



OPEN The development of specific emotion comprehension components in 1285 preschool children

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The goal was to examine the development of specific components of emotion comprehension in 1285 preschool children aged 3 to 5 years. Three tasks were used: context-free facial recognition of four primary (and neutral) emotions, and comprehension of external causes (i.e., pointing to which emotion a character feels in several situations, and labelling each of them). Main results showed that emotion comprehension improves in 3-4-5-year-olds. However, some components seemed to improve faster regardless of age. Context-free facial recognition of emotions was better mastered compared to the ability to identify and label (respectively non-verbal and verbal causes comprehension tasks) an emotion after presenting the external cause (visually/verbally) of emotion. Labelling facial expressions remained the most complex task. When external causes that generate emotion were presented, joy tended to be the most recognized emotion, while anger, fear, and sadness came after and improved with age. At age 3, on the context-free facial recognition task, anger and sadness were best recognized, joy came in third place. At age 5, joy took first place for this task. Fear remained the most difficult emotion to recognize along with neutral expression on this task for each age group. Finally, neutral emotions were the most difficult to recognize in all three tasks and for each age group.

Key-words face, emotion, recognition, preschool period, labelling

Emotion comprehension by children represents a multifaceted construct that involves a variety of components. There is currently little agreement regarding the exact number of components that make up this competence. The term “emotion comprehension” is used for tasks related to emotion perception, emotion labelling, situation understanding, and emotion modeling/miming¹. Eisenberg et al. (2005)² included in their definition both the perceptual and comprehensive dimensions of emotion. For the perceptual component, emotion comprehension refers to the ability to successfully process emotional aspects in the language as well as relevant emotionally charged information in our environment (emotionally charged environmental stimuli), to identify our own and others’ emotional experiences and expressions. For the comprehensive component, this definition includes the ability to understand which emotions are appropriate given the circumstances and to identify the causes and consequences of emotions. In the current study, we focused on facial expression recognition based on an emotional label. We also focused on understanding the external causes of an emotion by recognizing the facial expression of this emotion and by labelling the emotion. This study was finally centered on certain basic emotions (anger, sadness, fear, joy and a neutral emotion) for several reasons. First, these emotions were selected to allow for comparison with other studies that have examined the developmental trajectory of these emotions³. Second, it was essential to understand how these emotions are influenced by age in the preschool period and what type of tasks may influence their comprehension, as some researchers consider them to be the foundational basis for the development of more complex emotions (i.e. secondary), which emerge from combinations of basic emotions, such as contempt, optimism, and others⁴. We also chose to include a neutral emotion. Gasper et al. (2019)⁵ defined a neutral emotion as feeling nothing in particular. This emotion would reflect a lack of preference one

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way or the other (english terms would be: “so-so”, “meh”, “nothing in particular”). The integration of this emotion allowed us to examine differences in the abilities of 3- to 5-year-olds to understand emotions that neither have a clear oriented positive or negative valence nor a distinguishable level of arousal (high or low)⁶, such as simply feeling ‘okay’ or ‘calm’. Including this type of emotion gives us a more precise view of the differences among 3- to 5-year-olds in understanding a range of emotions, from those with more evident characteristics (valence and arousal) to those whose qualities may be less apparent for a young child to discern—just as they might be for an adult (for a review on this topic, see Gasper et al. (2019)⁵). Finally, from a practical intervention perspective, some programs specifically target these basic emotions with preschool children first before focusing on more complex emotions, like disgust or surprise (e.g. Richard et al. (2023)⁷). Our research carried practical implications, as we aim to develop an age-appropriate, open-access assessment tool and to enhance interventions in socio-emotional learning for young children.

