Educação & realidade

Production and Recognition of Linguistic and Numerical Notations by Children

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ABSTRACT – Production and Recognition of Linguistic and Numerical Notations by Children. Alphabetic and numeric notation systems exhibit distinct properties, which require children's ability to produce and recognize their own graphic marks. This quasi-experimental study investigated the notation knowledge of children (4–6 years old) through tasks of production and recognition of notations in the linguistic and numeric domains. The data revealed that, beginning at the age of four, children differentiated letters and numbers and adopted conventional notations appropriate to each domain, even while still using drawings. A comparison between ages showed differences in performance only in the production task. Conclusions suggest that the ability to recognize notations precedes the ability to produce them.
Keywords: **Notation Knowledge. Letter. Number. Representation. Children.**

RESUMO – Produção e Reconhecimento de Notações Linguísticas e Numéricas por Crianças. Os sistemas notacionais alfabético e numérico possuem propriedades distintas, exigindo das crianças a capacidade de produzir e reconhecer as marcas gráficas que lhe são próprias. Este estudo de desenho quase-experimental investigou o conhecimento notacional de crianças (4 a 6 anos) por meio de tarefas de produção e reconhecimento de notações dos domínios linguístico e numérico. Os dados revelaram que, desde os 4 anos, as crianças diferenciavam letras e números e adotavam notações convencionais apropriadas a cada domínio, mesmo ainda utilizando desenhos. A comparação entre idades evidenciou diferenças no desempenho apenas na tarefa de produção. Conclusões sugerem que a capacidade de reconhecer notações antecede a capacidade de produzi-las.
Palavras-chave: **Conhecimento Notacional. Letra. Número. Representação. Crianças.**

Introduction

Notations are forms of representation that refer to graphic records; their use and creation are exclusive capabilities of *Homo Sapiens* and not observed in other species. Since prehistory, even the most isolated peoples produced a wide variety of notations: paintings, drawings, marks to represent paths, quantities, etc. Tolchinsky (1993, p. 111) defines notational capability as associated with the use of "tools to leave permanent marks of intentional acts".

According to Munn (1998), there are three types of notational signs: (i) those that have a direct relationship with what they indicate, such as footprints that reveal the presence or passage of someone, (ii) those that physically resemble what is referred to as drawings of objects, and (iii) the more complex ones such as those representing sounds and ideas, as is the case of linguistic and numerical notational systems. In this article, notational knowledge is examined from this third perspective, focusing on children's ability to recognize and produce notations specific to the linguistic and numerical domains.

Many historians consider the emergence of writing a milestone in the evolution of civilizations. Cave paintings were man's first attempts to record the events around him (Morais, 1997). In this way, pictographic writing emerged, consisting of marks similar to the objects they represented. Ideographic writing, another advance in the notational system, consisted of marks that moved away from the physical appearance of objects to get closer to the ideas they conveyed. Even so, it was not possible to communicate efficiently, resulting in the need to record oral language, in this case, the sounds of speech. The sounds emitted when speaking then began to be recorded through graphic marks, as occurs in the syllabic and alphabetic systems, giving users the possibility of recording and communicating complex ideas and abstract situations.

As for the numerical system, its creation resulted from the need to understand and have some control over nature, such as forming sets, identifying patterns and sequences, and counting (Boyer; Merzbach, 2019). Even using different material resources, there was the challenge of developing a system that used the smallest number of symbols possible and that allowed large quantities to be recorded. This need gave rise to numerical symbols and different numbering systems that were modified over time, taking different paths until they reached the systems that exist today.

The alphabetic and numeric systems have their own characteristics. For example, while in the alphabetic system, a graphic sign corresponds to a phoneme (sound made when speaking), in the numerical system, a sign represents an idea (quantity, identity, order). In numerical notation, any combination is possible, including repetition and variation in the number of graphic marks (examples: 122, 333). In linguistic notation in the Portuguese language, although the repetition of marks is possible, it is rare (for example: voo). The number can be used as an isolated graphic mark, while the letter, in the vast majority of

cases, loses its meaning when used in isolation (Tolchinsky, 1993). Despite these differences, numbers and letters have similar visual aspects, since in both systems graphic marks are made up of straight and curved lines, continuous and discontinuous curves, and right and oblique angles (e.g., A, 4, E, 3, L, 7, B, 8). Furthermore, letters and numbers can be associated in their uses, as is the possibility to record a given quantity through a number (3, 15) or a word (three, fifteen). This possibility generates conflict among children when they discover that numbers can also be read (Teberosky and Tolchinsky, 1997; Tiggemann, 2010).

There is much research on children on notations, whether about the ability to produce them or the ability to recognize them, which requires differentiating and moving between different types of representation. Some of them focus exclusively on the linguistic domain, others on the numerical domain, while others seek to examine these two domains in the same investigation. Some of these studies, and their results, are briefly described below.

