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DEVELOPMENTAL STAGES IN CHILDREN'S DRAWINGS OF A CUBE AND A DOLL

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Abstract. Drawing developments of cubes and human figures are often described in taxonomies with very little in common. We created a taxonomy based on the basic principles of Luquet (1927) and Willats (1997). Children's (N = 757; age range 2–13) and adults' (N = 232; age range 17–43) drawings of a doll were compared with their drawings of a cube. The data suggest that the proposed stages appear in an invariant order: First children draw only Scribbles or Patterns; next Volume-Prototypes emerge; after that 2-D-Exemplar drawings develop; and finally 3-D-Exemplar drawings can be achieved. The same developmental sequence characterises the drawings of both a cube and a doll (human figure).

1. Introduction

Children's drawings have been studied for more than a century. Considerable amount of this research has been dedicated to the drawings of two models, a human figure (or a doll) and a cube. Comparison of the studies with these models, however, gives an impression that drawings of a cube and a human figure have very little in common. Developmental changes in the representation of a cube are analysed in terms of lines, number, orientation and integration of the faces of a cube, utilisation of obliques, perspective (e.g., Cox & Perrara 1998, Nicholls 1995, Nicholls & Kennedy 1992, Toomela, 1999). Drawings of other geometric solids, like cylinders (Caron-Pargue 1992, Toomela 1999), tetrahedrons and cones (Chen & Cook 1984) are usually analysed in similar terms.

In most cases the drawings of human figures are analysed in a very different language. Perhaps the most commonly used scheme for the analysis of human figure drawings describes the number, proportion and quality of body parts drawn (Goodenough 1926, Harris 1963). Other schemes differentiate scribblings, "tadpoles," where the head is not differentiated from the body, and "conventional figures," which include the main body parts, head, torso, arms, and legs (Cox 1993).

2. General stages in drawing development

2.1. Stages proposed by Luquet

The most influential taxonomy of drawing development was proposed by Luquet (1927). According to him drawing develops over four phases or ages. First scribblings or **involuntary designs** are followed by **fortuitous realism**, after that **intellectual realism** develops, and finally drawings are characterised by **visual realism**. Progression from one phase to another is not abrupt. The earlier phases, especially intellectual realism, do not entirely disappear after the next phase has begun. In the last decades Luquet's taxonomy, especially the transition from intellectual to visual realism has been extensively studied. The studies have shown that the strong form of the proposition according to which young children "draw what they know", whereas older children and adults "draw what they see", does not hold. Even quite young children have the capacity for view-specific "what they see" drawing. Nevertheless, the differentiation of intellectual and visual realism is not entirely wrong. There is at least a shift in emphasis from one kind of depiction to another (e.g., Cox 1992, 1993). The age-related shifts in drawing style from intellectual realism to visual realism are a function of growth in awareness of the distinction between an object and its visual presentation. Children acquire the understanding of what to change and what to ignore in visual input for creating a "visually realistic" drawing (Reith, 1988, 1990).

2.2. Problems with Luquet's approach: drawings of a cube

Luquet's taxonomy is not sufficient for describing simultaneously the development of drawing a cube and a human figure. It can be proposed that drawings of a cube, where more than three visible faces are depicted, reflect "intellectual realism" whereas drawings with only three depicted faces are "visually realistic". There is, indeed, such a developmental shift in the depiction of a cube. First intentional representational drawings of a cube, however, are single squares (Cox & Perrara 1998, Nicholls & Kennedy 1992, Toomela 1999). Thus, instead of two stages, intellectual and visual realism, at least three stages should be differentiated in the development of the intentional representation of a cube – a single square, which is followed by drawings where more than one face of a cube in visually unrealistic relations between faces is depicted, which, in turn, is followed by a convergent or foreshortened oblique drawing of a cube (Toomela 1999).

2.3. Stages proposed by Willats

In the present context it is important that Luquet's taxonomy does not differentiate wholistic drawings from drawings where faces or regions of a model are denoted. These kinds of drawings are differentiated in the version of the developmental taxonomy of drawings proposed by Willats. According to him drawing development can be understood in terms of projection systems and denotation systems (Willats 1992, 1995 1997). Willats recognises that projection systems cannot readily be used to describe children's drawings of smooth objects, like people. He proposed that drawing development, at the most fundamental level, can best be described in terms of changes in the denotation systems that children use. In the first stage of representational drawings, children use a system in which regions stand for whole volumes. In the next main stage, children use regions to denote either the faces of objects or regions in the visual field. In that stage relationships between faces or regions in drawings are not visually realistic because the regions, that denote true faces of a model, will not join up properly. In the final stage children change to a system in which lines are used to denote views of edges (viewer-centred descriptions that correspond to the projections of edges in the visual field) and contours. That denotation system allows children to create convergent or oblique perspective drawings.

