Children's Understanding and Production of Pictures, Drawings & Art

Theoretical and Empirical Approaches
Children’s Understanding and Production of Pictures, Drawings, and Art

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(Editors)
In 2006 and 2007, researchers in psychology of the visual arts sustained a double blow. Two revered members of our community, John Willats and Rudolf Arnheim, passed away. Both of these men were avid and productive students of the arts, and although they did not share some of their theoretical positions, they did share a commitment to the rigorous pursuit of knowledge, impeccable scholarship, and methodical analysis. Above all, they shared a deep love of the visual arts and what the arts, at their best, could bring to humanity. Their erudition, humor, and synthetic flair will be sorely missed, but their rich and multiform contributions will continue to inform and generate discourse and research in our field for years to come.

This book is dedicated to the memory of John and Rudy, whose legacies have provided much of the wisdom and inspiration for the contributions in this volume.
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Preface

The ideas and conception of this book grew out of symposia and poster workshops at several conferences and meetings in which many of the contributors of this volume were involved. Most of these symposia and poster workshops took place at meetings of the Jean Piaget Society (JPS).

The first personal contact of the two editors was at the 25th Annual Symposium of the JPS in Berkeley, CA, USA, 1995, where Constance Milbrath organized a symposium on *Hearing, Seeing, and Thinking in Music and the Visual Arts*, and where Christiane Lange-Küttner, Anna Silvia Bombi, Guiliana Pinto, and Hanns M. Trautner met in a poster session on drawings. A year later, Emiel Reith and Constance Milbrath organized a poster workshop at the Piaget Centennial Conference “The Growing Mind” in Geneva in 1996 (titled, *Contemporary Perspectives on the Nature and Development of Pictorial Representation in Children*), including eighteen posters that covered a wide range of issues. In the following years, varying groups of people doing research on the subject met again at conferences and exchanged ideas and research findings. Of particular note are the poster workshops, symposia, and individual papers at the 30th Annual Meeting of the JPS in Montréal, QC, Canada, in 2000 (poster workshop entitled *Children’s Knowledge and Judgments About Drawings and Drawing Processes*, organized by the two editors), several presentations at the 36th Annual Meeting of the JPS in Baltimore, MD, USA, with the theme of *Art and Human Development*, and, recently, the symposium on *Artistic Representation and Aesthetics* (organized by the two editors) at the 37th Annual Meeting of the JPS in Amsterdam, The Netherlands, in 2007. The European contributors to this volume were also among the participants of two symposia at the 12th European Conference on Developmental Psychology in Tenerife, Spain, in 2005. Topics of the symposia were *Children’s Perception and Depiction of Affective Information in Drawings* (organized by Hanns M. Trautner and Maria A. Tallandini), and *Productivity in Pictorial Space* (organized by Christiane Lange-Küttner and Anne Vinter).

In the course of the meetings of the past years, we noticed the rapidly growing interest of psychologists in children’s theories about the way the self, others, and things in the world work and the numerous studies of children’s metacognitive abilities in the areas of perception, language, and problem solving. However, at the same time, we saw little attention devoted to children’s theory and knowledge of pictorial representation, drawing, and art, and how this knowledge evolves with age. In recent years, we are pleased to say, this trend has reversed and there are now a number of new and interesting empirical studies and theoretical advances that are starting to fill the gap in what is known about children’s theories and metacognitive abilities in the domain of pictures, drawing, and art. Researchers have studied children’s conception of what counts as a picture and of the role of the artist in picture production, how children adapt to specific drawing conditions and monitor their drawing processes, and children’s appreciation of age differences in drawing performance, and their aesthetic preferences.

As these contributions are scattered across various journals and other sources (e.g., presentations at conferences), we felt the lack of a single book that surveys current theory and research in this domain. Building upon the fruitful exchanges with our colleagues...
at the several meetings, we developed the idea for this book as a means of bringing togeth-
er researchers and theorists whose work contributes substantially to our knowledge of
children’s understanding and production of pictures, drawings, and art. This will be the
first volume to focus explicitly on children’s knowledge and interpretations of pictorial
representations, including their understanding of the role of the artist as producer of pic-
tures and of the viewer as beholder of pictures, in the context of their developing abilities
to understand and produce pictorial representations. It addresses what children of differ-
ent ages know about the nature of pictures as representations of the world, as intentional
communications conveyed by artists, and as aesthetic objects, as well as what children of
different ages understand about the different ways to depict objects and scenes.

