Beyond Literal Depiction: Children's Flexible Understanding of Pictures

1. Introduction

Symbolic representation is one the most sophisticated human abilities as it allows us to share meaning, acquire new knowledge about the world, and contemplate other points of view with members of our communities (Callaghan, 2020; Callaghan & Corbit, 2015; Nelson, 2007; Tomasello, 2003). Pictures are pivotal symbols that can represent objects, actions, events and ideas. Artists' depictions can take the form of iconic representations, which bear perceptual resemblance to their referents; or abstract ones, which may not physically represent or look like a referent from the real or imagined worlds. In some cases, pictures are ambiguous and open to more than one interpretation. For instance, a circle atop a vertically oriented line could represent a balloon, lollipop or indeed a frying pan. Pictures can also be interpreted both literally (based on their appearance) and non-literally (as a referent *contiguously related* to what the picture looks like). A picture of a cup with a handle on a store facade can stand for "mug" or "coffee shop" while one of a brown leaf might symbolise a single "leaf" or depict "the Autumn".

A mature understanding of the representational function of pictures involves the acknowledgment of the artist's specific intention (Freeman, 1995) while also recognising the plurifunctionality of the shapes depicted. The ability to see pictures as denoting more than one referent has been termed *representational flexibility* and appears to emerge in early childhood (see Allen et al., 2016). Symbolism is crucial for underlying human cognition (DeLoache, 2004), thus it is important to investigate the factors that contribute to how children acquire a theory of pictures (Freeman & Sanger, 1995). Here we study representational flexibility of pictures in terms of literal vs. non-literal (representational) types of images in preschool-aged children.

Formulating a sophisticated theory of pictures is a gradual process. Children must move from an implicit and mimesis-based understanding of pictorial representations to a more conceptual, reflective and explicit understanding of their representational function (Callaghan, 2020; Callaghan et al., 2012; Winner, 1988, 2007). Studies using simple word-picture-object extension tasks suggest that the onset of representational understanding emerges around 15 months of age, becoming more entrenched by 24 months (Ganea, et al., 2009; Ganea et al., 2008; Preissler & Bloom, 2008; Preissler & Carey, 2004). Children's understanding of the dual nature of pictorial representations (i.e., they are marks on a bidimensional surface while also representing something else) (DeLoache, 1987, 1995) can be found from 24 to 30 months, in tasks where children need to use a picture to find a toy hidden in a room (DeLoache, 1991, 2002; DeLoache & Burns, 1994; Peralta & Salsa, 2009) or in match-to-symbol tasks (Callaghan, 1999; Salsa & Vivaldi, 2016). Several studies have also demonstrated that pictorial interpretation is mediated by referential intentions (Armitage & Allen, 2015; Bloom, 2000; Bloom & Markson, 1998; Gelman & Ebeling, 1998; Hartley & Allen, 2015; Preissler & Bloom, 2008; Salsa & Vivaldi, 2016). For instance, children are sensitive to *how* a drawing was created when asked to label it. Gelman and Ebeling (1998) asked 2-to-4 year-olds to name a series of ambiguous pictures after the contexts in which they were produced were described as either intentional (*John used some paint to make something for his teacher*) or accidental (*John spilled some paint on the floor*). Even though the pictures shown were identical across conditions, children tended to name the intentionally produced creations based on their shape (e.g. *sun*), whereas they showed a trend for describing the accidentally produced ones as the materials they were made of (e.g. *paint*). These results revealed that the context in which a picture was intentionally or unintentionally produced influences the way children interpret it. When

shape cannot facilitate the interpretation of what an artist meant to represent, 4-year-olds rely on other features (e.g. size and oddity) to infer the artist's intentionality (Bloom & Markson, 1998). For example, when requested to name a pair of differently sized shapes made by an artist who was unable to produce representational drawings due to a 'broken arm', they successfully mapped a large form to an elephant and a small one to a mouse and not the other way around.

These studies demonstrate children's developing understanding of the representational relationship between pictures and referents in the first several years of life (see also Liben, 2009 for later, protracted, development of map competence). Nevertheless, authors such as Freeman (1995, 2008) claim that a complete theory of pictures rests on an understanding of the intentional network between four interdependent factors: the picture, the artist, the world and the beholder. Therefore, a more explicit understanding of how individuals use these representations involves reflecting upon how a beholder's knowledge and beliefs can affect pictorial interpretation (e.g., pictorial false-belief understanding, see for example Callaghan et al., 2012), the acknowledgment of vantage point in photographs (Liben & Downs, 1993), and how an artist's attributes can affect the pictorial outcome (for a review, see Allen & Armitage, 2017; Vivaldi et al., 2020). For instance, Callaghan et al. (2012) created a pictorial version of one traditional false-belief task (e.g. Gopnik & Astington, 1988) where 3-to-5-year-olds were asked to sort two different types of toys (e.g., dishes or cars) into two identical boxes. The boxes were then labelled by the researcher using two drawings of their contents. Before leaving the room, the researcher announced they would play with one of these sets (e.g., cars) later. While the experimenter was away, a second researcher proposed to the child to trick their colleague and switched the pictures. Participants were asked where would the first researcher look for their chosen

toys once they returned. Only children from 4 years of age considered the researcher's false belief when providing an answer.