2.4. Problems with Willats' approach

Willats' taxonomy misses a point made by Luquet and several other authors (Gardner 1980, Milbrath 1998) – drawings of young children often do not refer to any particular object but to a generic type, a prototype. According to these authors, human figures, dogs, trains, planes, suns, and stars stand for the entire class or represent an ideal type, instead of depicting particulars. Cox and Moore (1994), for example, studied human figure drawings in different conditions. After asking children to draw from imagination they presented a doll as a model. Front views of a doll drawn by tadpole drawers did not differ from their figures drawn from imagination. Many of the conventional drawers, however, depicted a doll's spiky hair, distinctive necktie or hook-like hands. These findings suggest that instead of "Bob", tadpole-drawers depicted a prototypical doll or a prototypical human figure. Older children, however, drew the particular model presented to them.

In addition, Willats' taxonomy does not take into account many findings, which suggest that after children start to draw particular models or "exemplars", their drawings are still influenced by the internal model. Even though a particular model is drawn, a drawing is "intellectually realistic" – more information is depicted than can be seen from a given vantage point. Children, for example, may make a drawing of a cup showing its handle even though the real cup's handle is not visible to them (Davis 1984, Lewis et al. 1993). Children also draw more than two faces of a cube, which is presented so that only two faces are visible (Cox 1986). Sometimes children use more than three colours when colouring a cube even though only three faces of a cube, each with a different colour, can be seen from a given vantage point (Moore 1986). In sum, Willats' taxonomy of denotation systems does not explain why younger children depict more than can be seen from a given vantage point.

Comparison of Luquet's and Willats' taxonomies indicates that they may be complementary rather than mutually exclusive. Luquet's taxonomy describes development in the content – what exactly is drawn – of the drawing. Willats, in turn, describes development of denotation systems, that is, how the content is drawn.

3. Hypothesised stages of drawing a cube and a human figure (a doll)

We propose that drawing development of the two models as different as a doll and a cube can be described as a stage-like progression defined in two lines of development, from prototypical categorical representations to exemplars, and from wholistic drawings to the depiction of lines, which denote edges and contours.

Before going further, the meaning of the notion of "visual realism", as understood in the following theoretical analysis, should be clarified. In many studies, including those cited above, the authors have not defined "visual realism" with sufficient precision. Costall (1995) has found five different ways in which the "visual realism" is operationalized: (1) The drawing excludes a certain occluded detail; (2) The drawing excludes all hidden surfaces and features; (3) The drawing is in "informal perspective" where perspective convergence is used inconsistently; (4) The drawing is in consistent linear perspective, but the projection does not conform to the actual station point of the artist; (5) The drawing is in accurate linear perspective.

For us "visual realism" includes the following characteristics: (a) the drawing represents an exemplar, a particular model rather than a prototype; (b) the drawing is vantage-point specific, only those surfaces and features are depicted that can be seen from a certain point; (c) either linear or parallel projection perspective is used. So, for us, the accurate linear perspective is not necessarily used for creating a "visually realistic" picture. The main reason why we do not constrain visual realism to the "optically correct" linear perspective is that vision is guided both by "bottom-up" and "top-down" mechanisms (e.g., Coren et al. 1994, Hoffmann 1983, Todd & Reichel 1989). If "bottom-up", i.e., data-driven mechanisms were involved in perception, only the accurate linear perspective drawings would be "visually realistic". But visual processing involves also "top-down" mechanisms that exploit knowledge of the specific problem being solved (visual search and object identification, for example). That explains why, for example, in some cases observers accept parallel projections, which are not produced with polar projective geometry, as accurate representations of 3-dimensional objects (Nicholls & Kennedy 1993). Even more, within a certain range of circumstances a divergent perspective may be as perceptually legitimate an experience as convergent perspective (Deregowski & Parker 1992). So, in addition to purely optical characteristics of the visual array, the notion of "visual realism" includes a subjective component.

We also differentiate "visual exemplar" and "intellectual exemplar" drawings. With those notions we refer only to the content of drawings. "Visual exemplar" drawings are not necessarily "visually realistic". Visual exemplar drawings are drawings of specific exemplars where only those attributes are drawn that can be seen from a specific vantage point. "Intellectual exemplar" drawings depict specific exemplars but include more information than can be seen from a specific vantage point. Both "visual exemplar" and "intellectual exemplar" drawings are not necessarily related to any particular projection system.

If the two lines of drawing development, that of content (what is drawn) and that of denotation systems (how the content is drawn), were independent from one another we should find nine types of drawings. Three general kinds of denotation systems should be combined independently with “prototypical”, “intellectual exemplar” and “visual exemplar” drawings. It is more likely, however, that not all possible combinations of drawings can be found. This proposition can be supported by theoretical and empirical considerations. First, it is important that the development of denotation systems is related to the development of projection systems: only the last of the three stages in denotation systems development allows creation of oblique projection or perspective drawings, whereas the two earlier stages may result in drawings which do not fit with any of the possible projection systems (Willats 1997). In the content line of drawing development the “prototypical” and “intellectual exemplar” drawings may both include attributes of the models, which cannot be seen from one vantage point. Drawings in oblique projection and perspective projection systems, however, must be viewpoint specific by definition. Thus, we can expect the last stage of denotation systems development to be related only to the last stage of content development where “visual exemplars” are drawn. This prediction, of course, needs to be empirically supported because “visual exemplars”, by our definition, are not necessarily related to the utilisation of a specific projection system.