The contributions of this volume should be of value for researchers of children’s cog-
nitive development, and particularly those working in the field of symbolic and represen-
tational development, and to researchers and educators in the field of art education who
wish to understand young children’s grasp of what pictures represent and their compre-
hension of the relationships between picture and artist and between picture and viewer.

We, as editors, were extremely pleased at the prompt response to our invitations to
contribute to this volume. We wish to thank the authors for their collegial cooperation dur-
ing the earlier process of writing, for their thoughtful responses to our many comments
and suggestions, and for their effort to keep to the deadlines we set.

We have been helped by many people in preparing this book. We particularly wish
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Additional thanks of Constance Milbrath go to Gerald Cupchik, Jeanne Bamberger,
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the ideas on metacognition and drawing generated from this collaboration, as well as
the pleasant experience of our joint teaching and doing research on children’s drawings
with advanced students of our psychology department.

We hope that the approaches advanced in this volume will stimulate innovative
research in the field of children’s understanding and production of pictures, drawings, and
art. Knowledge of how children think about pictures and drawings as representations and
intentional communications about a state of affairs, and of art as aesthetic objects will
depth our understanding of the drawings they produce and provide valuable insights into
children’s comprehension of the many forms of graphic representation that are part of
contemporary culture.

Constance Milbrath
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Part I

Introduction
Chapter 1

Children’s Knowledge About Pictures, Drawing, and Art

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Introduction

When psychologists deal with pictures, drawings, and art (for ease of description, in the following: pictorial representation) they either use pictorial representations as an instrument for studying psychological processes and mental life or they are interested in pictorial representation as an activity in its own right (Reith, 1996). Pertaining to the first category (easily outnumbering the studies in the second category) is the use of pictorial representations to test cognitive abilities (e.g., intelligence, spatial cognition, perception, memory), to diagnose the personality of a person (e.g., traits, emotions, unconscious conflicts), as a means for planning or carrying out therapeutic interventions in clinical contexts, or to explain and illustrate tasks or verbal information. Piaget and Inhelder’s classical book on the child’s conception of space (Piaget & Inhelder, 1956) using children’s drawings to verify their hypotheses about the development of spatial concepts is a typical example in developmental psychology.

The focus of our book is different. Our particular interest is directed at children’s knowledge, ideas, and theories in the domain of pictorial representation. We are concerned with problems and research about the perception, production, and judgment of pictorial representation in itself and in the description and explanation of the developmental changes related to understanding and producing pictorial representations. Although we can build upon the extant developmental literature on the relation between cognition and drawing that has been published in the last decades (e.g., Freeman, 1980; Freeman & Cox, 1985; Lange-Küttner & Thomas, 1995; Van Sommers, 1984), we go beyond these traditional cognitive approaches by referring to more recent concepts under the umbrella of metacognition and theory of mind.
Cognition and drawing

Understanding pictures requires that one recognizes pictures as representations. Understanding the representational nature of pictures includes four components (Winner, 2006): to recognize “(1) the similarity between a picture and what it represents, (2) the difference between a picture and what it represents, (3) the dual reality of a picture as both a flat object and a representation of the three-dimensional world, and (4) the fact that pictures are made with intentionality and are to be interpreted.” (p. 863). Understanding the representational nature of pictures also requires the ability to perceive the illusion of the third dimension in a two-dimensional picture, as well as to perceive aesthetic properties in pictures (Winner, 2006).

Drawing as symbol system

Cognitive approaches of pictorial representation are mainly focused on drawings as representations of the drawn object. The attention is on the relation between symbol and referent (symbol function). What children understand or misunderstand about the symbol-referent relation, about depiction as a symbolic or representational system, how this changes with age, and the situational factors that can influence this understanding are the main questions of this research.