We propose that another way to test children's explicit understanding of the pictorial representational function is to investigate whether they grasp that an ambiguous picture has possibilities other than what the artist meant to depict. Allen et al. (2016) addressed this by asking 4-and-6-year-olds if a drawing could be interpreted differently from what was stated as the artist's intention (e.g. a balloon) when the picture was paired alongside either a perceptually similar drawing (e.g. a lollipop) or a perceptually different one (e.g. a snake). Even though six-year-olds successfully remembered what the artist originally intended to represent, they accepted a second label for the target picture (e.g. "lollipop" for the picture of a balloon) under both conditions. Four-year-olds only did so in presence of no competing drawings. Complementary evidence of these findings was provided by a game-like scenario in which 4-year-olds were asked if a second participant could use children's pictures to stand for a different referent. Unlike in the first study, children were able to provide a behavioural response to the stimuli by selecting one of the available representations. Under this version of the task, the authors found that even the younger age group understood that pictures may denote more than one referent, suggesting that in certain contexts 4-year-olds show *representational flexibility* (see also Karmiloff-Smith, 1990 for flexibility in terms of expressive drawing).

Nonetheless, shapes do not always represent their referents literally. Concepts difficult to portray can be represented indirectly, using *figures of depiction*, analogous to figures of speech, such as visual metonymy and synecdoche (Tversky, 1995, 2001). A figure of depiction is where a related object stands for a given concept (e.g., the trash bin for 'to delete' or a pumpkin for 'Halloween'). A common feature of these types of

pictorial representations is that they fall outside the “iconic” vs. “arbitrary” distinction. They are not “iconic” since they do not resemble what the artist meant to depict; they are not “arbitrary” because the concrete object depicted evokes the artist’s intention by association. These representations involve contiguity relationships such as object used-for-user (e.g., ‘crown’ for ‘queen’) and instrument-for-action (e.g., ‘pencil and notebook’ for ‘to write’). Another interesting aspect of these representations is that meaning becomes quite transparent when using contextual cues (Tversky, 2001). For instance, a picture of a human figure literally stands for a person but if that picture is hanging on a door at a shop or a public space, it also stands for “bathroom”.

There is a general agreement among researchers on how the complexity of these flexible visual representations can be challenging for young children to grasp (e.g., DeLoache & Burns, 1994; Myers & Liben, 2012). Nevertheless, these pictures are widespread throughout western culture; they can be found in traditional picture books, road signs, fast-food logos, and especially on digital devices. These representations can be used as a communication aid between children, their parents and their educators (Teubal & Guberman, 2014). When displayed in computers and mobile screens, they also help users of all ages to intuitively navigate technological devices (Ma et al., 2015). Therefore, having an understanding of the flexible nature of such icons is critical for effective communication and participation in technology-driven societies.

Although children’s cognitive flexibility (i.e. the ability to think simultaneously about or switch between multiple concepts) in language understanding (e.g. Nicoladis et al., 2018) and in quantity representation (e.g. White & Szücs, 2012) has received growing attention in recent years, their flexible interpretations of pictorial representations have been scarcely explored. Our aim is to extend research on children’s explicit understanding of the representational function with respect to flexible pictorial

interpretations. Specifically, our research question is whether 4-6-year-old children can understand that a single picture can be interpreted literally and non-literally, when it is presented with different contextual cues.

Our main aim was to explore whether children treat this class of pictorial representation flexibly, showing a similar developmental progression as when they reason about truly ambiguous images (i.e. graphic representation with more than one literal interpretation, as per Allen et al., 2016). More specifically, children show emerging understanding by 4 years old, but adult-like performance at 6 years old. We report two studies using complementary methodology to explore whether children can interpret the content of a picture both literally and non-literally, in different contexts.

Based on previous studies which showed that even when representationally flexible, young children are bound to the original interpretation of the picture (e.g., Allen et al., 2016), we examined whether the order in which the different contexts were presented had an effect on children's performance. This manipulation allowed us to determine whether children found it more difficult to switch from literal to non-literal interpretations rather than the reverse, and whether this differed developmentally.

In Study 2, following Allen et al. (2016), we used a game to confirm the results of Study 1 by assessing both children's verbal and behavioural responses. We expected 6-years-olds and adults to show representational flexibility both when their interpretations of pictures were assessed through open questions (Study 1) and through a game version of the task, where they had to select the correct picture for a given non-literal meaning, and consequently, show a more implicit knowledge of pictorial possibilities (Study 2). In contrast, and in line with previous studies (Allen et al., 2016; Browne & Woolley, 2001), 4-year-olds were expected to stick to the literal interpretations at the verbal questioning version of the task. Finally, as the

understanding of non-literal meaning develops throughout early years (Chahboun et al., 2016), we expected children of both age groups to have a lower level of performance than adults. Taken together, these studies can provide a developmental account of the understanding of literal and non-literal visual representations in young children and adults.

2. Study 1

2.1. Method

2.1.1. Participants

A total of 80 typically-developing children, 40 4-year-olds (18 female, M_{age} = 4.5 years, age range: 4.0 - 4.11) and 40 6-year-olds (23 female, M_{age} = 6.2 years, age range: 6.0 – 6.11), and 40 adults (26 female, M_{age} = 30 years, age range: 19 – 64) participated. Participants were randomly assigned to the *Literal First* or *Non-literal First* conditions (N = 20 for each age group and condition). Children were recruited from nurseries and primary schools in Rosario, Argentina. Children and adults were from middle-class SES. Informed consent was obtained from adult participants and from the children's teacher and parents or legal guardians. Children provided verbal assent prior to participation.