Second, some empirical findings suggest that “intellectually realistic” drawings may also be related to the specific denotation system. Cox and Moore (1994), for example, found that many 4-year-old children depict model-specific information in their drawings (no information was given whether the exemplar information was “intellectual” or “visual”). The studies of cube drawings, at the same time, indicate that the ability to use regions to denote faces emerges around the same age and about three or four years earlier than the ability to create drawings in oblique projection or perspective projection systems (Toomela 1999), which corresponds to the utilisation of lines to denote edges denotation system in Willats’ scheme. Correspondingly, it is possible that “regions as faces” denotation system is specifically related to “intellectual exemplar” drawings.

Thus, we expect to find four stages of drawings. First, at the **Scribbles** or **Patterns** stage children do not produce recognisable drawings. Instead, the results of children’s attempts to draw an object are marks on a paper that just denote “something there”. There is one problem with differentiating that stage from representational drawings. Sometimes non-representational drawings may take quite regular forms, including squares (Kellogg 1970). A single square may also be a “realistic” representation of a cube. In our study, reported below, all the participants drew two different objects. To take into account the possibility that some regular closed forms, including squares, may actually be “patterns”, we introduced an operational definition of Scribbles or Patterns: A drawing is coded as a Scribble or Pattern when the same form has been used for drawing different objects. We assumed that, whereas a closed form or a square may be a representational drawing of a cube, the other model, a doll, is sufficiently different from a cube to elicit a different drawing if the child were intentionally representing the models.

The next stages of drawing development are representational drawings. The second stage should be characterised by drawings that are both prototypical **and** use a denotation system where round regions are intended to stand for round volumes and the lines and long regions for long volumes. We call this stage **Volume-Prototypes**. In that stage a cube, a single volume that is equally extended in three orthogonal directions, should be represented by a single square. Human figure drawings should include all prototypical drawings where volumes that are more or less equally extended in three dimensions, like a body, are represented with a closed form, whereas volumes where one dimension is significantly more extended than the other (like legs and hands) are represented by single lines (cf. Willats 1992, 1997).

The third stage, which we call **2-D-Exemplars**, comprises drawings of the model, where regions are used to denote either the faces of object volumes or regions in the visual field. So, whereas in the second stage the model is analysed into volumes, in the third stage each of the volumes is analysed further into faces and regions. In principle, we hypothesise that there is a progression in the drawing development from initially relatively undifferentiated to highly differentiated perceptual analysis underlying the drawing. That hypothesis can be supported by the developmental studies of picture analysis. In one study children and adults were asked to find parts within figures. It was found that preschool children are not able to find embedded segments in figures (Kolinsky et al. 1987). It has also been demonstrated that pictorial depth perception, as reflected in the perception of "impossible objects" in line drawings, continues to develop after the age of 7 (Young & Deregowski 1981). Thus, sophisticated "dimension by dimension" visual analysis is a relatively late development.

In the third stage, we expect to find drawings where a volume of a cube is differentiated into parts. Presumably subparts of a drawing represent different faces of a cube with different angular forms. The relationships between subparts should be "visually unrealistic", because there is a tendency to draw outlines of different faces of a cube as "typical contours" in more fronto-parallel plane than on a retinal projection (Deregowski & Dziurawiec 1994, 1996, Dziurawiec & Deregowski 1992). Thus, the result is visually "flat"; the third (depth) dimension is not realistically depicted. The same characteristics should apply to the drawings of a human figure – we expect to find "flat" exemplar drawings of a model. In principle, drawings in the third stage may (but not necessarily do) include attributes of the model that cannot be seen from a given vantage point. The drawing of nonvisible attributes would stem from the "intellectual" nature of exemplar drawings in the content line of drawing development.

The notion of "flatness", as used in the present context, needs clarification. We do not imply with that term that no depth information is or can be given in pictures. First, there is evidence that within-object and between-object spatial information is processed by different perceptual mechanisms (Enns 1992, Humphreys & Riddoch 1994, van Lier et al. 1994). Correspondingly, we assume that mechanisms responsible for representing within-object and between-object depth in drawings may be different. "Flatness" in the context of the present studies refers only to "within-object" characteristics of drawings. Second, we do not expect that no "within-object" depth information is given in drawings. Drawings at the third stage should not correspond to a linear or parallel projection system. Depth can be represented in other projection systems, as "horizontal-oblique projection", for example, as well (Nicholls & Kennedy 1995). In the latter case, however, the drawing is not "visually realistic" in the projection system sense, nor subjectively. A similar subjective kind of "flatness" characterises, for example, older Russian icons. In medieval Russian icons the saints are depicted by utilising not only contours but also "shadows". Still, the resulting figures lack the third, "bulk" or depth, dimension (cf. Brjusova 1995, Smirnova 1970). It should also be mentioned that "flatness" characterises medieval icons and is gradually replaced by figures "with depth" in 19th and 20th century icons (cf. Knjazeva et al. 1994).