It would be naïve to assume that children’s drawings are a direct reflection of how they understand reality or of their mental representation of reality. On the contrary, most researchers today assume that the mental representation of an object drawn and the manner in which an object is drawn are rather independent of each other. According to Reith (1996) and Bremner (1996) there are several processes involved mediating between object (referent) and drawing, i.e., perception of the object, knowledge about the object, conceptual, visual (mental) images, experiential knowledge, representation of the drawing, knowledge of graphic symbolization systems, motor-skills, graphic planning, execution and monitoring of the drawing process and product.

The problems of the symbol-referent relation described above bear upon the relationships between seeing, knowing, and drawing. While Luquet (1927) stated that before reaching the stage of visual realism, children draw what they know, not what they see, Freeman (1980) argued that children draw what they know only if they don’t know enough to draw in a different way. Others make the point that children draw according to their knowledge about how an object is depicted and by copying drawing schemata from other pictures, not necessarily according to their knowledge about the real world referent (Gombrich, 1977; Schuster, 1993). For them, “drawing is not a problem of seeing or knowing, it is a problem of drawing per se, that is, knowing the rules for translating knowledge and perceptual experience of real objects into forms on the page” (Thomas, 1995, p. 77). Goodnow (1977) terms this creating graphic equivalents of real objects. One reason for the loose relationship between
what is seen and what is drawn, in particular by young children, is that children’s spontaneous drawings are usually not drawn from life or by looking at the drawing object, but by relying on memory or by copying from other pictures (Milbrath, 1998; Thomas, 1995).

The preceding discussion of the symbol-referent relation and of the match between mental representation and drawing implies that the child’s intention when drawing is to produce a more or less realistic representation of the referent; that is, to depict specific objects and spatial relations with a concern for accuracy and clarity. However, there might be other intentions behind children’s drawings than a representational intention (Reith, 1996). The production of the drawing may aim to convey certain emotions or to induce specific effects in the observer (expressive intention). The child may want to tell a story or an episode with her drawing (narrative intention). Or the main purpose of the drawing may be to produce a composition of form and color that is pleasing or that serves a decorative function (aesthetic intention). Because cognitive approaches are mainly concerned with drawings as representations, the drawings are usually analyzed under the implicit assumption that the drawing follows a child’s representational intention. As the drawing itself does not reveal the child’s intention, to assume a representational intention is only justified when the child directly expresses a representational intention, or when the instruction for a drawing task warrants such an intention.

In dealing with the symbol-referent relation and the role of seeing and knowing in children’s drawings, the distinction between figurative thought and operative thought, introduced by Piaget (1977), is of relevance. “Figurative thought relates to the mental reproduction of objects, events, and relationships experienced in the world, not to their transformation”, and “includes perception, imitation, and the constructed visual image” (Milbrath, 1998, p. 11). Unlike figurative thought, “operative thought acts on objects, events, and relationships experienced in the world to modify or transform them”, and “includes logical, mathematical, spatial, and causal reasoning” (Milbrath, 1998, p. 11). For Piaget, figurative thought was increasingly informed by operative thought in the course of a child’s development. In his conclusions to the Mechanisms of Perception, Piaget states “that a direct analysis of operations shows that the irreducible elements they bring to figurative organizations supports [a] hypothesis …of an autonomous development of intelligence from action (sensory-motor activities) accompanied by a continuous enrichment of perceptual structures under the influence of the development of structures of action and of intelligence” (Piaget, 1969, pp. 310-11). The graphic equivalent even at its most realistic, therefore, is never simply a reproduction of the referent because it always includes the transformative actions the child performs a) in the remembered referent, b) to render 3-dimensional spatial relationships in a 2-dimensional space, and c) in the intentional and non-intentional transformations that serve the child’s expressive, narrative, and/or aesthetic goals. Nevertheless, the degree to which children coordinate figurative and operative modes of thought may differ. For example, some children discover rules for graphic equivalents that produce more realistic visual equivalents.
because they appear more sensitive to the visual world (Milbrath, 1998; Munro, Lark-Horowitz, & Barnhart, 1942; Rosenblatt & Winner, 1988).