2.1.2. Materials

We used five gray-scale pictures (4 in. X 4 in.) presented in landscape format on laminated paper. Picture 1 portrayed a female figure; Picture 2, a burger and a beverage; Picture 3, a notebook and a pencil, Picture 4, a crown and Picture 5, three flowers (see Figure 1). After being presented with the target pictures for this study, teachers confirmed that each child who took part was previously exposed to similar pictures, portraying both their literal and their non-literal meaning. These were presented in the

context of calendar and thematic board activities where children were encouraged to use icons to represent items (e.g., ‘flowers’), activities or events (e.g. ‘Christmas’), and seasons of the year.

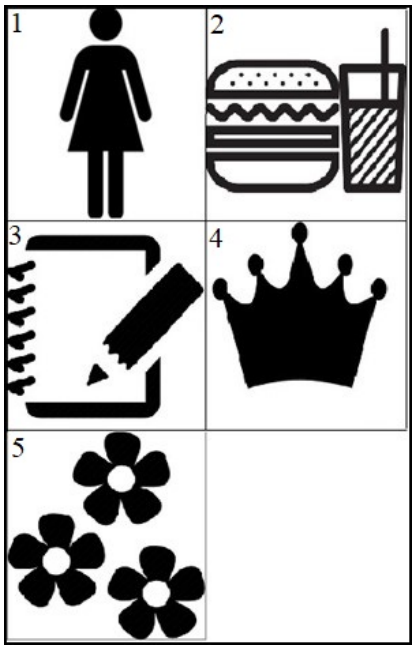

Figure 1. Pictures used in Study 1.

2.1.3.Procedure

Participants were tested individually in an empty room at their nurseries or primary schools. They were seated at a table opposite the experimenter and the materials were placed within their reach. The task consisted of two phases: Literal Context (LC) and Non-literal Context (NLC). Each phase had 5 trials, one for each target picture. All children received both phases in a within-subjects design (Literal First vs. Non-literal First). They were told the same fictional character had created or produced an identical picture in both contexts. At the beginning of each phase and following Gelman and Ebeling’s (1998) scheme, the experimenter read aloud a brief story explaining how a fictional character had created or used a picture intentionally (Literal Context or Non-literal Context, depending on the condition). In the Literal Context phase, the stories were about characters whose pictures represented their

intended referent directly (e.g., a crown for Picture 4, see Figure 1). In the Non-literal context, the intended meaning of the pictorial representation could only be grasped by contiguity (e.g., a 'queen' for Picture 4, see Figure 1). Once participants completed all 5 trials for a phase (e.g., Literal Context), the procedure was repeated with the remaining phase. Appendix 1 shows all the stories used for each phase and picture. Immediately after reading each story, the corresponding picture was then presented and the experimenter asked, "What does this mean?" If the children did not initially respond, the experimenter repeated the story and they were given one more opportunity to reply. A total of 5 children required this prompt to provide an answer.

To investigate whether the order in which the stories were presented has an effect on children's representational flexibility, participants assigned to the *Literal First* condition listened to all literal picture context stories prior to the non-literal ones. Children from the *Non-literal First* condition heard the stories in reverse order. The stories were between 2 and 4 sentences long ($M = 3$, $SD = 0.76$) and included between 24 and 40 words ($M = 32.25$, $SD = 5.5$) In all cases, picture order was counterbalanced.

2.1.4.Coding

The verbal responses of children were coded as belonging to one of three mutually-exclusive categories. Samples of participant's responses are included below:

a) 'Literal'—participants named the picture according to its shape (e.g., "girl" for Picture 1, "crown" for Picture 4, see Figure 1). This response indicated that the child interpreted the picture as a literal representation of the referent it resembled.

b) 'Non-literal'—participants named an object, an action or an idea linked to the shape of the picture by contiguity between the target concept and the content of the picture (e.g., "bathroom" for Picture 1,"queen" for Picture 4, see Figure 1). This

response indicated that the child could identify the picture as a Non-literal representation of the referent it resembled.

c) 'Other'—either the participants did not give an answer, indicated that they did not know what the picture stood for, or provided the name of an object/action/idea that did not correspond to what the artist meant to represent (e.g., "splinter" for Picture 3, "star" for Picture 4, see Figure 1).

Data was coded by two independent researchers. A Cohen's Kappa was calculated to determine the agreement on 100% of the coders' decisions. These indicated very high agreement between the reviewers, 99%, $k = .988$. The discrepancies were resolved by discussion and consensus obtained between the coders.

2.2.Results and discussion

Table 1 illustrates the frequencies of responses given by each age group according to context and category of answer.

Table 1.

Answer type for each context and age-group

Context	*Age group*	*Literal Answers (%)*	*Non-literal Answers (%)*	*Other (%)*
Literal	4 years	82	9.5	8.5
	6 years	84.5	15	0.5
	Adults	95	4	1
Non-literal	4 years	63.4	24	12.5
	6 years	17	81.5	1.5
	Adults	0	100	0

As this task was novel, we compared performance across trials to check for potential stimuli differences. The majority of answers were classified as 'literal' or 'non

literal', thus we focused on those two categories. McNemar tests (N=20) revealed a single significant difference in each context (LC: participants were more likely to interpret Picture 3 literally than Picture 2, $p = .022$; NLC: children were more likely to interpret Picture 1 non-literally than Picture 5, $p = .021$). These results allowed us to collapse answers across trials. Therefore, a total score for each condition was used to test for age, context, and condition differences.