Research on notations in the linguistic domain

The development of the ability to differentiate drawing and letters has been investigated in several studies (e.g., Karmiloff-Smith, 1992; Brenneman et al., 1996; Adi-Japha and Freeman, 2001). Karmiloff-Smith (1994) observed that pre-literacy children produce distinct graphic marks when asked to write the word "spoon" and to draw the object "spoon." Brenneman et al. (1996) found that, when pretending to write, children produce marks with interruptions, and when drawing, they make continuous and curved marks. These studies show that from an early age, albeit in an elementary way, children tend to differentiate between drawing and writing and use different graphic marks for each of these notations.

In a study with Greek preschool children, Yannicopoulou (2006) examined the ability to differentiate letters in different writing systems: the Latin and Greek alphabets. The results showed that even before being formally taught about writing, participants differentiated between notations in the two systems. The main conclusion was that children who live in multilingual contexts, as is the case with Greek children, can benefit from exposure to different writing systems and can distinguish letters from one system from another.

In terms of spontaneous written production, Munn (1998), based on a series of research, comments that emerging literacy schemes generally follow some stages, progressively starting from drawing, to scribbled writing, then to letters that look like words, writing that resembles syllables and, finally, writing that consists of letters that represent sounds. Amid attempts to transmit or record information, children gradually improve their notational knowledge.

Ferreiro (1990) and Ferreiro and Teberosky (1999) found that since the preschool period, children have attempted to produce lines, different from drawings, with a varied graphic appearance, which they refer to as letters or numbers. When interacting with different graphic

marks in their daily lives, children develop their own hypotheses about the alphabetic system. Many of these hypotheses are mistaken, for example, the concept that to be considered a word, a graphic must have many letters (quantitative criterion), and these cannot be repeated and must have some variation (qualitative criterion). In this case, it is common to see children assert that the word "egg" cannot be a word since it does not meet these two criteria. Another misconception is the idea that words resemble the physical appearance of the objects they represent, so that big words refer to big things and small words to small things, a notion called by Piaget (1926) nominal realism, which leads children to believe that the word "train" is bigger than the word "telephone," and that the word "orange" is similar to the word "ball" because both are round (Carraher; Rego, 1981).

Research on notations in the numerical domain

According to Hurst, Anderson and Cordes (2017), the numerical system materializes through three types of representation: recorded quantities, numerical words, and digits. These types of representation are necessary for the individual to effectively communicate in a society like ours, where letters and numbers are part of everyday life. The authors use the expression "numerical communication" to highlight the relevance of this knowledge and its acquisition by children from an early age. Based on this premise, several studies investigated how children between two and five years of age developed the ability to move between these three types of numerical representation (e.g., Benoit et al., 2013; Hurst, Anderson; Cordes, 2017; Lira et al., 2017; Marinova; Reynvoet; Sasanguie, 2021).

Benoit et al. (2013) examined how children move from one numerical representation to another, and observed that: (i) at three years of age, they can move from representing arrangements to numerical words, but have difficulty moving from arrangements to digits; and (ii) at four years of age, they are equally successful in moving from arrays to digits (and vice versa) and in moving from number words to digits (and vice versa); and (iii) at five years of age, they can successfully switch from one representation to another (and vice versa) without difficulties, this being observed not only about small numbers (1 to 3) but also larger numbers (4 to 6). These results indicate that development in dealing with these types of representations begins with the ability to move from number words to arrays, then from digits to arrays, and, finally, from number words to digits. It seems that children do not acquire the representation of digits directly from number words. One explanation for the difficulty in dealing with numerical words is that these representations disappear from working memory as soon as they are spoken, while arrangements and digits are more evident and stable, remaining available for longer.

Marinova, Reynvoet and Sasanguie (2021) investigated how children deal with these forms of representation, associating this knowledge with mathematical activities carried out at home in interac-

tion with their parents. The results of the study corroborated those obtained in previous research, adding the fact that mathematical activities carried out in the family environment played an important role in children's ability to deal with these representations.

In addition to examining how children move between different types of numerical representations, authors have analyzed spontaneously produced notations (e.g., Bialystok; Codd, 1996; Brizuela, 2006; Cañellas; Rassetto, 2013; Hughes, 1986; Sinclair, Siegrist; Sinclair, 1983; Sinclair; Sinclair, 1984). Hughes (1986) and Cañellas and Rassetto (2013), for example, observed that children between three and five years old used different graphic marks to record the quantities of objects. Taken together, the results of these studies showed that the graphics adopted varied, being classified into idiosyncratic representations (without interpretable meaning), pictographic (drawings similar to the objects presented), iconic (symbols suitable for representing the objects), and symbolic-conventional. Idiosyncratic, pictographic, and iconic representations were more frequent among younger children, while conventional notations were more adopted by five-year-olds, concluding that with development, conventional notation starts to be adopted systematically.