Emotion comprehension is sensible to be fostered in the preschool period, particularly for two reasons. Firstly, a recent meta-analysis of meta-analyses⁸ highlighted that when interventions target emotional aspects (e.g. emotion comprehension), age was a significant moderator for five of eight socio-emotional outcomes (and in each case, younger students benefited more than older students). Although results are inconsistent regarding the moderating effect of age, it appears that when age does significantly moderate outcomes, it is consistently younger children who benefit the most. Secondly, multiple researches show close links between emotion comprehension, social competence, and academic performance in preschool period and later in children’s schooling^{9–13}. For instance, regarding academic performance, preschoolers’ understanding of emotions is a significant predictor of children’s academic success in the first grade¹⁴. Other studies confirm the link between emotion understanding (and more specifically emotion perception) and social competence in young children. For example, a longitudinal study of children aged 3–6 years found that emotion recognition (naming four basic emotions from drawings of faces depicting happy, sad, angry, and frightened facial expressions (expressive knowledge) and identifying each face nonverbally by pointing to it (receptive knowledge)) was positively related to adaptive social behaviors one year later¹⁵. More specifically, emotion recognition was associated to positive social interactions (e.g., accepting compromise, working easily in groups) and prosocial/empathetic behaviors (e.g., sharing toys). These findings suggest that the ability to identify emotional facial expressions would promote the ability to interpret emotional cues from others and, as a result, would allow children to appropriately respond to the needs of others.

Given the importance of this ability, it is essential to expand research targeting this construct to better understand its developmental trajectory during the preschool period in typical development.

From a developmental point of view, important changes take place in the emotion comprehension between the ages of 3 and 11. Three main developmental phases have been identified^{16,17}. Each of these phases is characterized by the consolidation of a particular mode of understanding. Children between the ages of 3 and 6 initially develop an “external” emotion comprehension. This comprehension includes the context-free facial recognition of emotions, the identification of emotions resulting from situational or external causes, and the understanding that a reminiscence can recreate a past emotional response. From ages 7 to 9, the comprehension is more “mental”. Children are able to understand hidden affects and they conceive that desires and beliefs produce emotional responses. Finally, from ages 9 to 11, emotion comprehension becomes reflexive. Children can understand the mixed nature of emotions; they understand that emotions can be regulated with cognitive strategies, and that their emotions can be influenced by morality.

In the current study, we focused on some components of the first phase described by Pons et al. (2004)¹⁶: the “external” emotion comprehension. More specifically, we focused on context-free facial recognition of emotions and the non-verbal comprehension of their causes. The verbal causes comprehension (which includes, free production of labels for facial expression) was also examined contrary to Pons et al. (2004)¹⁶ who did not integrate this aspect in the evaluation of emotion understanding. In the next two sections, we describe in more detail these aspects and more specifically the facial emotion recognition (without verbal abilities) and the verbal categorization of emotions.

Regarding the facial recognition of primary emotions without a verbal component, infants can perceive changes in facial expression and are attracted to happy faces probably from birth. After the first few months of life, they gradually show an ability to distinguish happy faces from other facial expressions. More specifically, it is from 6 to 7 months of age that infants show an attraction to fearful faces and become able to distinguish between expressions other than joy¹⁸.

During childhood, a meta-analysis conducted on the developmental trajectory of children’s emotion recognition competencies showed that the percentage of basic emotions recognition (with and without verbal abilities) significantly increases between 2 and 12 years of age³. Happiness seems to be the most easily recognized emotion category, followed by anger, surprise, sadness, disgust, and fear. According to this meta-analysis, recognition of all basic emotions appears to improve across development in a similar fashion. Discrete emotions that are the best recognized at 3-years-old, are also the best recognized at 10- years-old. The recognition for all emotions seems to follow the same developmental trajectory.

However, although the order of basic emotion recognition is not affected by the type of task, accuracy in emotion recognition is dependent on task-type. Children’s accuracy in free-label tasks (e.g. verbal causes comprehension, in our study) appear to be lower than multiple-choice type tasks (including forced-choice and match to sample paradigms, which correspond respectively to the non-verbal causes comprehension and context-free facial recognition tasks in our study). Free-label seems to be more difficult than a task engaging less verbal abilities, but more perceptual features³.