A repeated-measures ANOVA was performed with the number of literal and non-literal responses in both LC and NLC as the dependent variables, and age group and order of presentation (Literal First vs Non-Literal First) as the between-subject variables.

This analysis revealed a significant effect of context, $F(1, 117) = 97.138$, $p < .001$, $n^2 = .460$. Significant interactions were found between context and age group ($F(2, 117) = 62.372$, $p < .001$, $n^2 = .523$), context and order of presentation ($F(2, 117) = 14.562$, $p < .001$, $n^2 = .113$) and context, age group and condition ($F(2, 117) = 5.121$, $p = .007$, $n^2 = .082$) [1]. Tukey HSD post-hoc tests showed a developmental progression in the participants' representational flexibility. The adults provided more interpretations that aligned with each context (i.e., literal responses in the LC contexts and non-literal answers in the NL contexts) than both groups of children, and 6-year-olds did this significantly more than 4-year-olds (all *ps* <.001). Pairwise comparisons for each specific context demonstrated more expected answers from the adult sample both in the LC ($p = .008$ and $p =. 04$, respectively) as well as the NLC (both *p*s <.001). On the contrary, older children provided more non-literal answers than the younger group in the NLC ($p <.001$), but not more literal responses in the LC ($p = .827$).

[1] Observed power was between .814 and 1.

Follow up t-tests showed both age-groups did significantly better in the LC than the NLC (4-year-olds: $t(39) = 11.774$, $p < .001$, *Cohen's d* = 2.22; 6-year-olds: $t(39) = 2.86$, $p = .007$, $d = .741$). In contrast, adults' performance was at ceiling levels thoughout the task although significantly higher performance was shown at the NLC than the LC, $t(39) = -2.912$, $p = .006$, $d = .651$.

Finally, follow up t-tests showed that although the order in which stories were presented had no effect in the adult sample ($t(38) = .433$, $p = .668$, $d = .137$). Six-year-olds were more successful at a context (LC or NLC) when it was presented first: this age group was more likely to interpret pictures non-literally when they were exposed to the NLC in first instance ($t(38) = - 2.27$, $p = .029$, $d = .718$) and the same for the LC ($t(38) = 4.11$, $p < .001$, $d = 1.3$). For 4-year-olds, this was only true for the LC, (4-year-olds: $t(38) = 2.629$, $p = .012$, $d = .832$). This group had poor performance in the NLC regardless of the order in which this context was presented ($t(38) = .37$, $p = .714$, $d = .119$). This means that 6-year-olds showed some inflexibility, even after correctly labelling a picture non-literally. Meanwhile, most 4-year-olds tended to stick to literal answers thoughout the task.

On the whole and in line with previous research (Allen et al., 2016), 4-year-olds tended to interpret pictures literally, and were less flexible in their interpretations of pictures across contexts. For instance, they interpreted a picture of a crown always as 'crown' (i.e., literally) even if the artist intended it to refer to a sovereign ('queen'). In contrast, children from 6 years of age and adults showed representational flexibility by naming a single picture as the object it looks like or as a referent directly associated with it, depending on the context in which it was either produced or used.

As stated by Allen and collaborators (2016), one of advantages of an open-ended question to test children's representational flexibility is that it allows them to provide a

rich variety of interpretations. However, this methodological approach could have been challenging particularly for the 4-year olds as language-based assessments only tend to reveal children's explicit, conceptual-based knowledge of the representational function and could, therefore, underestimate children's abilities (Callaghan & Rochat, 2003, 2008; Vivaldi et al., 2020).

This led us to the question of whether children, and particularly 4-year-olds, could improve their performance if an alternative methodology was used where they were able to demonstrate a more implicit understanding of how a picture can be interpreted both literally and non-literality. Consequently, we used an adaptation of Allen's et al. picture game-format (Study 3, 2016) to complement our findings. We expected this format to be more accessible for the younger age group, as children would only be asked to indicate which picture could be a better symbol for a given non-literal meaning and they could provide either a behavioural (i.e., pointing at the flexible picture) or a linguistic (yes or no) response to complete the task. This in line with previous work showing that behavioural or game-like studies are designed to demonstrate not only explicit but also implicit pictorial understanding hence there are more suitable to investigate the onset of children's picturial understanding (Callaghan & Rochat, 2003, 2008; Vivaldi et al., 2020).

As young children particularly struggled with Non-literal meaning understanding and even 6-year olds find it easier to switch from Literal to Non-Literal interpretations, we focused on this transition.

3. Study 2

3.1.Method

3.1.1.Participants

A total of 40 typically developing children participated: 20 4-year-olds (8 female, M_{age} = 4.6 years, age range: 4.1 – 4.11) and 20 6-year-olds (9 female, M_{age} = 6.7 years, age range: 6.2 – 6.11). Children were from middle-class SES. They were tested at their nurseries or primary schools in Rosario, Argentina.

3.1.2.Materials and procedure

The task lasted approximately 20 minutes and consisted of pre-trials, test and control trials.