Brizuela (2006) describes and discusses examples of children's inventions, meanings of representations, and conceptions about the numerical system. Among the data presented here, it is worth highlighting what was called "capital numbers" by one of the children interviewed, which referred to two-digit numbers and served as a tool to find a pattern in the way these numbers are written. This tool expressed an intuitive understanding of the relevance of the position of the digits in a number. Another relevant fact was the use of punctuation marks to write and read "difficult numbers," in this case, large numbers such as 10,000, as well as to record amounts of money. The author comments that the notations invented by children both reveal knowledge about the properties and functioning of the numerical system and also play an important role in the acquisition of this knowledge.

Research on notations in the linguistic and numerical domain

There is research that examines the knowledge and conceptions of children from the same group of participants about three notational domains: figurative drawing, writing, and numerical notation (e.g., Teubal; Dockrell; Tolchinsky, 2007; Klein; Teubal; Ninio, 2009; Scheuer; Cruz; Iparraguirre, 2010). In general, the results of these investigations show that the production of marks in these three domains begins at different moments in development: the production of drawings that resemble objects precedes the notations that represent linguistic expressions and the notations that represent numerical ideas.

The ability to use and differentiate letters and numbers can be facilitated, according to Tolchinsky (2003) and Yamagata (2007), by the context or activity in which numbers and letters are inserted, since the

child will be able to determine whether a given mark is useful for reading or counting. The ability to distinguish letters and numbers from an early age based on their visual characteristics can contribute to literacy and numeracy so that children can, for example, "read" the price of a product and a word in an advertisement. With experience, the ability to differentiate letters and numbers based on their communicative functions contributes to the understanding that these representation systems have their own characteristics (combination rules, basic characters, and functions) that need to be understood and differentiated by their users.

In terms of development, notational knowledge starts from a global perception and representation, progressively starting to include details and particularities of systems. Ferreiro and Teberosky (1999) point out three moments in the process of discriminating letters and numbers. At first, both are confused due to visual similarities and the fact that the child still does not fully identify the differences between drawing and other graphic marks, such as numbers and letters. Secondly, letters and numbers are differentiated based on their functions; that is, numbers are used for counting and letters for reading. In a third moment, despite being able to make this differentiation, the child becomes confused again when he/she realizes that numbers can also be read. The resolution of this problem occurs when he/she begins to understand that numbers are part of a system other than the alphabetic one, even when written.

Tolchinsky (1997) investigated the ability to differentiate written and numerical notations from other graphics in children aged three to six years. Cards with different combinations of letters and pseudo-letters were presented to participants, who were asked to indicate those that were not suitable for writing. Cards were also presented with different combinations of numbers, with drawings of objects and geometric figures, and children were asked to indicate the cards that were not suitable for counting. The results showed that: (i) combinations in which drawings appeared were rejected by the majority of children, i.e., even before the age of four, there seems to be no doubt regarding the differentiation between drawing and written and numerical graphics; (ii) the unanimous rejection of combinations of letters and numbers on the same card; (iii) the number of letters did not affect the percentage of rejection; and (iv) the repetition of letters was a significant factor in rejection in the writing domain, while the repetition of numbers was accepted in the numerical domain. No differences were detected between ages regarding these results. The conclusion was that young children understand some peculiarities of both notational systems.

In this same work and with the same participants, Tolchinsky (1997) analyzed the production of notations. Pairs of cards were presented, some with pictures of the same object in different quantities (two wheels and five wheels) and others with different objects in the same quantity (three cars and three wheels). Each child was asked to place pairs of cards in envelopes and fill out labels corresponding to each card so that, by looking at the labels, it was possible to know which

and how many objects were inside each envelope. Letters or words were expected to be used to represent the names of objects, and numbers to represent quantities. In general, participants produced distinct marks to record the names of objects and quantities. However, even those who knew how to draw some letters and some numbers tended to use drawings. According to the author, these children possibly believed that using only letters and numbers would not be enough to represent, thus resorting to more explicit elements such as drawings. The conclusion was that there is no hierarchy in the sense that drawing is the most basic form of representation, since children can use different types of notation without one systematically replacing the other.

Dockrell and Teubal (2007) asked children aged three to five to produce notations to communicate numerical and linguistic information. The task consisted of filling out an "identity card" containing questions about personal data to be provided in writing by the participants. Some questions involved information that required linguistic graphics (What is your name? What color is your hair?), and others required numerical graphics (How old are you? How tall are you?). Graphics similar to letters were more commonly used when questions involved linguistic notations. Notations similar to letters were used more frequently to represent responses with numerical content than the opposite. This demonstrates that children in this age group realize that words can represent numbers, but numbers are not used to represent words. The authors also verified that drawings and other graphics are not abandoned even with advancing age, since they coexist with symbolic graphics such as words and numbers. This result reiterates what was observed by Tolchinsky (1997).

The production of linguistic and numerical notations was investigated by Sousa, Silva and Spinillo (2021) to examine whether children aged four to six would be able to distinguish these notational domains and whether there would be differences depending on the age of the participants. The task presented to participants was an adaptation of that adopted by Dockrell and Teubal (2007) in which the child was asked to fill out an "identity card" with questions about personal data that involved writing words (name, hair color, and food preferred) and numbers (age, height, weight). Due to the COVID-19 pandemic, the task was applied remotely, so the changes made sought to adapt the original task from an in-person format to a remote format.