**Conception, perception, and production in children’s drawings**

Milbrath (1998) describes three approaches that have had a major impact on research to the present time and that contribute to an understanding of children’s drawings: (1) The first approach emphasizes conceptual development, regarding drawings as consistent with children’s ability to reconstruct or internally represent objects and their spatial relationships. (2) The second approach emphasizes perception, focusing on the development of children’s perceptual abilities and capacity to analyze objects and spatial relationships visually. (3) The third approach emphasizes the production of a drawing and views development in drawing as based on a child’s ability to solve the multitude of problems inherent in graphic production. Similar to the time lag between comprehension and usage in language, the treatment of spatial information by the perceptual system is more advanced than its integration by the conceptual and production levels.

Two assumptions lay the foundations of the conceptual approach: that the stage of cognitive development determines a child’s semiotic abilities (Piaget & Inhelder, 1956), and that the strategies that guide perceptual analysis are strongly influenced by cognitive development (Piaget, 1969). In the tradition of Piaget and Inhelder’s book on the child’s conception of space, drawings are mainly used to index conceptual knowledge (in particular, object knowledge and spatial cognition), and to show that object knowledge and object-centered views dominate the drawings of young children.

The perceptual approach attempts to explain children’s drawings by emphasizing visual analysis and perception (Gibson, 1971, 1979; Marr, 1982; Willats, 1987). According to Gibson, perception is aimed at detecting aspects of the optic array that remain invariant under movement-induced transformations, which explains why young children’s drawings are object-centered rather than viewer-centered. Using Marr’s computational model of visual processing, Willats (1987) suggests a sequence in drawing development that starts with symbolic equivalents that stand for whole objects. Gradually the child differentiates the various lower levels processed by the visual system so that a shape that initially stood for the whole comes to stand for an object’s surface and the lines that at first merely bounded the object come to stand for the object’s edges.

The third approach emphasizes the difficulties young children have planning and executing a drawing, in particular the problem of translating three dimensions into two and to organize a coherent whole (Freeman, 1980; Van Sommers, 1984). Therefore, phenomena such as synthetic incapacity, intellectual realism, or mixed viewpoints are better explained as strategies for organizing a drawing than as failures in perceptual analysis or conceptual understanding of spatial relationships. Freeman concludes from his studies that young children have difficulty organizing a drawing...
because certain mental biases guide drawing production, e.g., canonical view of an object resulting from the child’s inability to inhibit internal generic representations. This appears to be particularly true when children are asked to draw familiar objects in nontraditional orientations. A key point also is that production decisions made early in the drawing determine the direction a drawing takes.

**Drawing as problem solving**

In the eighties, several books were published that proposed a view of children’s drawings as problem solving. Of special importance were the books *Strategies of Representation* by Freeman (1980), *Visual Order* by Freeman and Cox (1985), and *Drawing and Cognition* by Van Sommers (1984). According to Freeman (1980) the problem solving process consists of four sub-processes: planning, decision making, execution, and monitoring. If a child, for instance, is asked to make a drawing of “My friends and me”, she has to solve at least the following problems: how many people to draw, in which situation, what figure first, what further sequence of figures, where to place each figure, which spatial relations and perspective of figures and objects to draw, what size to make each figure and figure parts, which sequence and details of each figure to draw, in what order, and which sequence and direction of strokes.

When making a drawing, finding solutions for these problems has to take into account the fundamental problem of transforming the three-dimensional reality onto a two-dimensional surface. This includes knowledge of denotation rules and graphic conventions, and how they relate to objects and scenes; that is, how children understand the relationship between the lines they draw and the objects they are drawing, as well as their knowledge of denotation rules associated with graphic representation (Willats, 1997, 2005).

To learn something about the way a child passes through the series of problem solving steps one has to analyze the drawing process. Analyzing only the end product of the drawing, may result in too quick an interpretation of certain details of the drawing, like the number, size, or the distance between figures in a drawing of “My friends and me”. Observing the process during the making of a drawing, may reveal that a figure has been drawn small or far apart from another figure, because of previous decisions that, for instance, led to the consequence that there was little space left for the final figure.