Pre-trials. In order to familiarise the children with the experimental 'game', several pre-trials were conducted. The researcher introduced each child to a stuffed gopher (Winnie the Pooh's 'Gopher') and invited the child to play a game with him. The researcher explained to children that gophers spend most of the lives hidden in the underground or under water, so they do not know much about our world. Hence, the experimenter asked the children to help Gopher learn about the way humans live. For each of the four trials Gopher was shown one picture (either three balloons, a thumbs up, a fork, or a mug). The researcher provided the literal meaning of the target picture (e.g.'a thumbs-up') and asked the puppet if the pictures could represent something else – a non-literal meaning (e.g. could this also be a picture of 'to agree'?). Children were thus exposed to trials in which 'yes' was an acceptable answer and trials in which 'no' was an acceptable answer (e.g. if the picture of a fork could be a 'school').

Test and control trials. After children were familiarised with situations in which pictures can either be interpreted flexibly or not in the pre-trials, they were presented with 7 pairs of sets. Each pair consisted of a set of 4 pictures of a related theme (Child's 'complete' sets: bathroom, going to the supermarket, celebrations, kingdom, things in the sky, after-school activities, and things in the park) and a another set of 3 pictures, also of a common theme (Gopher's 'incomplete' sets: people, school

items, Christmas presents, restaurant, clothes, food and seasons of the year, see for example Figure 2). Five pairs were used as the test trials, and two were used in the control trials; the order of presentation of these was counterbalanced. We selected items that would be familiar to Argentinean pupils of the age range tested, and simply rendered (See Table 2 for a list of the stimuli). Reassurance that participants were previously exposed to visual stimuli portraying both the literal and the non-literal meaning of the target items (i.e. pictures that had flexible meaning) was given by their teachers. In a separate pilot study, 17 Spanish-native-speaker adults confirmed the interpretation of the stimuli as 'flexible' representations. All the Literal and Non-literal picture meanings were rated for the extent to which each of the pictures were a suitable representation for the target meanings on a 7-point Likert scale (1 = low aptness; 7 = high aptness) by all participants. The target pictures' rates ranged from 6.2 to 6.88. Meanwhile, non-target pictures (non-flexible pictures, used as distractors in the task) had an average rate of 2.77.

Child's pictures

Gopher's pictures

Figure 2. Example of stimuli for the test trials in Study 2. The child's picture set ('things in the park') includes flowers and Gopher's picture set ('season of the year') is missing "spring". The flowers were used as a graphic representation of spring, to complete Gopher's set (see Test trials).

Table 2

Stimuli set for Study 2. Gopher's 'missing' item (i.e. target picture) and substitute interpretation in the child's display are highlighted in bold.

Child's 'complete' picture set		Gopher's 'incomplete' picture set	
Test trials			
People	**Woman**, boy, baby girl, man	Bathroom	**Women's bathroom sign**, toilet, sink, toilet paper
School items	**Pencil and notebook**, legos, bag pack, books	Going to the supermarket	**To write the grocery list**, to take a trolley, to pay for your items, to bag groceries
Christmas presents	**Crown**, doll, football, videogame console	Kingdom	**Queen**, dress, horse, castle
Restaurant	**Burger and beverage**, spoon, table and chairs, cook's hat	After-school activities	**To have dinner**, to watch TV, to brush teeth, to sleep
Things in the park	**Flowers**, bench, children on a seesaw, tree	Seasons of the year	**Spring**, summer, autumn, winter
Control trials			
Clothes	T-shirt, sock, beanie, trousers	Things in the sky	**Sun**, star, moon, cloud
Food	Pumpkin, chicken leg, beverage, apple	Celebrations	**Family day**, Christmas, Easter, Birthday

Test trials. For each set of pictures, children were shown 4 pictures belonging to their (complete) set and 3 pictures belonging to Gopher's (incomplete) set; crucially one of Gopher's pictures was 'missing'. Each of the sets belonged to a different theme. For instance, the children were shown 'things in the park' (a tree, children on a seesaw, three flowers and a bench, see Figure 2, and for full list of stimuli, see Table 2). Children were encouraged to label and talk about the pictures in order to emphasize their communicative function and ensure they could name them accordingly. All child's pictures were expected to be labelled as the specific referent of the real world they look like (i.e. literal interpretation). The experimenter then placed a separate set of pictures in front of Gopher with a different theme (e.g. 'seasons of the year'). Unlike the child's sets, these pictures were expected to be interpreted non-literally (snowman as "winter", see Table 2). The researcher then pointed out that one of Gopher's pictures was 'missing' (e.g. 'spring'). Crucially, for the test trials, the picture Gopher needed to complete his set had to be a suitable symbol for the missing object, action or idea (e.g., flowers).The child was asked if Gopher could borrow a picture from their set to use in his display. The main question was whether children were able to show flexible interpretations of pictures, that is, to choose a picture previously interpreted literally as an acceptable substitute for a non-literal referent, only connected to what the marks on paper resembled by association (in this case, flowers as a representation of 'spring'). To test whether the type of non-target pictures included in the sets had an effect on children's performance, half of Gopher's set included non-targeted pictures labelled literally and half included non-literal labels.

Control trials. Two control trials were included to ensure children were not simply handing over any picture to please the experimenter. The control trials consisted of two sets of four related pictures, identical to the procedure of the test trials. In the

control trials, however, none of pictures of the set could literally or non-literally stand for the object, action or idea Gopher wanted to borrow a picture of. Thus, here children should answer 'no' when the experimenter asks to borrow a picture from the display in these trials, if they were paying attention to what the picture could be a representation of. In accordance with the test trials design, one (50%) of Gopher's set had literal meaning distractors and the other one non-literal distractors.