The notations produced were classified into iconic/pictographic, use of letters, use of numbers, and hybrid notations in which more than one graphic representation was used. Age did not have a determining effect on the use of types of notations since participants tended to use numbers in the identity card items relating to the numerical domain and letters in items relating to the linguistic domain. The effect of age was only observed on the use of iconic/pictographic representations, which decreased with advancing age. The data also showed that using these representations was more frequent in the linguistic domain than in the numerical domain. The main conclusion was that from an early age, children differentiate between notations in these two domains,

and that the linguistic domain seems to encourage the use of iconic/pictographic marks more than the numerical domain. The explanation for this lies in that the numerical system involves fewer characters than the alphabetic system, which makes it easier to memorize and use numbers, reducing the possibility of using other marks. Furthermore, writing words can more easily refer to visual aspects than numbers, which refer to more abstract aspects.

Dockrell and Teubal (2007) comment that notational knowledge has usually been examined through production tasks and recognition tasks. Production tasks explore linguistic and numerical notations considering their respective contexts of use, i.e., the ability to associate a given graphic mark with a given communicative situation. Recognition tasks, in turn, focus on the ability to identify and distinguish the visual characteristics of graphic marks specific to one or another domain. From the point of view of someone who performs one or another type of task, it is possible to state that production tasks require the individual to carry out actions and procedures, and recognition tasks require the individual to make judgments about a given situation or stimulus presented to them. These considerations regarding the methodological resources adopted in research evidence that different tasks evaluate different facets of the same phenomenon. Thus, notational knowledge can be investigated by combining different methodological resources that make it possible to obtain distinct but complementary information about this phenomenon. This seems to be particularly important when notational knowledge involves distinct domains, such as linguistic and numerical.

Based on these considerations, the present study examined notational knowledge in the linguistic and numerical domains in the same group of participants through two tasks: one of production and one of recognition. Through the combination of different methodological resources (produce and recognize), the study aimed to investigate whether there were differences between these domains in terms of children's ability to produce and recognize notations or whether the pattern of results would be the same in both domains. Additionally, we sought to examine whether it would be easier to produce or recognize notations and the role of age in this process. In this way, we sought to expand the data obtained by Sousa, Silva and Spinillo (2021), which dealt exclusively with the production of linguistic and numerical notations.

Method

This research was characterized as a quasi-experimental cross-sectional study that investigated groups of children of different ages and school years. Their participation was not random, but rather convenient, due to the availability of the necessary materials and conditions to conduct the interviews. According to Dutra and Reis (2016), quasi-experimental studies are so named because maintaining experimental control through randomization and the application of the in-

tervention is not always possible. The independent variables were participants' age and education level, as well as the two types of tasks they performed.

Participants

Fifty-one children of both sexes, students from public and private schools, were equally divided into three groups: 17 children aged 4, students in the 1st grade of Early Childhood Education (average age: 4 years and 7 months); 17 children aged 5, students in 2nd grade of Early Childhood Education (average age: 5 years and 6 months); and 17 children aged 6 years, students in the 1st grade of Elementary School (average age: 6 years and 5 months).

As an inclusion criterion, in addition to age and school year, only children whose parents or guardians signed the Informed Consent[1] and who did not present sensory or intellectual limitations or any neurodevelopmental disorder, as informed by the parents or guardians. The sample was selected by convenience, depending on the availability of the children and their parents or guardians, and the fact that they had access to the internet, a computer, or a cell phone with a camera, since data collection was carried out remotely via video call. Participant recruitment occurred through publicity on social networks, an informative poster about the research, and the snowball technique, in which participants indicated other potential participants to the investigated population (see Dewes, 2013). In this case, parents or guardians nominated other possible participants. Remote collection made it possible to recruit children from different states in Brazil.

Material and procedure

Two tasks were individually presented to each participant in a single session with free time, lasting a maximum of 30 minutes. Initially, the Notation Production Task was applied, and then the Notation Recognition Task. This order of presentation was used to prevent the graphic marks presented in the Recognition Task from influencing the spontaneous productions made by participants in the Production Task.

Due to the health restrictions imposed by COVID-19, the research was carried out remotely via video call using the Google Meet platform. The calls were recorded to store the content of the sessions in protocols relating to each participant. During the entire session, the adult responsible for the participant was present, monitoring the implementation of the two tasks, helping the child with the management of electronic resources, and was instructed not to interfere during the performance of the tasks.

Notation Production Task

The task was exactly the one used by Sousa, Silva and Spinillo (2021), which, in turn, was an adaptation of the one originally proposed by Dockrell and Teubal (2007). The objective was to examine the production of notations to communicate information involving numbers

and words, with the participant individually being asked to record on a sheet of paper their answers to six questions that dealt with personal data. The material provided consisted of an A4 sheet of paper, a pencil, and an eraser.