Moreover, the visual context is also an essential variable that enhances emotion recognition. Indeed, in real-life situations, a person rarely encounters faces in an isolated fashion, as facial expressions are generally experienced within a context that influences the interpretation of these expressions^{19,20}. Children aged 5 to 15

years recognize facial emotional expressions more accurately when presented with congruent visual contextual cues than in the absence of contextual information²¹.

Finally, in an intervention study aimed at evaluating the effect of a program targeting emotional learning in children aged 3 to 5²², using the same types of tasks (measures) as in our study, the authors emphasize that the observed improvement depended particularly on the nature of the emotion task (with all emotions combined) and its interaction with age. In the recognition task without visual context (free-context facial recognition task), children aged 3 to 5 showed no significant differences in performance on this type of task compared to the control group. The effect was demonstrated in 3-year-old children in tasks that evaluated emotional understanding with a non-verbal response (non-verbal causes comprehension task) and emotional denomination with a verbal response (verbal causes comprehension task). The effect was also demonstrated in 4-year-old children when they were asked to label the emotion. Older children seemed to have benefited less from the intervention compared to younger children. This suggests that it is possible to improve the development of certain components of emotion comprehension early in the development and that younger children appear to be more receptive to this type of intervention on certain tasks than their older peers.

In other words, according to certain research, the developmental trajectory of basic emotions appears to show consensus regarding their order of recognition. The type of task seems also to affect the accuracy with which they are recognized.

In this vein, concerning more specifically the verbal categorization of emotions (including free-labelling and verbal recognition, which refers to the categorization of emotions based on a label heard previously). From the age of 2, they can make an initial verbal categorization of certain emotions based on their valence (intrinsically pleasant or unpleasant quality of a stimulus), either “positive” (pleasant) or “negative” (unpleasant). It is only later in development that children achieve a specific distinction between each emotion as in adults²³. These early recognition abilities improve considerably with age throughout childhood and (pre)adolescence (for a review, see Gosselin (2005)²⁴). According to the dimensional view²⁵, children begin by classifying facial expressions into two broad categories on the basis of the positive and negative dimensions of valence and arousal (low to high activity or engagement) before categorizing them into specific emotional categories, as adults do^{23,26}. Verbal recognition of the emotion of joy is already well mastered at 3 years of age²⁷. The verbal recognition of the emotions of sadness, anger, and fear evolves more slowly (accurate recognition of sadness around 5–6 years, fear around 7 years, and anger around 9 years²⁸). Finally, the emotion of disgust is recognized around 9 years old and with subsequent improvement continuing gradually until the late teens or early adulthood²⁹. Concerning the expression of emotion words, it increases from 4 to 11 years old³⁰ to adolescence and adulthood³¹. According to Baron-Cohen et al. (2010)³², between the ages of 4 and 11, the size of the emotional lexicon doubles every 2 years, and the growth rate of the emotional lexicon stabilizes between the ages of 12 and 16.

All together, these studies suggest that the emotion comprehension improves during childhood and is dependent on the type of task used. However, no study has yet demonstrated the evolution of this competence exclusively in 3–5 years old over a large population of children and when different components of the “external” aspects and free production of emotional labels are involved (verbal causes comprehension, in our study). Indeed, most studies with typically developing children included relatively limited samples per age to examine the development of some of these emotion comprehension components (e.g.^{16,21,26,28,30,32–38}). When the sample is large-scaled, the study does not examine the effect of age for the exclusively preschool period on the understanding of basic emotions, such as happy, angry, sad, fear, and a neutral emotion (e.g.³⁹).

The main goal of the current study was to better understand the development of specific components of emotion comprehension in 1285 preschool children; specifically, the emotion comprehension differences between 3-, 4- and 5-year-old children. Emotion comprehension was assessed by three emotion comprehension tasks⁹ adapted from previous work⁴⁰.