3.1.3.Coding

Response categories for test trials included: participant said 'yes' and chose the flexible (correct) picture (scored 2); participant said 'yes' and chose an incorrect picture (scored 1), or participant said 'no' (scored 0, maximum score of 10). Results were then compared to a chance level of 25% for the test trials, as the child could select one of four pictures in each trial. For control trials, responses were scored as correct (participant says no and does not select a picture, scored 1) or incorrect (participant says yes and hands over any of the pictures, scored 0), and thus chance was set at 50% (maximum score of 2).

3.2.Results and discussion

To test for stimulus effects, we ran 21 individual Mc Nemar tests. None of these were significant (all *ps* > .05), thus responses were collapsed across trials.

Test trials. Table 3 summarises the number of times children's responses fell into each of the three categories by age-group. One sample t-tests revealed children's performance was significantly above chance in both age groups (4-year-olds: $t(19) = 10.8$, $p < .001$, Cohen's $d = 2.41$; 6-year-olds: $t(19) = 12.78$, $p < .001$, $d = 2.56$). In addition, an independent sample t-test showed no significant differences across age-groups, $t(38) = -.473$, $p = .639$, $d = 1.002$.

Table 3

Frequencies for each response categories by age group

		'yes'/correct picture	*'yes'/incorrect picture*	*No*
4-year-olds	Test trials	75	15	10
	Control trials	n/a	10	30
6-year-olds	Test trials	82	11	7
	Control trials	n/a	2	38

Control trials. Contrary to the test trials, 4-year-olds successfully said 'no' 75% of the time while 6-year-olds did so on 95% of the trials.Although both age groups' performance was above chance (4-year-olds: $t(19) = 5.6$, $p < .001$, $d = 1.25$; 6-year-olds: $t(19) = 20.34$, $p < .001$, $d = 4.55$), an independent sample t-test revealed a significant age difference, $t(38) = 2.457$, $p = .021$, $d = .591$[2].

Non-targeted picture type. To examine whether the type of non-target picture (literal vs. non-literal) affected responses, paired sample t-tests were performed. Context only had an effect for 4-year-olds (4-year-olds: $t(19) = 2.65$, $p = .016$, $d = .593$; 6-year-olds: $t(19) = .295$, $p = .772$, $d = .099$). The younger age group were more likely to complete Gopher's sets successfully when the distractors were presented as literal rather

[2] Observed power was between .92 and 1, with the exception of a single control trial analysis revealing age differences in performance, which showed a power of .656. Although all remaining control trial analyses were amply powered, caution is advised in interpreting this result.

than as non-literal representations (for non-literal meaning picture examples, see Figure 2).

These findings provide further evidence of children's flexible understanding of pictures. When a game-format procedure is used, even 4-year-olds are able to interpret a single picture both literally and non-literally, depending on the context in which is being presented. Crucially, both age groups did this only when the object the picture resembled to could also be associated with the target meaning. For example, flowers were also interpreted as a representation of spring, but a football was not interpreted as a representation for queen. Along with Study 1, our results also show that 6-year-olds were consistently successful making flexible interpretations of pictorial representations regardless of the methodological approach used.

4. General Discussion

Children's representational flexibility lies at the heart of pictorial competence development. In order to acquire a mature understanding of their representational function, children need to acknowledge the role of the context in which a picture is produced and used, which impacts a viewer's interpretation (Freeman, 2004). Here we examined whether 4- and 6-year olds can interpret pictures literally and non-literally, in different contexts. Our findings supported our hypothesis in that we found a developmental difference in this ability. Whereas 4-year-olds labelled a picture literally regardless of how it was described, 6-year olds could describe it both literally and non-literally, just like adults. When a game format was used, however, the 4-year-olds also showed representational flexibility. We discuss these findings in turn.

In our first study, 6-year-olds and adults demonstrated representational flexibility by not merely naming the picture according to its literal interpretation context

but taking a non-literal interpretation of the same stimuli into consideration as well. Nonetheless, the 6-year-olds were more likely to show representational flexibility when they heard the literal story first. Conversely, and unlike adults, they found switching from non-literal to literal interpretations more difficult; they tended to stick to non-literal interpretations when this context was presented at first instance.

Four-year-olds were significantly rigid in their interpretations of pictures: they labelled pictures literally regardless of the order in which the stories were presented. Their reticence to accept alternative labels for a single picture is consistent with previous studies (Allen et al., 2016). Altogether, our results revealed that a tendency to be bound to the first intentional interpretation of a picture might still exist even in the older age group. These findings can also be explained by the salience of certain meanings over others. As reported for linguistic representations (Giora, 1999), meanings that have been learnt recently (e.g., non-literal for 6-year-olds and literal for 4-year-olds) or triggered in a previous context can be more salient, and therefore are prioritised over alternative meanings.