Besides stressing the necessity of observing the actual drawing process, proponents of viewing drawing as problem solving argue for the use of experimental designs in drawing research. Systematic variation and control of task demands and drawing conditions, allows for disentangling children’s conceptual and perceptual knowledge of drawn objects, their knowledge about denotation rules and graphic conventions, and their sensory-motor skills in transforming a three-dimensional reality onto the two-dimensional pictorial surface. Such experimental designs also offer the opportunity to test the flexibility of children’s drawings when referents/models are
varied, and to distinguish what children actually draw under specifiable conditions. For example, in varying the standard *Draw-a-Person* task by asking children to draw a human figure not only from imagination, but also by copying and by tracing a model drawing, Trautner (1995, 1996) observed significant differences in children’s segmentation or contouring of body parts, as well as in the sequence in which the body parts were drawn.

**Metacognition, theory of mind, and children’s understanding and production of pictures, drawing and art**

While traditional cognitive research puts pictures (drawings) at the centre of analysis, metacognitive approaches place minds rather than pictures at the centre of analysis. That means, one goes beyond studying the cognitive foundations of children’s drawing performance and looks at children’s explicit, objectified knowledge and theories of pictures, including their knowledge about artists as producers of pictures and about viewers as evaluators of pictures.

This perspective on drawing research guides the present book. It is a more recent focus and in comparison to other areas of cognitive development widely underrepresented. Developmental psychologists have dealt extensively with children’s theories of mind, in particular the notion that young children reason about their world by building naïve theories about the way the self, others, and things in the world work. Accordingly, there is a lot of literature on children’s theories in what are considered core domains of knowledge; in particular on children’s understanding of others’ minds and of mentalistic terms such as *know, belief,* or *desire* (Wellman, 1990), and on the notion that the young mind represents reality with naïve theories of biology, physics, and psychology (Karmiloff-Smith, 1992; Wellman & Gelman, 1998). There are also numerous studies of children’s metacognitive abilities in the areas of perception, language, or problem solving (Gombert, 1992; Kuhn, 1999; Weinert & Kluwe, 1987).

Little attention, however, has been given to children’s theories of pictures, drawing, and art, how these theories evolve with age, and children’s metacognitive knowledge in this domain. According to Freeman (see Freeman, Chap. 3), the reason for this neglect is perhaps that art is not a unitary domain but rather arises from the confluence of domains “… a mentalistic competence communicative in nature, in which pictures are used prosthetically to extend the range of viewers’ vision, in the sense of our visual understanding and our visual imagination” (p. 33). Another distinction, made by Gelman (2000), applies here, i.e., the distinction between core domains and noncore domains. While physics, biology and psychology, together with language and number may be classified as core domains in which to research children’s theories of mind, making pictures, together with music, dance, play, and sculpture, may be regarded as noncore
domains. In the case of the latter domains the product is left as an independent object external to the child while in the case of the former domains the outcome of the process is internal. Further, knowledge acquisition in core domains, according to Gelman (2000), builds upon a set of universal skeletal principles that help “to identify inputs that can be structurally mapped to its existing domain” (p. 855), whereas in noncore domains “the learner must acquire both the structure and the domain-relevant content pretty much from scratch.” (pp. 855-856).

A model of metacognitive abilities applied to children’s drawings

Two types of knowledge are usually distinguished when dealing with metacognition: factual or declarative knowledge (knowing what) in a particular content domain and procedural knowledge (knowing how) to organize cognitive activities to solve problems and take action. Flavell (1987) developed a general taxonomy of metacognitive variables that seems well suited to model the metacognitive abilities of relevance in the domain of children’s drawings. He proposed to subdivide metacognitive knowledge into three categories: person variables, task variables, and strategy variables. While the person and task variables contain mainly declarative knowledge, strategy variables involve mainly procedural knowledge. However, Flavell (1987) points out that person, task, and strategy variables always interact, and that intuitions about their interaction also are acquired.

Person variables can be further subdivided into knowledge or beliefs about (a) intra-individual variation in one’s own or someone else’s aptitudes, (b) inter-individual comparisons between, rather than within, persons, and (c) universal aspects of human cognition or psychology, i.e., about the way the human mind works.

Task variables contain the knowledge about specific features and demands of a task that influence how it is conducted or performed and solved (e.g., the knowledge that it is easier to learn the essence of a story than to learn it verbatim).