Firstly, this study aimed to examine the main effect of age on emotion comprehension with a large-scale of preschool children.

Secondly, we wanted to examine if some components of emotion comprehension were better mastered than others. The targeted components were the context-free facial recognition based on an emotional label and the comprehension of the causes of emotions by pointing and labelling the correct emotion (non-verbal and verbal causes comprehension tasks). In other words, do we find an effect of task type³? In this perspective, how does the type of components interact with the age of children?

Thirdly, we wanted to examine whether certain components were more developed as a function of age.

Fourthly, this study examined the effect of age on the global comprehension of basic emotions, such as joy, anger, sadness, fear, and neutral emotions.

Finally, we focused on the differences in the patterns of success in the different emotions tested in the three age groups depending on the component of emotion comprehension.

In other words, we intended to extend the research realized on the development of some aspects of the first emotion comprehension phase highlighted by Pons et al. (2004)¹⁶. The comprehension of external causes of emotions was explored by adding an original task of verbal production of emotional labels to the classic pointing task^{16,40}.

Method

Participants

In total, 1285 children (age range: 36 to 71 months, $M = 54.4$, $SD = 10.4$; 639 girls and 646 boys) were retained for the study. Among this total, data from 740 participants were collected during the 2019–2020 academic year and have already been the subject of a published article⁹ (link to the creative commons attribution 4.0 International license: <https://bit.ly/rightslink>). The remaining data ($n = 545$) were collected during the second year of the research project (i.e. academic year 2020–2021).

Three age groups were constructed: 3-year-olds ($n = 385$, age range: 36–47 months; $M = 41.2$, $SD = 3.5$, 194 girls and 191 boys); 4-year-olds ($n = 381$, age range: 48–59 months; $M = 53.5$, $SD = 3.4$; 206 girls and 175 boys) and 5-year-olds ($n = 519$, age range: 60–71 months; $M = 64.9$, $SD = 3.1$; 239 girls and 280 boys). They were recruited in 66 classes from 39 public preschools located over a very large area of France in rural (< 1000 inhabitants; $n = 320$; 24.9%), village (1000–6000 inhabitants; $n = 568$; 44.2%), and urban (> 6001 inhabitants; $n = 397$; 30.9%) areas. These were single-, double- and triple-grade classes, taught by 54 experienced teachers, with between 6 and 31 children (average 19 ± 7) per class. There were 19 classes with only one level (four classes of 1st grade, two classes of 2nd grade and 14 classes of 3rd grade), 28 double-level classes (three classes of 1st and 2nd grade, three classes of 1st and 3rd grade and 12 classes of 2nd and 3rd grade) and 19 three-level classes. Children were all French-speaking and came from families with low to high SES: 145 (11.3%) with low SES, 273 (21.2%) with middle-low SES, 420 (32.7%) with Medium SES, 234 (18.2%) with upper-middle SES, and 213 (16.6%) with high SES. Data from children ($n = 18$) reported to have special educational needs because of learning difficulties or any other disability as well as data that encountered procedural errors in their collection were excluded from the study. All participants had to be French-speaking to be included in the study, and not have learning disabilities or any other form of impairment.

The study (including experimental protocol and data collection) was conducted in accordance with ethical principles for research involving human subjects (World Medical Association Declaration of Helsinki) and was approved by the DSDEN-73 committee and its Academic Director (DASEN) of French National Education (MEN). A written informed consent of each child's parent was obtained from all participants. The project had been approved by the ethics committee of the University of Savoie Mont Blanc.

Procedure

Children were tested in schools under normal classroom conditions by their teachers who had been previously trained to set up, perform, and rate, in standardized ways, the emotion comprehension task. An assistant was specially hired to teach and manage the class while the teacher tested each child individually. All evaluations took place in the first months of the school years (2019–2020 and 2020–2021).