In a general and summarized way, the following instruction was given: "I will need some information from you. I need you to record on the sheets of paper that you have with you the answers to the questions I will present. You can record your answer however you know; there is no right or wrong answer." Three questions were related to the numerical domain (How old are you? What is your weight? How tall are you?), and three to the linguistic domain (What is your name? What color is your hair? What is your favorite food?). The questions were read aloud by the researcher, one at a time. The order in which the questions were presented was randomly defined by drawing lots with each participant. After reading each question, the child was asked to record their answer on one of the sheets of paper (one for each question) and then share it through their cell phone or computer screen, stating out loud the answer given. At the end of the task, the productions were photographed and sent to the examiner by the child's guardian.

Notation Recognition Task

This task was designed especially for this research to examine the child's ability to recognize whether a given notation belonged to the linguistic or the numerical domain. Fourteen cardboard cards were presented one at a time, seven from the linguistic domain and seven from the numerical domain. The linguistic domain cards contained short (three to four letters) and long (six to eight letters) words written in capital print letters, some with accentuation, with vowel cluster and consonant cluster, namely: *pé*, *asa*, *lua*, *dado*, *brinco*, *pássaro*, and *telefone*. The numerical domain cards contained single-digit and multi-digit numbers, numbers with repeated digits, fractional numbers, decimal numbers, and zero, namely: *4*; *333; 2/8*; *2,5*; 1.000.000; 87942136; and 0.

The order in which the cards were presented was random, drawn with each participant, and shown on the cell phone or computer screen. The child was asked to classify the cards into two groups: those that were used for reading and those that were used for counting. In a general and summarized way, the following instruction was given: "I'm going to show you some cards, and I want you to place the cards that are used for writing on the orange side of the screen and the cards that are used for counting on the green side of the screen."

Data analysis and results

Data analysis and results obtained are presented separately for each task, starting with the Notation Production Task, followed by data relating to the Notation Recognition Task. At the end of this section, comparisons are made between the results obtained in both tasks.

Notation Production Task

Three types of representation were identified: alphabetical representation (use of letters), numerical representation (use of numbers), and hybrid representation (use of letters or numbers associated with drawings, dashes, and other graphic marks).

In the questions in the linguistic domain, productions that involved the spelling of any letters were considered correct (Figure 1), while in the questions in the numerical domain, productions that involved the spelling of any numbers were considered correct (Figure 2).

Figure 1 – Alphabetical representation given in response to the question "What is your favorite food?" by a 6-year-old child

Source: Research data.

Figure 2 – Numerical representation given in response to the question "How old are you?" by a 6-year-old child

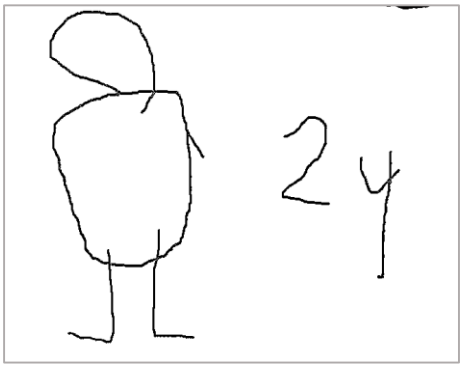
Source: Research data.

Hybrid answers, i.e., notations that involved letters or numbers combined with iconic or pictographic marks (drawings, lines) were considered correct only when the conventional notation used corresponded to the notational domain to which the question belonged. For example, in the linguistic domain questions, productions that involved the spelling of any letters combined with iconic and pictographic graphics were considered correct (Figure 3); while in the numerical domain questions, productions that involved the spelling of any numbers combined with iconic and pictographic graphics were considered correct (Figure 4).

Figure 3 – Hybrid representation given in response to the question "*What is your favorite food?"* by a 6-year-old child

Source: Research data.

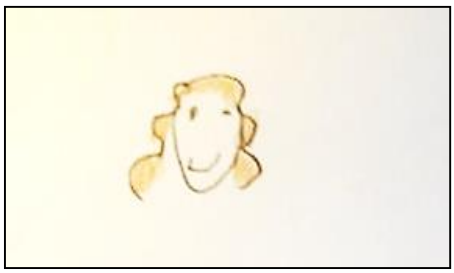
Figure 4 – Hybrid representation given as an answer to the question *"What is your weight?"* by a child of 4 years old



Source: Research data.

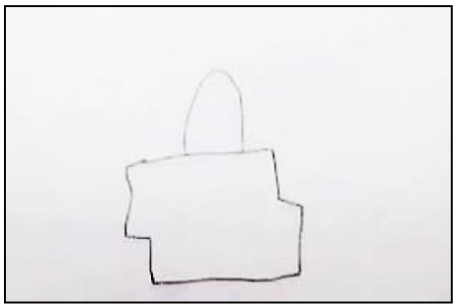
Responses containing only iconic or pictographic marks were considered errors and fell into the same analysis category because they were elementary notations. Pictographic notations are illustrated in Figures 5 and 6, and an iconic representation is shown in Figure 7.