Finally, the fourth stage, which we call **3-D-Exemplars**, comprises exemplar drawings of a model, where lines are used to denote edges and contours. In this stage object faces are analysed further so that contour information is differentiated from shape information. Contours can be represented in drawings with lines independently from information about "invariant" characteristics of shape. Both a cube and a human figure should be depicted as exemplars, which are "visually realistic", as defined in the present article. We also expect that only "visual exemplar" drawings can be found in the fourth stage. In other words, the drawings in this stage should be vantage point-specific in both projection system and content aspects.

4. Method

4.1. Participants

There were 989 participants, ranging in age from 2 years to 43 years. The children were observed on a voluntary basis at nine different kindergartens in four towns and six schools in the same towns. The adults (N = 232) were either last-grade students from a high school or university students who got course credits for participating in the study; all were older than 17 years. Participants under 14 years were classified as "children" (N = 757).

The participants were divided into five age periods as differentiated by Toomela (1999) in a study of the development of cube and cylinder drawings: Period 1 (2;0-2;5, years; months), Period 2 (2;6-3;9), Period 3 (3;10-7;11), Period 4 (8;0-13;11), Period 5 (17;1 and above). The male/female ratio was 0.39, 0.36, 0.37, 0.57, and 0.21 for Period 1, Period 2, Period 3, Period 4, and Period 5, respectively. Of 989 participants who drew a doll, 799 drew also a cube. The age and sex distribution of participants in that subgroup did not differ significantly from the whole group. The distribution of participants according to age and drawing type is shown in Table 1.

Table 1. Frequency (Percentage) of Participants Producing Each Drawing Type of a Doll or a Cube at Each Age Level

Age	Doll drawing category				Cube drawing category			
	1	2	3	4	1	2	3	4
2	29	2			30	1		
	(94)	(6)			(97)	(3)		
3	22	23			26	18	1	
	(49)	(51)			(58)	(40)	(2)	
4	3	24	3		4	23	3	
	(10)	(80)	(10)		(13)	(77)	(10)	
5		27	6			29	4	
		(82)	(18)			(88)	(12)	
6		23	19			26	16	
		(55)	(45)			(62)	(38)	
7		19	43			31	31	
		(31)	(69)			(50)	(50)	
8		56	73			32	57	5
		(43)	(57)			(34)	(61)	(5)
9		43	97	1		11	72	19
		(31)	(69)	(.7)		(11)	(71)	(19)
10		2	35			2	32	3
		(5)	(95)			(5)	(87)	(8)
11		5	25				22	8
		(17)	(83)				(73)	(27)
12		14	60			1	27	20
		(19)	(81)			(2)	(56)	(42)
13		17	84	3		1	24	30
		(16)	(81)	(3)		(2)	(44)	(55)
Totals:								
Adult		30	183	18		2	45	143
		(13)	(79)	(8)		(1)	(24)	(75)
Child	54	255	445	4	60	175	289	85
	(7)	(34)	(59)	(.5)	(10)	(29)	(47)	(14)

Note Percentages are in parentheses

4.2. Materials

The stimuli for drawing were a doll and a cube. In this experiment an unusual doll was used. Our goal was to differentiate between prototypical and exemplar drawings. Usual dolls would not be suitable for that purpose. Even though every specific doll has distinct characteristics it would always be possible that a child's attentional capacities are limited and the drawing would be "prototypical" not because a child depicted a prototype but because she or he "forgot" to draw those particular attributes. We used, instead, an unusual doll which had **fewer** attributes than usual dolls: It did not have hair, its hands were not visible because they were covered with a dress, its legs were melted together so that only a mild groove separated the legs (see Figure 1 for a **3-D-Exemplar** drawing of the model). We assumed that if participants drew a prototype, then they should **add** attributes to the drawing. Those attributes must have originated from an internal prototypical model or from internally represented performance routines. The other model was a 2.5 × 2.5 × 2.5 cm yellow cube.

4.3. Procedure

Participants were tested individually. All participants were given a pencil and asked to draw models. Each model was presented separately and a new blank piece of A4 (21 × 29.7 cm) paper was given for every drawing. The order of presenting the models was random. With every model the subjects were asked “to draw exactly this”. The subjects were allowed to draw the model however they wished, but they were not allowed to change its orientation. The doll was presented standing and facing the participant; the cube was placed on the table so that the top and two sides of the cube were visible to the participant. The viewing distance for all models was about 50 cm.