Measures

Emotion comprehension was tested through two main tasks, the second of which was subdivided into two subtasks, which is why we refer to three separate tasks throughout the manuscript. These tasks were based on previous work^{9,16,21,40}. Task 1: Context-free facial recognition of primary emotions (fear, anger, joy and sadness) as well as a neutral facial expression (word comprehension). After laying out five cards with different emotional faces on them in front of the child, the teacher gave the following instructions for each emotion: “Look at these pictures. Give me the picture of the child who feels happy/sad/alright/angry/scared (in this order)”. Thus, the child had to match emotion labels previously heard to the corresponding facial expressions presented among a set of five options (for each emotion tested, a new set of five cards was placed in front of the child). Each participant was asked to identify the facial expression associated with a given emotion label provided by the teacher. The maximum score for this task was 5 points (one point per correct answer).

Tasks 2 & 3: Non-verbal and verbal comprehension of the external causes underlying these emotions in others, divided into two tasks: (2a) *pointing* to the correct emotion felt by a character in given situations (non-verbal causes comprehension task), and (2b) *labelling* the emotion felt by the protagonist in each situation based on external contextual elements (verbal causes comprehension task). For this second subtask, the teacher presented five pictures of a protagonist facing a specific situation (e.g., “This boy just got a birthday present”). While showing a given scenario, the teacher read the story about the character depicted. The face of the protagonist in the cartoon was left blank. Each of these situations could prompt four emotional responses (anger, sadness, fear and joy) plus one neutral expression. For each board, the child was asked to answer how the protagonist felt in that situation, first by *pointing* (non-verbal responses) to one of the five pictures representing the facial expressions of the character's emotional responses and the neutral response mentioned above, and afterward, by *labelling* the emotion felt by the protagonist (verbal responses). The accepted terms for each emotion were: “angry”, “upset” and “annoyed” for anger; “afraid”, “frightened” and “scared” for fear; “happy”, “joyfull”, “pleased” and “glad” for joy; “sad”, “unhappy” and “distressed” for sadness and “neutral”, “normal”, “alright” and “okay” for the neutral condition. These terms were defined based on our previous study where they were selected following an intercoder agreement procedure between two research assistants and the principal investigators⁹. While the first two tasks were inspired by the previous work of Pons et al. (2004)¹⁶, the last task, which tested the comprehension of the causes generating emotions in others in a given situation via the verbal production of the emotion label, was not part of Pons et al.'s work and was taken from the previous study by Cavadini et al. (2021)⁹. The maximum score for each of these two subtasks was 5 points (one point per correctly identified item and one point per correctly labelled emotion).

The detailed content of these tasks, the test sheet, and its scoring key are available in the online Supplementary Information file to this manuscript.

By summing up the points obtained in the three tasks (context-free facial recognition task, and non-verbal and verbal causes comprehension tasks), we then calculated each child's emotion comprehension total score (range: 0 to 15 points).

Data analysis

Statistical analyses were computed using TIBCO Statistica 13.2 computer software. We started by performing a one-way analysis of variance (ANOVA) to test the effect of age group (a 3-modality between-subject factor) on the total emotion comprehension score. According to Gpower (version 3.1.9.7), the total sample size had to

be a minimum of 156 participants per group considering an error of $\alpha=0.05$, a power of 0.95, an effect size of 0.40, 3 groups and N-1 degrees of freedom as parameters of an a priori analysis computing the required sample size with an ANOVA. Then, in order to investigate the effect of three preschool age groups on three components of emotion comprehension, we performed a 3 (age group; between-subjects) x 3 (task type; within-subjects) x 5 (emotion; within-subjects) mixed ANOVA. Tukey HSD tests were run post-hoc when the results of these analyses were significant ($p\text{-value}\leq0.05$). Finally, we tested the factors “living location”, “SES” and “teacher” as potential covariates in each analysis, but none proved to be significant.