Figure 5 – Pictographic representation given as a response to the question *What color is your hair?* by a 5-year-old child



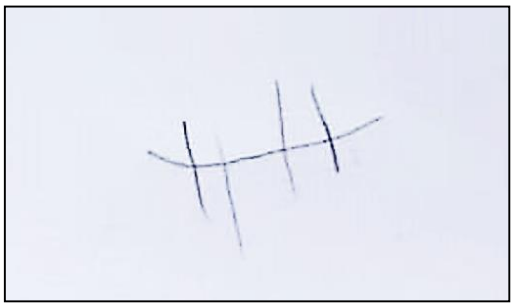
Source: Research data.

Figure 6 – Pictographic representation given as an answer to the question *What is your weight?* by a 5-year-old child



Source: Research data.

Figure 7 – Iconic representation made in response to the question *How old are you?* by a 4-year-old child



Source: Research data.

Data Analysis of the Notation Production Task

Table 1 lists the percentage of correct answers at each age depending on the domains. The Wilcoxon Test applied to each age separately revealed significant differences between the domains only for 5-year-old children ($Z = -2.008$; $p = .045$). This occurred because performance in this age group was better in the numerical (86%) than in the linguistic domain (69%).

Table 1 – Percentage of correct answers in the linguistic and numerical domains at each age in the Notation Production Task (maximum: 51)

Domain	4 years	5 years	6 years
Linguistic	57%	69%	79%
Numerical	71%	86%	92%

Source: Research data.

According to the test, no significant differences were detected in the performance of 4- and 6-year-old children between the two domains. As can be seen in Table 1, conventional representations considered appropriate in each domain were equally less frequent by 4-year-old children (linguistic: 57% and numerical: 71%) and more frequent by 6-year-old children (linguistic: 79 % and numerical: 92%). At 5 years of age, the use of conventional notations specific to each domain becomes more differentiated, with better performance observed in the numerical domain.

In a complementary way, it seemed relevant to examine, more specifically, the participants' performance concerning each question in the linguistic and numerical domains. As values in the cells were low, it was not possible to apply any appropriate statistical treatment, and the data in Table 2 (linguistic domain) and Table 3 (numerical domain) were discussed in terms of trends.

Table 2 – Number of correct answers to each question in the linguistic domain at each age in the Notation Production Task (maximum: 17)

Question	4 years	5 years	6 years
Name	17	17	17
Hair color	7	9	13
Preferred food	5	9	10

Source: Research data.

In Table 2, since the age of 4, children produce graphic marks specific to their linguistic domain (alphabetical representation) when answering the question "What is your name?", understanding that the person's name is spelled using letters. However, this understanding does not seem to be as evident when it comes to the questions "What color is your hair?" and "What is your favorite food?", especially for 4-year-old children whose performance was very limited on these two questions. A possible explanation for this is that hair color and preferred food refer to concrete objects that can be recorded graphically through pictographic representations associated with their physical characteristics. In fact, analyzing the erroneous notations produced in response to these two questions, the vast majority of errors consisted of drawings. This explains the lower percentages of correct answers in notations in the linguistic domain than in the numerical domain (see Table 1).

Regarding the numerical domain, as presented in Table 3, in general, the number of correct answers tended to be significant in the three questions at all ages. Children from an early age seem to produce graphic marks specific to the numerical domain when answering questions related to this notational domain.

Table 3 – Number of correct answers to each question in the numerical domain at each age in the Notation Production Task (maximum: 17)

Question	4 years	5 years	6 years
Age	13	16	17
Height	10	12	14
Weight	13	16	16

Source: Research data.

Notation Recognition Task

In this task, it was considered correct when the child classified the cards containing letters as "used for writing" and those that contained numbers as "used for counting". Table 4 lists the participants' performance on this task.

Table 4 – Percentage of correct answers in the linguistic and numerical domains at each age in the Notation Recognition Task (maximum: 238)

Domain	4 years	5 years	6 years
Linguistic	93%	98%	100%
Numerical	97%	96%	99%

Source: Research data.

The Wilcoxon Test evidenced no significant differences between the domains at any of the ages investigated since the percentage of correct answers was very high, ranging from 93% to 100%. This result indicates that from the age of 4, children can successfully recognize graphic marks specific to the linguistic domain and graphic marks specific to the numerical domain, differentiating them.

Comparison between tasks

Table 5 presents the results obtained in the Production Task and the Recognition Task, considering jointly the number of correct answers in both domains.

Table 5 – Percentage of correct answers in the Production Task and the Recognition Task at each age

Task	4 years	5 years	6 years
Notation Production	58%	70%	78%
Notation Recognition	95%	97%	99,6%

Source: Research data.