4.4. Coding

The drawings of dolls and cubes were coded into one of the four categories (see Figure 1): Category 1 (**Scribbles or Patterns**), Category 2 (**Volume-Prototypes**), Category 3 (**2-D-Exemplars**), and Category 4 (**3-D-Exemplars**). For coders the categories were described as follows. **Scribbles or Patterns**: In this category the models were represented with scribbles or a regular pattern or patterns. In the case of regular patterns the same pattern must have been used for representing different models so that it was not possible to decide which of the patterns refers to which of the models. **Volume-Prototypes**: clearly distinguishable volumes of the model were represented with regions or single lines depending on whether the volume was extending about equally in three dimensions or not; a drawing might include attributes that did not belong to the model. A doll was classified as Volume-Prototype only when one or more “prototypical” attributes, which did not belong to the model, were depicted; a cube was classified as Volume-Prototype, when it was (and the other model was not) represented with a single square. **2-D-Exemplars**: volumes in drawings were differentiated into faces, only actual attributes of the models were represented. More than vantage point specific information might be represented in the drawing. The drawings were not in the oblique or perspective projection, the volumes represented in a drawing seemed to be “flat”, and the depth dimension of a volume was not realistically depicted. **3-D-Exemplars**: oblique or perspective projection drawings of the specific model. The drawing was “visually realistic”.

It should be remembered here that the coding of cube drawings allowed only for characterisation of the denotation systems aspect of drawings. In the case of dolls, however, mainly the content line of development could be described. Fortunately it was possible to characterise drawings of the doll from a denotation systems aspect too. “Lines for contours and edges” denotation system drawings could be differentiated from the two earlier stages of development, even though we did not find an unambiguous way of differentiating the two first stages from one another. So, as an intermediate step, all drawings of a doll were categorised in two aspects: in the content aspect the presence/absence of prototypical attributes was recorded, in the denotation systems aspect the drawings were, independently of the content, coded as utilising or not utilising the lines for the edges and contours denotation system which allows depiction of objects in oblique or perspective projection systems. So, in essence, the differentiating characteristic of the lines for edges and contours denotation system was the oblique or perspective projection system, which, according to Willats, is related to the denotation system. Subjectively, the two earlier denotation systems result in drawings that are perceived as "flat".

The coders received the following training. First, the author of the taxonomy characterised the content and denotation systems aspects of drawings, and the four stages of the taxonomy theoretically. After that every one of the coders coded the same 30 drawings randomly selected from the database. Then the coders compared the results of coding with each other, the disagreements were discussed until agreement was found. All further coding was performed by coders independently from one another.

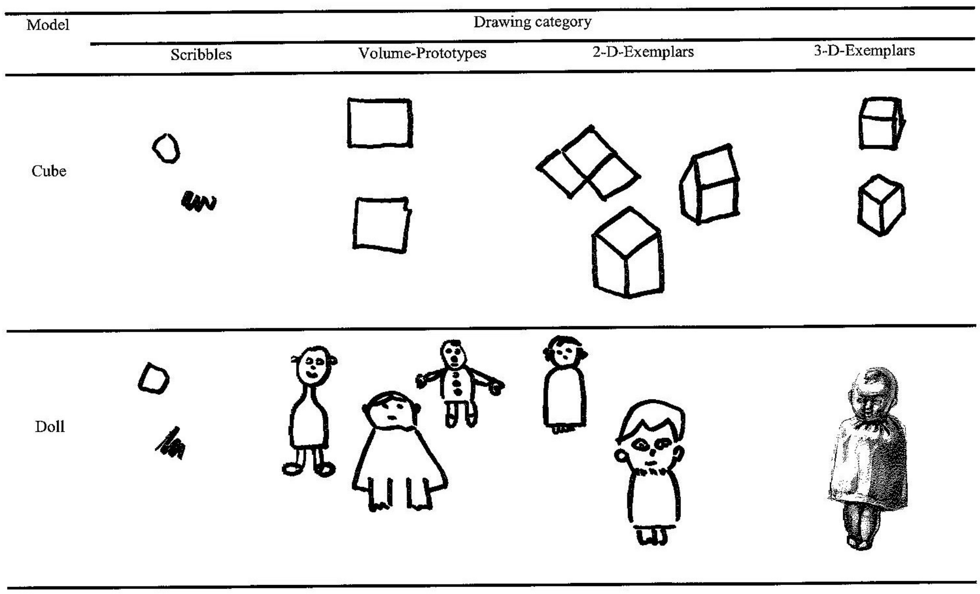

Figure 1. Examples of drawings of a doll and a cube in each category.

The drawings were coded by six assistants and by the author. In addition, 200 randomly selected drawings of a doll and 200 randomly selected drawings of a cube were coded independently by two coders (there were three pairs of coders) for checking the inter-rater reliability. Inter-rater agreement was adjusted for chance, Cohen's $\kappa = 0.93$ for drawings of a doll and Cohen's $\kappa = 0.95$ for drawings of a cube.