Data are available in supplemental materials.

Results

Descriptive statistics for all variables measured by age group and for the total sample are presented in Table 1. The one-way ANOVA testing the effect of age (differences between the three age groups) on the total emotion comprehension score was significant, $F(2, 1282)=326.56, p<.001$ (partial eta-squared=0.338): the 5-year-olds ($M=11.579, SD=2.552$) had on average a higher score than the 4-year-olds ($M=9.907, SD=2.853$), who also had a statistically higher score than the 3-year-olds ($M=6.852, SD=2.927$). The mixed ANOVA carried out subsequently also revealed some interesting results (see Fig. 1 for an illustration). First of all, the main effect of task type was significant, $F(2, 2564)=1229.087, p<.001$ ($\eta_p^2=0.489$): regardless of the children’s age, the context-free facial recognition task was clearly the most successful, and the pointing task (non-verbal causes comprehension task) was also significantly more successful than the labelling task (verbal causes comprehension task). The interaction effect between task type and age group was significant, $F(4, 2564)=21.61, p<.001$ ($\eta_p^2=0.033$): at the age of three, the context-free facial recognition task was significantly more successful than the non-verbal causes comprehension task, which was itself significantly more successful than the verbal causes comprehension task. On the other hand, for both 4-year-olds and 5-year-olds, only the context-free facial recognition task was significantly more successful than the other two types of task, for which the children obtained statistically equivalent results in their respective age groups. This analysis also revealed that the interaction effect between the five emotions tested and the age group was significant [$F(8, 5128)=5.024, p<.001$ ($\eta_p^2=0.008$)]: while joy was the emotion that obtained the highest scores in the three age groups and neutral expression the lowest scores, the patterns of success for the three remaining negative emotions (anger, fear and sadness) differed between the three age groups. Post-hoc analyses revealed that in the 3-year-olds, the following decreasing pattern was observed: joy, anger, sadness, fear and neutral expression (where the anger score was equivalent to the sadness score, which in turn was equivalent to

	3-year-olds (n = 385)		4-year-olds (n = 381)		5-year-olds (n = 519)		Total (N = 1285)	
	M	(SD)	M	(SD)	M	(SD)	M	(SD)
Emotion comprehension (/15)	6.85	(2.927)	9.907	(2.853)	11.579	(2.552)	9.667	(3.387)
Context-free facial recognition task (/5)	3.434	(1.240)	4.273	(0.994)	4.605	(0.781)	4.156	(1.114)
Non-verbal causes comprehension task (/5)	1.821	(1.171)	2.874	(1.244)	3.487	(1.083)	2.806	(1.350)
Verbal causes comprehension task (/5)	1.597	(1.330)	2.760	(1.317)	3.487	(1.175)	2.705	(1.488)
Total comprehension score for ANGER (/3)	1.543	(0.970)	2.089	(0.991)	2.337	(0.926)	2.026	(1.014)
Context-free facial recognition task (/1)	0.862	(0.345)	0.958	(0.201)	0.967	(0.178)	0.933	(0.250)
Non-verbal causes comprehension task (/1)	0.348	(0.477)	0.575	(0.495)	0.699	(0.459)	0.557	(0.497)
Verbal causes comprehension task (/1)	0.332	(0.472)	0.556	(0.497)	0.671	(0.470)	0.535	(0.499)
Total comprehension score for FEAR (/3)	1.275	(1.074)	1.984	(1.078)	2.358	(0.986)	1.923	(1.133)
Context-free facial recognition task (/1)	0.574	(0.495)	0.790	(0.408)	0.881	(0.325)	0.762	(0.426)
Non-verbal causes comprehension task (/1)	0.356	(0.479)	0.606	(0.489)	0.740	(0.439)	0.585	(0.493)
Verbal causes comprehension task (/1)	0.345	(0.476)	0.588	(0.493)	0.738	(0.440)	0.576	(0.494)
Total comprehension score for JOY (/3)	1.844	(1.032)	2.488	(0.826)	2.842	(0.483)	2.438	(0.887)
Context-free facial recognition task (/1)	0.719	(0.450)	0.908	(0.289)	0.971	(0.168)	0.877	(0.329)
Non-verbal causes comprehension task (/1)	0.605	(0.489)	0.798	(0.402)	0.936	(0.244)	0.796	(0.403)
Verbal causes comprehension task (/1)	0.519	(0.500)	0.782	(0.413)	0.934	(0.248)	0.765	(0.424)
Total comprehension score for SADNESS (/3)	1.410	(0.983)	2.147	(0.973)	2.522	(0.821)	2.078	(1.028)
Context-free facial recognition task (/1)	0.821	(0.384)	0.945	(0.229)	0.969	(0.173)	0.918	(0.275)
Non-verbal causes comprehension task (/1)	0.312	(0.464)	0.601	(0.490)	0.773	(0.420)	0.584	(0.493)
Verbal causes comprehension task (/1)	0.278	(0.449)	0.601	(0.490)	0.780	(0.414)	0.577	(0.494)
Total comprehension score for NEUTRAL expression (/3)	0.779	(0.745)	1.198	(0.878)	1.519	(0.965)	1.202	(0.930)
Context-free facial recognition task (/1)	0.457	(0.499)	0.672	(0.470)	0.817	(0.387)	0.666	(0.472)
Non-verbal causes comprehension task (/1)	0.200	(0.401)	0.294	(0.456)	0.339	(0.474)	0.284	(0.451)
Verbal causes comprehension task (/1)	0.122	(0.299)	0.232	(0.374)	0.363	(0.436)	0.252	(0.393)