In the Notation Production Task, each child answered six questions, totaling 102 answers (17 children x 6 questions). In the Notation

Recognition Task, each child classified 14 cards, totaling 238 responses (17 children x 14 cards). Given the difference in the number of items in each task, the Chi-Square Adherence Test was applied to compare the proportionality of correct answers in the two tasks at each age. No significant differences were found between ages since the pattern remained the same in each of them, namely, better performance in the Notation Recognition Task than in the Notation Production Task. Thus, the data suggest that in the age group investigated, it is easier to recognize graphic marks specific to each domain than to produce graphic marks related to these domains.

Discussion and conclusions

The ability to adopt different types of representation is a recurring theme within cognitive psychology and is investigated from different theoretical approaches. The interest in this topic arises from its relevance in the individual's cognitive development process and its complexity, as it is multifaceted. In this scenario, notational knowledge has attracted the attention of scholars in the field, especially concerning the knowledge presented by children about two systems whose creation revolutionized the ways of living of their creators: linguistic and numerical. Therefore, entry and success in a literate and numeralized society like ours depend on knowledge about notations to communicate and record information of a linguistic and numerical nature that is present in the different situations that individuals face from a very early age in their daily lives.

Two aspects emerge as important regarding knowledge about notations: (i) dealing with different types of representation within each of these domains, such as differentiating letters in different writing systems (Yannicopoulou, 2006) and moving between different types of numerical representation (Benoit et al., 2013); and (ii) differentiating the signs specific to each of these domains (Tolchinsky, 2003; Yamagata, 2007). The present study is part of this second perspective, examining the ability of children aged 4 to 6 to produce and recognize notations specific to the linguistic and numerical domain in the same population of participants. To this end, two tasks were presented to all participants and analyzed separately, each contributing in a specific way to how children's notational knowledge is configured in these two domains, as discussed below.

Children's representations when producing notations in each domain

The representations produced by the children involved the use of letters, numbers, and other graphic marks. Those that presented conventional signs of each domain were considered correct, whether used in isolation (just letters or just numbers) or combined with other graphic marks (pictographic or iconic). In general, the data revealed that since the age of 4, they tended to adopt conventional representa-

tions appropriate to each domain, although they tended to use drawings to represent notations in the linguistic domain more than in the numerical domain.

Another important result was that among children aged 4 and 6, performance was the same in both domains. This occurred because, at 4 years of age, they presented the same, more limited performance in both domains, while at 6 years of age, their performance was more elaborate in both domains. This result can be derived from the fact that at the age of 6, attending the 1st grade of Elementary School, they had already had more contact with the numerical system and the alphabetic system at school.

Also, 5-year-old children performed better in the numerical domain. This data raises the following question: Why was performance worse in the linguistic domain than in the numerical domain? This may be because the alphabetic system of the Portuguese language is more extensive than the decimal numeric system, which is made up of ten symbols, while the alphabetic system is made up of 26 symbols. Furthermore, notations in the linguistic domain can lead children to refer to concrete aspects of the information to be recorded, as observed among 4-year-old children who tended to make pictographic representations to answer questions in the linguistic domain, while the numerical system does not lead to this association. Additionally, Morais (2012) lists a variety of properties related to alphabetic notation that are intertwined in the acquisition of knowledge about the nature and functioning of writing. Notations in the linguistic domain can also lead children to refer to concrete aspects of the information to be recorded. This was observed among four-year-old children who tended to make pictographic representations to answer questions in the linguistic domain. The numerical system does not lead to this association. This discussion complements and meets the comments made by Rodrigues, Silva and Spinillo (2021, p 17) about the fact that "notational knowledge in a given domain does not depend exclusively on the user but also on the characteristics of the representation system itself".

Recognition of notations by children in each domain

Recognizing notations specific to each domain was an activity successfully carried out by the children investigated. This was observed at all ages, showing that from the age of 4, children can recognize graphic marks that are typical of the linguistic domain and graphic marks that are specific to the numerical domain. Age, therefore, was not a factor that influenced the ability to recognize notations in each domain, although it did have some effect on the ability to produce notations, as observed in the better performance of 5-year-old children when producing notations in the numerical domain.

Regarding the results obtained in the two tasks, the children performed better in the Notation Production Task than in the Recognition Task. Given this conclusion, the following question arises: Why is recognizing easier than producing notations? To answer this question, it

is necessary to consider the cognitive demands required by the different methodological resources used in this investigation.

The use of different methodological resources and the cognitive demands of each task

To meet the goals, our study consisted of applying one task for notation production and another for notation recognition. The differences between them are not only because they have different quantities of items, but, above all, due to the nature of these tasks that require different cognitive demands of those who perform them. From a cognitive point of view, recognizing is easier than remembering, as widely documented in studies on memory. In the Notation Recognition Task, participants had to perform a targeted action that consisted of retrieving information that was stored in their memory, while in the Notation Production Task, participants had to perform a broader action that, in addition to retrieving stored information, required that something be done, in this case, producing notations that answered the question addressed.

