of graphic rules to the study of the global strategies followed by children when they copy more or less complex patterns. At a local level, the authors show that the rules are applied segment by segment, then are planned taking into consideration the entire figure, before children become able to take simultaneously into account the constraints imposed by the segments and by the overall figure configuration. A similar three-step model seems to characterize drawing syntax development at a more global level, where authors consider children's graphic strategies or their capacities to introduce innovations in their drawings (representational flexibility) through modifications of their drawing movement sequences (procedural flexibility). Note that such a perspective is not contradictory to a functionalist view asserting the role of working memory in this development, for instance. Indeed, managing part–whole relationships necessitates focusing simultaneously on both the parts and the whole. Finally, in the same way as Pew (1974) has shown that visuo-manual tracking behaviour can become an interesting non-verbal test of implicit learning (see also Wulf and Schmidt, 1997), Vinter, Picard and Fernandes conclude their chapter