5. Results and discussion

5.1. Drawings of a doll

Table 1 presents the percentage of adults and children at each age level producing each type of drawing of a doll, from Categories 1 to 4. Inspection of Table 1 shows a non random distribution. All theoretically higher categories emerged after theoretically lower categories in the proposed order. (The notion of "emergence" is defined here as the earliest age of appearance of a drawing type. This non-normative definition of the beginning of a stage may reflect participants with exceptional abilities. It is a very strict requirement for demonstrating that stages appear in a certain order.) Comparison of coding in the content and denotation system perspective revealed that the children never drew Prototypes with realistically depicted depth, all prototypical drawings were "flat".

Toomela (1999) differentiated in a study of a cube drawing development four categories of cube drawings, Scribbles, Single Units (single square, which stands for a whole cube), Differentiated Figures (more than one face of a cube is depicted but relations between faces are visually unrealistic), and Integrated Wholes (visually realistic depiction of a cube). These categories are in agreement with the stages proposed by Willats. Toomela found that the four categories fit into a stage-like scheme, where theoretically less developed categories always emerged before theoretically more developed categories. The youngest children (age range 2;0-2;5) drew only Scribbles. First Single Units emerged after the age of 2 years 5 months, Differentiated Figures after the age of 3 years 9 months, and Integrated Wholes after the age of 7 years.

If the developmental taxonomy of drawings, we propose, can be used for the description of drawing development of angular (cube) and smooth (doll) models, we should expect that the drawings of a doll fit into the same age periods as proposed by Toomela for the development of a cube drawing. Correspondingly, we classified participants into five age periods as described above. We constructed a 5 by 4 (Age Period by Drawing Category) table. There were zeros in several cells; when in cross-tabulations one or more cells include less than five observations, a usual chi-square analysis may give false estimations of the probability. To avoid that problem we conducted a Configurational Frequency Analysis (CFA, von Eye 1990). CFA compares the observed and expected frequencies in a cross-tabulation for every cell in a table. The results of the analysis reveal "Types" (observed frequency is significantly higher than expected frequency) and "Antitypes" (observed frequency is significantly lower than expected frequency). An exact test for the comparison of observed frequency with expected frequency is the binomial test. Because it makes no assumptions concerning underlying distributional parameters, the binomial test is conservative. The analysis was performed with the program SLEIPNER 2.0 (Bergman & El-Khouri 1998). The results of the CFA, observed frequencies, expected frequencies, and p – values are shown in Table 2.

Table 2. Number of Observations, Expected Frequencies, and *P* –Values at Each Age Period and Doll Drawing Category

Age Period	Drawing category*				
	1	2	3	4	N
1	**5**	0	0	0	5
(2;0-2;5)	**.27**	1.44	3.17	.11	
	<.001	n.s.	n.s.	n.s.	
2	**45**	18	*0*	0	63
(2;6-3;9)	**3.44**	18.15	*40.00*	1.40	
	<.001	n.s.	*<.002*	n.s.	
3	4	**100**	*71*	0	175
(3;10-7;11)	9.55	**50.43**	*111.12*	3.89	
	n.s.	**<.001**	*<.001*	n.s.	
4	*0*	137	**373**	4	514
(8;0-13;11)	*28.06*	148.12	**326.38**	11.43	
	<.001	n.s.	**<.02**	n.s.	
5	*0*	*30*	**184**	**18**	232
(17;1 +)	*12.67*	*66.85*	**147.32**	**5.16**	
	<.001	*<.001*	**<.02**	**<.001**	
Total	54	285	628	22	989

Note. – Observed frequencies, Expected frequencies, p – level, in every cell
Types are in bold and *Antitypes* in italics.
* Alpha levels are adjusted with Bonferroni's procedure

The results of the CFA demonstrate that the observed frequencies of drawing categories follow the theoretically expected pattern, a pattern very unlikely to have been obtained by chance. The emergence of new categories of drawings follows a clear pattern: first a higher order category is antitypical or neither typical nor antitypical; at the next age period the category that emerged in the previous period becomes typical. Categories 1 and 2 become antitypical in the adult group. Overall the results are similar to those obtained by Toomela (1999) in a study of cube drawing development with one exception: Category 3 became Antitypical in adults who drew a cube, but it remained Typical in drawings of a doll.

Our results are in agreement with the idea that four stages – Scribbles or Patterns, Volume-Prototypes, 2-D-Exemplars, and 3-D-Exemplars – emerge in ontogenesis in a fixed order. We assumed that, for differentiating stages, theoretically higher stages in the hierarchy must not emerge before or at the same time as theoretically lower stages. Our results for dolls provide substantial evidence for all major stages of development according to this criterion. Children younger than 2 years 6 months drew only Scribbles or Patterns. The next stage, Volume-Prototypes, emerged first only after that age. In that stage children always drew **more** attributes of a doll when compared with the model. 2-D-Exemplars emerged approximately one year after the emergence of Volume-Prototypes. In that stage participants drew only attributes that also characterised the model, but their drawings were "flat", depth of the model was not realistically depicted in the drawing. Finally, no children below the age of 8 years drew 3-D-Exemplars. In addition, participants who drew Prototypes, never depicted depth in their drawings visually realistically, all such drawings of a doll were “flat”.