A possible explanation of why 4-year-old children particularly struggled to understand the non-literal meaning behind pictures is that they tend to fail to use intentional cues when the artist's mental state is pitted against appearance (Armitage & Allen, 2015; Browne & Woolley, 2001; Hartley & Allen, 2014; Richert & Lillard, 2002). Children do this particularly when the stimuli are, as the ones used in our research, iconic representations. In contrast, they favour the artist's intention when pictures are ambiguous enough to potentially represent either of the alternative referents. For example, in Armitage's and Allen's (2015) study, children from age 3 and adults were exposed to an artist producing a drawing (e.g. a blue duck) but shown that the pictorial outcome was portrayed in greyscale or in a different colour (e.g. pink

duck). Children and adults tended to interpret the ambiguous (greyscale) picture as what the artist meant to represent while they labelled them based on appearance in the colour change condition. Even though several studies (Egyed & Szalai, 2016; Gelman & Ebeling, 1998; Hartley & Allen, 2014, 2015; Preissler & Bloom, 2008; Salsa & Vivaldi, 2016) have demonstrated children from age 2 incorporate the artist's mental state when labelling pictures, our results are consisted with research showing that young children continue to find it challenging to acknowledge that a representation might have more than one interpretation between 3 to 6 years of age, depending on task constraints (Allen et al., 2016; Bonitatibus & Beal, 1996; Doherty & Wimmer, 2005; Flavell et al., 1983; Gopnik & Astington, 1988; Rock et al., 1994) but they only demonstrate an explicit recognition of the multiple meanings representations can have by age 6 to 7 (Carpendale & Chandler, 1996; Lagattuta et al., 2010; Pillow & Weed, 1995). Young children are more likely to stick to their first interpretation of a representation (Ackerman, 1985, 1988; Ackerman & Jackson, 1991; Doherty & Wimmer, 2005; Gopnik & Rosati, 2001; Rock et al., 1994), and depend more on contextual cues to modify an initial interpretation (Ackerman, 1985, 1988; Ackerman & Jackson, 1991; Bonitatibus & Beal, 1996). This could be due children being sensitive to referential pacts from very early in their lives. A reaction time study (Matthews et al., 2010) revealed children were significantly slower to pick up items referred to with a novel label (e.g. *the pony*) when interacting with an agent who had used a different term for that same item (e.g. *the horse*) on a previous occasion. Children tended to protest when their partner labelled an item differently than they did in the first place. We argue that a picture produced or used by a single agent that can depict more than one entity in different contexts could break such a pact. It could also be argued that although participants could be using intentional cues in both contexts, these were not necessary to interpret the representation

in LC. To be successful in this phase of the task, participants only had to name the picture based on the perceptual similarity of the subject matter.

Previous research (Armitage & Allen, 2015; Hartley & Allen, 2014), in line with Cox's (2005), Parsons' (1987) and Freeman's (1995, 2008) pictorial understanding models, suggests that children focus on the picture-referent relation from early in development, and only later start to consider the role of the artist's state of mind in the pictorial outcome. If children and adults did not use intentional cues when making literal interpretations, our results are consistent with this developmental pattern. However, the fact that children and adults interpreted pictorial representations as the object they resembled in LC does not mean they disregard the artist's intention. In Bloom's and Markson's (1998) words: "children might call a picture that looks like a bird a 'bird' not merely because it looks like a bird but because its appearance makes it likely that it was created with the intent to represent a bird. In general, appearance and shape in particular is seen an excellent cue to intention" (p.203).

Another possible explanation for the developmental shift observed relates to cognitive flexibility. In Study 1, our participants were required to provide alternative interpretations based on picture-stories read to them. We argue that this required children to be cognitively flexible, as they had to switch their pictorial interpretations across contexts. On the other hand, previous research has shown that children under the age of 5 tend to be inflexible when completing tasks that required a significant amount of shifting (for a review, see Cragg & Chevalier, 2012; Diamond, 2006, 2013; Doebel & Zelazo, 2015) such as the dimensional change card sort (DCCS) task. Here, children must sort cards on a different dimension than they were previously reinforced for such as shifting from shape to colour (Frye et al., 1995). Young children's difficulties with these tasks can be explained by low inhibitory control levels (Kirkham et al., 2003) and

low selective attention skills (Hanania & Smith, 2010) in children younger than 5 years of age.

In Study 2, we reduced the amount of shifting within the task as we only focused on the transition between literal and non-literal meanings; all target pictures were labelled as their literal referents by the child, at the beginning of the task. Children only had to make a forced-choice out of a limited number of pictures to identify which one could be interpreted non-literally, in a different context (Gopher's theme set). Thus it is possible that cognitive flexibility contributed to task performance between studies 1 and 2.

Study 2 showed children's flexible interpretations of pictures are indeed influenced by task constraints. Using a game-format approach where they gave a linguistic ('yes' or 'no') or a behavioural (pointing to or handling a picture) response, even 4-year-olds were able to provide a Non-literal interpretation to a picture previously labelled as their literal meaning. The younger age group demonstrated they were able to select a picture only when a suitable representation was available and not merely to please the examiner, as seen in both Control trials. Another possible reason why 4-year-olds demonstrated representational flexibility under this particular format is that participants were given the intended meaning to be depicted (e.g., 'spring') beforehand rather than asked to provide it through an open question (Study 1). Callaghan and Rochat (2003) argue that verbal responses to interview questions (in our case, "What does this mean?") might only trigger explicit knowledge on children's pictorial understanding and hence, underestimate their abilities. Consequently, our results still leave open different possible roles for the above-mentioned factors in children's flexible interpretations of pictures.