A similar fact occurs with other cognitive phenomena. For example, in research on textual comprehension, the task of answering questions about a story is easier than the task of reproducing the story (Brandão; Spinillo, 1998). A similar fact was documented in a study on mathematical reasoning in which the task of judging the chance of obtaining a chip of a given color in an array of two-color chips was easier than the task of constructing an array of two-color chips from the level of chance specified by the researcher (Spinillo, 1996).

It seems that many cognitive phenomena are not characterized as a single construct, as is the case with notational knowledge, which has several facets that emerge in different tasks. The use of different methodological resources also allows us to identify, from a development perspective, which capability precedes another. About notational knowledge, the ability to recognize and differentiate notations precedes the ability to produce notations in the numerical and linguistic domains.

Educational implications and future research

Knowing how knowledge about notations is configured in the linguistic and numerical domains and identifying what is specific to each of these domains have educational implications regarding the differences and similarities between learning to read and write numbers and words, as highlighted by several authors (e.g., Lopes-Silva et al., 2016; Moura et al., 2021). From an educational point of view, the question that arises is when and how to promote this knowledge through teaching situations. Children already differentiate and produce numerical and linguistic notations from the age of 4, so it is in Early Childhood Education that this knowledge can be stimulated and developed. However, there is still little room for the development of this knowledge in this school segment, as can be seen in the learning objectives listed in

the National Common Curricular Base (Brasil, 2017) which focus more on literacy practices and the social uses of reading and writing than on learning the conventional alphabetic writing system.

Undoubtedly, the social use of reading and writing is of unquestionable relevance, as stated by Soares (2011), who highlighted the importance of children's interactions with reading and writing practices as a means of provoking and motivating the acquisition of writing skills. Furthermore, according to the author, this does not mean that systematic literacy teaching should be neglected, since reading and writing practices, although necessary, are not sufficient to lead children to understand the relationships between speech and writing. This premise is represented in the term *alfaletrar*, coined in Portuguese language by Soares (2020), which emphasizes that alphabetization and literacy are interdependent and inseparable. Thus, by associating the learning of writing with a reflection on its notational properties, children are given the opportunity to differentiate different systems, such as linguistic and numerical, from an early age.

This idea is shared by Neumann et al. (2013), who argue that understanding numbers and letters in Early Childhood Education provides a solid foundation for developing future mathematical and reading skills and that knowledge about a symbolic system can be generalized and facilitate the development of other symbolic systems so that preschool children should be introduced to teaching experiences that jointly involve the use of multiple symbolic systems such as alphabetic and numerical systems. According to these authors, meaningful and contextualized activities should be presented to children to promote the identification of letters and numbers, the ability to differentiate these symbol systems, and thus contribute to later linguistic and numerical acquisition.

In this sense, didactic situations can be proposed in the classroom based on the tasks adopted in this and other investigations documented in the literature on notations in children. Tasks originally created to assess children's knowledge can be subject to didactic transposition to adapt to teaching situations in the school context. The important thing is that these situations are accompanied by discussions highlighting the differences between the two domains. Furthermore, social situations should be promoted, which require recording and communicating numerical and linguistic information.

As for future research, there is still much to be revealed about notational knowledge in children. A field of research that is still poorly explored is what the literature has called family literacy (Cruz; Ribeiro, 2009; Grieshaber; Shield; Luke; Macdonald, 2012; Sénéchal; Whissell; Bildfell, 2017; Palinha; Mota, 2019) and family numeracy (Spinillo; Cruz, 2018; Soto-Calvo et al., 2020; Cheung; Dulay; McBride, 2020; Marinova; Reynvoet; Sasanguie, 2021; King; Purpura, 2021). In the case of family literacy, it would be interesting to identify the reading and writing practices carried out at home by children and their influence on notational knowledge in terms of the ability to produce notations

increasingly closer to conventional notations. In the case of family numeracy, it would be interesting to identify the mathematical activities carried out in the family context and their relationship with the ability to produce and move between different types of numerical representation documented by Hurst, Anderson and Cordes (2017), namely, recorded quantities, number words, and digits. Participants in these studies could be children from different social classes since reading and writing practices and mathematical activities carried out at home can vary depending on the families' socioeconomic profile.

Regarding the linguistic domain, one of the results obtained here but not properly analyzed was that children tended to use pictographic notations more frequently to write words that referred to material things, such as hair color and preferred food, rather than abstract things such as the person's name. Although the possible reasons for this have been discussed previously, it is necessary to gather empirical evidence through investigations specifically aimed at this purpose that provide support for these explanations and can serve as a basis for generalizations about the development of notations in the linguistic domain. This aspect deserves further examination and ultimately involves a question about the relationship between signifier and signified in notations produced by children. Research of this nature would specifically clarify whether pictographic representations would be more frequently produced to represent concrete objects and whether conventional representations would be more frequently produced to represent abstract information. The results of such an investigation could have an important theoretical contribution regarding notation production by children.

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