In sum, there is evidence for a shift in drawing performance from drawings that are derived from internal, prototypical models to drawings of particular exemplars. That result is in agreement with several authors (Gardner 1980, Luquet 1927, Milbrath 1998). There is also evidence for a shift from “visually unrealistic” to “visually realistic” depiction of depth in exemplar drawings. Such a shift is in agreement with the taxonomy of drawings proposed by Willats (1997) and can be explained by children’s tendency to depict “typical contours” of the model being more in a fronto-parallel plane as compared to a given vantage point (cf. Deregowski & Dziurawiec 1994, 1996, Dziurawiec & Deregowski 1992).

There is no sufficient evidence, however, for the proposition that children used in prototypical drawings of a doll a denotation system where regions stand for whole volumes. It might be possible that children depicted different parts of a body in a “volumetric” way. But there is also a possibility that children used regions to denote either the faces of objects or regions in the visual field (the second stage in Willats’ taxonomy). Depiction of volumes cannot be easily differentiated from a depiction of regions in human figure drawings. To solve that problem we compared drawings of a doll with drawings of a cube. A cube has only one volume but several regions. If children used a “volumetric” denotation system in drawing prototypical dolls, then the same children should draw a cube as a single square. In the next stage, where exemplar drawings emerge, drawings of a cube should be differentiated into regions or faces and more than one face should be depicted. In addition, we also took into account the possibility that content and denotation systems line of development are mutually independent, and are correlated only because both develop with age. Consequently, we expected to find that the relationship between drawing categories for both models is independent of age.

5.2. Drawings of a doll and a cube

Eighty percent of the participants who drew a doll also drew a cube. Data about these participants allow us to determine whether a prototype-to-exemplar shift in children’s drawings is accompanied by a shift from the utilisation of a “volumetric” to the utilisation of a “region and faces” denotation system. In other words, drawings of different models should be “congruent”, that is, they should belong to the same category or stage. Not all drawings, however, should be “congruent”. In “non-congruent” cases we expect the drawings of a cube to be in a higher category than the drawings of a doll because a cube is visually much less complex than a doll. A cube has only one volume with six (three from a specific vantage point) faces with clear contours. The doll used in our study could be differentiated into three volumes (a head, a body, legs), each of the volumes can visually be differentiated into subregions which have less clear contours when compared with the faces of a cube (eyes, nose, mouth, ears in the head volume;

creases of a dress in the body volume; a groove distinguishing legs from one another and legs from feet in the legs volume).

We created a 4 by 4 (Category of Doll Drawing by Category of Cube Drawing) table and analysed the data with CFA. Results of CFA are presented in Table 3. As can be seen from Table 3, the observed frequency of congruent drawings is significantly higher than would be expected by chance. At the same time, the observed frequency in 6 out of 12 non-congruent combinations were significantly lower than expected by chance. It is noteworthy that one non-congruent combination, where the cube drawing belongs to Category 4 and the doll drawing belongs to Category 3, is typical. Despite that the overall number of congruent cases was significantly higher than the number of non-congruent cases (binomial $z = 2.58$; $p = 0.01$)

Table 3. Number of Observations, Expected Frequencies, and P-Values According to Category of Doll and Cube Drawing

Cube drawing category	Doll drawing category*				
	1	2	3	4	N
1	**51**	9	*0*	0	60
	4.06	17.05	*37.99*	.90	
	<.001	n.s.	*<.001*	n.s.	
2	*3*	**118**	*56*	0	177
	11.96	**50.29**	*112.09*	2.66	
	<.04	**<.001**	*<.001*	n.s.	
3	*0*	79	**255**	0	334
	22.57	94.83	**211.52**	5.02	
	<.001	n.s.	**<.007**	n.s.	
4	*0*	*21*	**195**	**12**	228
	15.41	*64.78*	**144.39**	**3.43**	
	<.001	*<.001*	**<.001**	**<.004**	
N	54	227	506	12	799

Types are in bold and *Antitypes* in italics.
* Alpha levels are adjusted with Bonferroni's procedure

Next, the analysis revealed that it is easier to draw a cube than a doll. There were 363 non-congruent combinations. In 298 (82.1%) cases the category of a cube drawing was higher than the category of a doll drawing. The number of cases in which the cube category was higher than the doll category is significantly higher than the number of cases in which the doll category is higher than the cube category (binomial $z = 12.23$; $p < 0.001$).

In sum, the results of the comparison of doll and cube drawings were as predicted. Drawings of both a doll and a cube were "congruent", that is, in the same category, significantly more often than would be expected by chance. Particularly, children who drew prototypical dolls drew almost always a cube as a single square, and participants who represented a doll with a 2-D-Exemplar drawing differentiated faces of a cube in their drawings. Thus, our empirical findings are in agreement with the idea that children who draw prototypical dolls use a "volumetric" denotation system and children who draw 2-D-Exemplar kind of dolls use a "region and faces" denotation system. We also found that in "non-congruent" cases drawings of a cube are usually in a higher category than drawings of a doll. This result fits with the idea that it is easier to draw a cube than a doll.