The overall age-related changes observed could have also be driven by the development of an interpretive Theory of Mind (iToM, Doherty & Wimmer, 2005; Lalonde & Chandler, 2002). Carpendale and Lewis (2006) define iToM as the "commonsense understanding that the mind itself influences how the world is experienced" (p. 193) and it is linked to the recognition that a picture can have two or more different interpretations. More importantly, success in iToM tasks has been found to predict an explicit understanding of the representational function of pictures (Callaghan & Rochat, 2008; Myers & Libens, 2012). In line with our findings, the onset of iToM is from age 6 (Carpendale & Chandler, 1996; Carpendale & Lewis, 2006). Nevertheless, research on children's sensitivity to ambiguity in the pictorial domain revealed children can identify the multiple possible interpretations of ambiguous figures sequentially (e.g. duck/rabbit) (Doherty & Wimmer, 2005; Gopnik & Rosati, 2001; Rock, et al., 1994) and reverse from one to the other from 5 years of age. In contrast, when participants had to explicitly acknowledge that a picture can have more than one equally correct interpretation simultaneously, even 6-year-olds found this challenging (Beck et al., 2011), suggesting an explicit understanding of the pictorial representational function is yet to be fully developed. Acknowledging the multiple layers of meaning of a representation is therefore tantamount as considering that other people might have different perspectives than our own (Myers & Liben, 2008, 2012). Consequently, future work should further address the relationship between iToM skills and flexible interpretations of iconic and ambiguous pictures.

Comprehension of icons can also be driven by experience (Winn, 1993). In this research, we have carefully chosen flexible pictures whose meanings were familiar to our participants. Frisson and Pickering (2007) reported that familiar non-literal meanings are easier to process than unfamiliar ones in the linguistic domain. Making

the context salient facilitates understanding (Özçalışkan, 2005; Waggoner et al., 1985), even when non-literal meanings are new to the receivers (Frisson & Pickering, 2007). We argue that contextual cues, particularly the ones proposed for Study 2, were effective for children from 4 years of age to grasp non-literal meaning in the pictorial domain. However, children could be less likely to be flexible with familiar rather than novel pictures, assuming that they are familiar with them in specific contexts. Future research should investigate the effects of familiarity with the stimuli in children's flexible interpretations of pictures[3].

Finally, our results are only informative of typically developing children. Further work should investigate these research questions in atypical populations that might find pictorial representations beneficial for expressive communication purposes. For instance, many children with Autism Spectrum Disorder (CWA) rely on pictorial representation aids such as the Picture Exchange Communication System (PECS; Bondy & Frost, 1998) and they have a tendency to interpret linguistic expressions literally (Happé, 1995). It would be interesting to assess whether CWA could improve their performance making flexible interpretations of pictures when using a game-like paradigm (Study 2) that does not rely on modal questioning.

Altogether, our findings complement Allen et al.'s (2016) evidence of children's awareness of the multiple layers of meaning pictures have. Far from being open to the possibility that a picture might represent a different object from that intended by an artist (Allen et al., 2016), our studies confirmed children also understand that these representations can be construed non-literally. Even though non-literal meanings might be more obscure as they strongly rely on contextual cues to aid understanding (Myers & Liben, 2012), it is also worth-noting that they make relevant aspects of a message more

[3] We thank the reviewers for this future research suggestion.

salient and thus more accessible to a wide audience (Forceville, 2009). Our research adds to current literature on children's non-literal meaning understanding, which has been widely studied in language (see for example Rundbland & Annaz, 2010), by examining the development of figurative understanding of visual representations. This study is the first to investigate children's flexible interpretations of pictures whose shapes depicted concepts non-literally. Our findings have implications for children's understanding of flexible iconic representations commonly used in picture books and high-tech devices and can inform the design of guidelines for educators and software developers to adjust the iconic representations used to make them suitable for children's abilities and understanding.

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Appendix 1. Stories used in Study 1 (LC =Literal context; NLC: Non-literal context)

Picture 1.

(LC) While she was in an art lesson, Mary was asked to make a picture of whatever she liked. This is what it looked like.

(NLC) After finishing her meal at a restaurant, Mary's hands were dirty. She walked towards a door with a picture hanging on it. She opened the door and went through. This is what the picture looked like.

Picture 2.

(LC) One day, John decided to do a computer quiz. One of the questions was: "What´s your favorite food?" He had to choose the one that best represented his answer. This is the picture he chose.

(NLC) John was looking at his classroom checklist. Every activity was accompanied by a picture. This is the picture of what John's class had to do at noon.

Picture 3.

(LC) Tom got new things for his first day of school. He took a picture of them and sent it to his bother. This is what it looked like.

(NLC) Tom was asked to choose a picture of what he likes most to do at school. He had lots of pictures to choose from but he only chose one. This is what it looked like.

Picture 4.

(LC) Since Lucy didn’t know how to write yet, she decided to draw a picture of the present she wanted for Christmas and sent it to Santa. This is what it looked like.

(NLC) Lucy was at her art lesson and the teacher asked her to draw what she wanted to do when she grew up. Once she finished with her drawing, she showed it to her teacher. This is what it looked like.

Picture 5.

(LC): Mark had to draw a picture of what he liked most about the park for his teacher. This is what it looked like.

(NLC): Mark's teacher was taking about the seasons of the year. Mark asked her which one was her favorite and she showed him a picture. This is what it looked like.