Strategy variables concern the knowledge about the procedures that are adequate and promising in order to achieve task related goals or subgoals (e.g., knowing that you have to add up to get the sum of a list of numbers, or that you have to check the result of a procedure to feel confident that the goal has been achieved).

In addition to the variables of metacognitive knowledge described before, Flavell (1987) introduced the concept of metacognitive experience. This means conscious experiences that are cognitive and affective and often accompany ongoing cognitive activities, e.g., the sudden feeling that something is hard to perceive, comprehend, remember, or solve. Changes in the development of the child that might possibly contribute to the acquisition of metacognition are the developing sense of the self as an active cognitive agent and as the causal center of one’s own cognitive activity, and an increase in planfulness, representing and interrelating past, present, and future actions and events (Flavell, 1987). One significant reason why young children seem to be so unintentional in their use of more effective strategies may be that they do not realize that they need them.
When applied to the metacognitive knowledge of relevance in the domain of children’s drawings, the person, task, and strategy variables can be translated in the following way:

**Person variables.** Knowledge about one’s own conceptual, perceptual, and sensory-motor skills, and those of others, in general, or to carry out a specific drawing task; knowledge about or evaluation of the age, talent, intention, individual style, or other individual characteristics of the artist behind the picture, and what it means to be a creative artist; and knowledge about people as cognizers of pictures, e.g., of viewers as evaluators of pictures.

**Task variables.** Knowledge about the referent object and the mental representation of the object; knowing that 3-dimensional objects can be depicted on a 2-dimensional surface; knowledge about the graphic equivalents for referent objects, the objects’ possible depictions, and spatial relationships; and knowledge about criteria to evaluate the difficulty and the quality of a drawing.

**Strategy variables.** Knowledge about denotation rules and graphic conventions and how they relate to the depiction of an object; knowledge about possible drawing strategies for coping with different tasks, e.g., when drawing from memory, copying, or tracing; knowledge about drawing aids; knowledge about planning, executing, and monitoring drawing processes; knowing how to inhibit irrelevant or misleading information; and skills in instructing, advising, or monitoring others in drawing.

The contents of this book

This volume is one of the first to attempt a specific focus on children’s metacognitive knowledge of pictures, drawing, and art, bringing together contributions from an international group of scholars, who either have been or are beginning to think seriously about how children develop a theory of pictures, drawing and art. The volume begins with three chapters that set the general foundations for metacognitive knowledge in the domain, as children take on the task of understanding how pictures as representations differ from their real world referents, become aware of and develop a theory about the mind of the artist that produces pictures, and acquire the domain-specific knowledge that yields strategies for increasingly effective and communicative representations. The three foundational chapters also attempt an answer as to why or how it is that young children begin to draw at all.

In the first chapter, Tara Callaghan addresses the foundations of symbolic development in infants and young children with the presentation of a model that proposes the perceptual, social, and cognitive skills that persons need to become symbol users. Critical to the emergence of symbolic competence in Callaghan’s model, is the infant’s drive to become a part of the socio-cultural environment that uses the culture’s symbols, and the support that others in the culture provide as they bring the child into the symbolic world. Callaghan tenders three main phases in the transition from pre-symbolic infant to symbolic child. The first precursor phase is marked by the development of a set of core perceptual, social, and cognitive mechanisms that
prepare the infant for the symbolic world. The following onset phase leads to the insight that pictures are a representation of their real world referents and is discernible as the beginning of symbolic functioning when young children deploy the core perceptual, social, and cognitive mechanisms to engage socially with others about pictures. In the final refinement phase, the representational intent and communicative function of pictures is more fully understood and it can be said that young children construct a theory of pictures.