We assume that correspondence between drawing categories for the two models is caused by the same mechanism that underlies both the content and the denotation systems line of drawing development. There is, however, a possibility that the two lines of development are not related through one underlying mechanism. Rather, it is possible that the two scales are related only through age. To test that possibility we estimated the correlation between drawing scores in the model where the effect of age was directly taken into account. We conducted a path analysis with the model where age was supposed to have a "causal" effect on the drawing of a doll and the drawing of a cube. The drawing scores were allowed to correlate. Drawing scores were treated as ordered polytomous variables. The model was analysed and the weighted least square parameter estimates with robust standard errors of the model were generated with Mplus 1.0 (Muthen & Muthen, 1998). The initial model did not converge. The most common reason for such a problem is that some levels of the categories are relatively infrequent. The inspection of the data revealed that, indeed, the Category 4 (3-D-Exemplars) of doll drawings comprised only 1.5% of the observations. We took three different approaches to overcome that obstacle. First, we conducted an analysis where Category 4 and Category 3 drawings of a doll were collapsed. The analysis revealed that drawings of both models were significantly influenced by age. The parameter estimate and robust standard error for the effect of age on a drawing of a doll were 0.189 and 0.006, respectively, and for a drawing of a cube 0.136 and 0.007, respectively. Both effects are statistically highly significant ($p < .0001$). The estimated relationship between two drawing scores was highly significant as well (parameter estimate = 0.627; robust standard error = .030; $p < .0001$). Thus, the two drawing scores are significantly correlated independently of age. The second approach, where we deleted the 12 cases who created a Category 4 drawing of a doll from a database and analysed the remaining 787 cases, and the third approach where we treated drawing scores as continuous and generated the Maximum Likelihood parameter estimates, led to similar results: both drawing scores are significantly affected by age and correlated significantly when the effect of age is directly taken into account in the model. Thus, we can conclude that the correspondence between drawing scores of different models is not caused only by age. It is noteworthy that the statistical analysis that supports this conclusion is very conservative because the hypothetical common mechanism that relates the content and denotation system aspects of drawings develops with age too.

6. General discussion and summary

Our aim was to find a taxonomy for describing developmental changes in drawing models as different as a human figure (or a doll) and a cube. We proposed that drawing development should be simultaneously described in two lines, that of content or what is represented in the drawing, and that of a denotation system or how the content is represented. We also hypothesised that these two dimensions are not independent. So, theoretically, four stages of drawing development were proposed: **Scribbles and Patterns**, **Volume-Prototypes**, **2-D- Exemplars**, and **3-D-Exemplars**.

The results of our studies confirm that content and denotation systems aspects can be distinguished in drawing development and that these aspects are not independent. First, children never depicted a specific model of the doll before the age of 3 years and 10 months. We used a specific doll whose hands were not visible, it did not have any hair and its legs were melted together. Young children, however, drew two separate legs, added hands and hair, sometimes even patterns to the dress and so forth. There may be many reasons why children omit some parts or attributes from their drawings: they may lack drawing skill, they may forget to draw some parts, they may have problems with planning of the drawing so that there would be no room for drawing all parts, they may find a simpler drawing "good enough" (Cox 1992). There are, however, many fewer sources from where **more** attributes could be taken. We suggest that drawings of young children are derived from internal prototypical mental representation rather than from the external model.

Next, we also found evidence for the development in the line of denotation systems. In the drawings of a doll, visually realistic depiction of depth was a very late development and never appeared before the age of nine years. We were not able to achieve an unambiguous definition of drawing categories to differentiate between "volumetric" and "regions and faces" denotation systems in the drawings of a doll because the doll had both several volumes (head, body, legs) and several faces and regions. So, we were not able to decide, for example, whether a round region in drawing represents a volume of the head or only the face. All three denotation systems were clearly differentiated in the drawings of a cube: the "regions and faces" system emerged after the "volumetric" system but before the "edges and contours" denotation system (see also Nicholls & Kennedy 1992, and Toomela 1999, for similar findings).

Finally, there was evidence that the two dimensions, "Luquet's content dimension" and "Willats' denotation dimension", are not independent. Visually realistic depth was never depicted in prototypical drawings of a doll. In addition, there were statistically significantly more children who represented both a cube and a doll with the same category of drawings than could be expected by chance. That relationship persisted when the effect of age was taken into account.

In conclusion, there is more in drawing development than lines, angles or faces in drawings of a cube or "tadpoles" and body parts in drawings of a human figure.

The problem does not lie in the choice of one single correct dimension of description. Many studies have demonstrated that different systems for describing drawings are valid and reliable. If our goal is to understand drawing development in general, then descriptive systems found useful with some specific models should be applied to drawings of very different models. We presented evidence that different descriptive systems can be joined into one taxonomy and that drawing development proceeds over the same sequence of changes independently of the model to be drawn.

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