The second chapter by Norman Freeman addresses some of the same issues as Cal laghan but with a markedly different approach, attempting as Freeman does an integration of visual-computational approaches to pictorial competence with those that treat pictures as intentional manifestations of mind. Freeman focuses on what constitutes “the minimum ontology” that the pictorial domain must take into account and the minimum number of core domains that allow for its initiation. Basic to an ontology of pictorial competence is knowledge about artist, viewer, picture, and its referent or the state of affairs the picture purports to represent. Although these four basic ingredients are necessary, Freeman argues they are not sufficient to initiate knowledge in the area of pictorial competence. As sources, Freeman proposes a minimum of two core domains that are fundamental to children’s intuitive theory construction; more specifically the crosstalk between the domain-specific representations of theory of mind and of naïve physics, as children’s intuitive theories of optics (as one aspect of naïve physics) get extended to predictions about what is in the minds of others. Thus, while Callaghan sources the infants’ social interactions with teaching infants about the referential function of pictures, Freeman proposes pictorial competence as an emergent property of the crosstalk between intuitive optics/physics and theory of mind. As such, the communicative function of pictures is one of the early discoveries a young child makes, and not grounds for the realization of the picture referent relationship. In a similar fashion, Freeman argues that pictures serve to extend the senses as a form of visual prostheses, making the case that “… while intention may be a clue to the shape that emerges on the page, likewise the shape that is seen on the page is a clue to what the artist had intended.” (p. 46).

In the final chapter of this section, Sergio Morra focuses on the memory and executive control processes that form the foundations for children’s drawing strategies and explains how these domain-general processes are coordinated with the domain-specific knowledge developed in drawing. Morra begins by describing the figurative and operative schemes that underlie the domain-specific knowledge necessary for drawing, noting that young children have a store of figurative (perceptual) schemes that represent how a topic should look and a corresponding repertoire of operative (motor) schemes to produce these drawing topics. Critical in the development of true graphic schemes from early scribbles to more advanced graphic solutions, is the coordination of these developing domain-specific figurative and operative schemes with domain-general processes, particularly with the capacity of working memory, defined as “…the information that we can hold in mind and work on,” and with inhibitory and other control processes. Using examples from his own research and that of others, Morra demonstrates the role of combinatorial processes, invention, and flexibility in
drawing development, and the constraints placed on these processes by a child’s working memory capacity. Developmental changes are accounted for, not by stages in realism, but instead, by increases in working memory capacity and increased cognitive controls. Morra closes his chapter with an intriguing puzzle about a particular type of drawing, narrative drawing. The results from his preliminary research on these under researched types of drawings suggest that neither working memory nor control processes relate in any systematic way to the coordination of these drawings. This is counter to what one might predict given that sequencing the narrative itself would seem to present more of a challenge for the working memory of younger children than older children.

The next section on understanding and developing pictorial competence, addresses the representational rules children adopt when drawing, how they use color and adapt to specific drawing conditions, and suggests how some rules might differ cross-culturally. This section concludes with a chapter on the increasingly important artistic medium of photography and how children come to understand the representational qualities of photographs.

In the first of these chapters by Christiane Lange-Küttner, the relationship between children’s graphic strategies and their emerging spatial concepts is examined. Historically, concepts of cosmological space have evolved from those that were geocentric with the earth at the center to those that construct an explicit spatial context of the universe. Lange-Küttner argues that the difficulties physics and astronomy have had in constructing a concept of universal space bear an interesting parallel to those encountered by children as they attempt to conceptualize the space on an empty sheet of paper. Using her own innovative research on developments in children’s depiction of size and space, Lange-Küttner demonstrates convincingly that children begin with an object-centered concept of space and transition to an explicit spatial axes system in middle childhood. Integral but prior to this shift, children adopt new denotation rules that map scene primitives such as edges and contours into corresponding picture primitives such as lines. The disparity between depiction of object concepts and children’s ambition to produce more visually realistic images propels these developmental changes. Lange-Küttner argues that although children have concepts for their drawings from the start, the changes which lead towards visual realism are also the result of a desire for specificity, immediacy, and flexible yet reliable visual communication.

Esther Burkitt, in her chapter, explores how children understand and use the emotionally expressive qualities of color in their drawings. As in the chapter by Lange-Küttner, the focus is on what children of different ages know about the depiction rules. Research on children’s relationship to color as a form of artistic expression is relatively sparse as most studies are concerned with children’s color preferences or the emotions children associate with different colors. Burkitt reviews studies carried out on children’s use of color to express emotional experiences but notes that the diversity of experimental approaches makes it difficult to draw conclusions about whether children actually use colors to express a feeling toward a drawing topic or in relation to their more general color preferences. Burkitt reviews her own research