Table 1. Descriptive statistics (M, SD) for the different dependent variables for each age group and for the total sample.

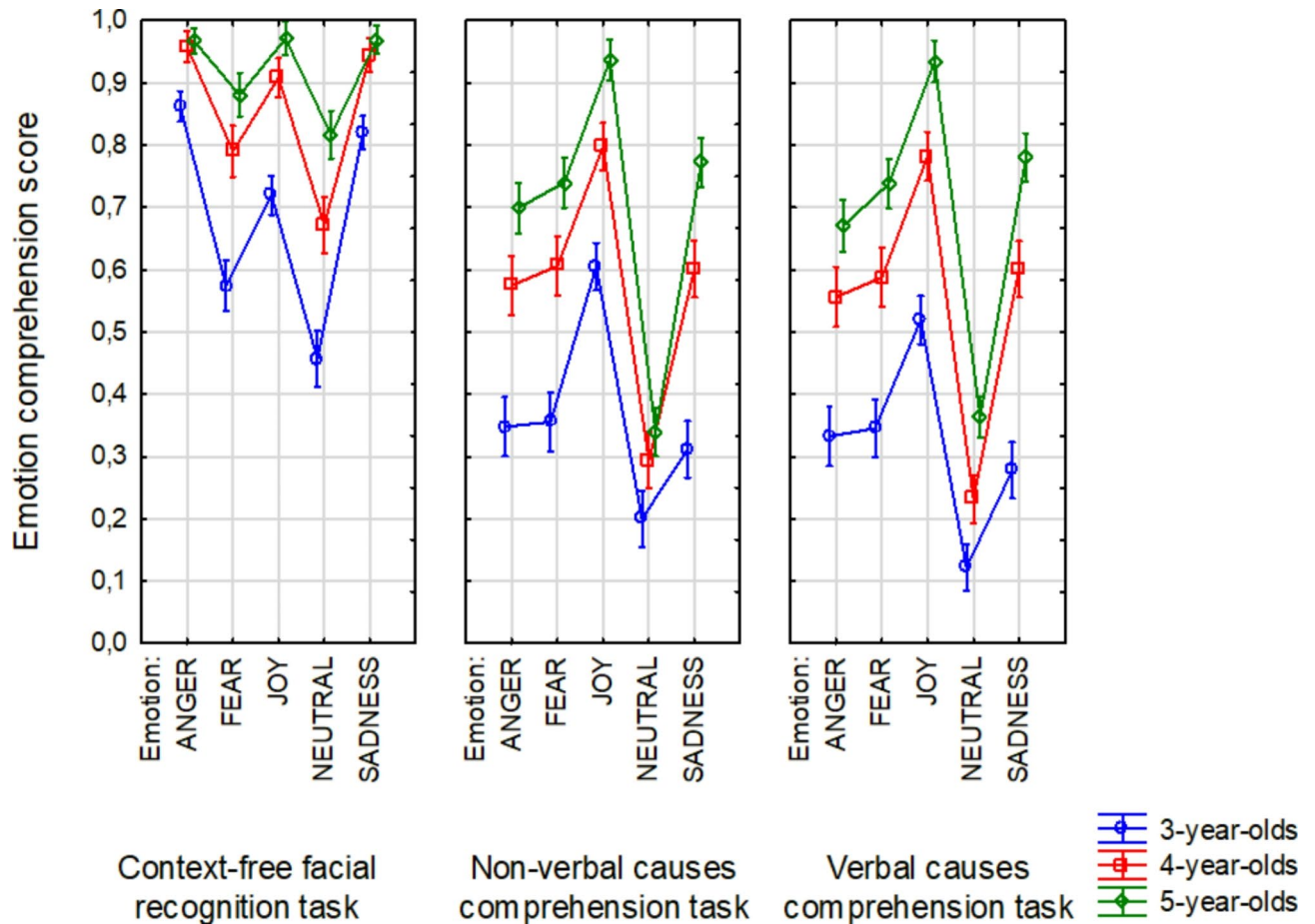


Fig. 1. Emotion comprehension score (M, SD) of each emotion for the three age groups in the three tasks tested.

the fear score, but where the anger score was significantly higher than the fear score). The 4-year-olds showed the following pattern: joy, sadness, anger, fear and neutral expression (where the sadness, anger and fear scores were all statistically equivalent). Finally, the 5-year-olds obtained the following pattern: joy, sadness, fear, anger and neutral expression (where the sadness score was equivalent to the fear score, which in turn was equivalent to the anger score, but where the sadness score was significantly higher than the anger score). These scores are detailed in Table 1.

This analysis also revealed that the triple interaction effect (type of task \times emotions tested \times age group) was significant [$F(16, 10256) = 13579, p < .001 (\eta_p^2 = 0.021)$]: we observed differences in the patterns of success in the different emotions tested in the three age groups depending on the type of task. First, in the context-free facial recognition task, the 3-year-olds showed the following pattern: anger, sadness, joy, fear and neutral expression (where the anger score was equivalent to the sadness score). The 4-year-olds showed the same pattern as the previous one (anger, sadness, joy, fear and neutral expression) but in this group the anger, sadness and joy scores were all statistically equivalent. The 5-year-olds obtained the following pattern: joy, sadness, anger, fear and neutral expression (where the joy, sadness and anger scores were all statistically equivalent).

Regarding the non-verbal causes comprehension task, we observed the following patterns of success in 3-year-old children: joy, fear, anger, sadness and neutral expression (where the fear, anger and sadness scores were all statistically equivalent). The 4-year-olds showed the following decreasing pattern: joy, fear, sadness, anger and neutral expression (where the fear, sadness and anger scores were all statistically equivalent). The 5-year-olds obtained the following pattern: joy, sadness, fear, anger, and neutral expression (where the sadness score was equivalent to the fear score, which in turn was equivalent to the anger score, but where the sadness score was significantly higher than the anger score).

Finally, for the verbal causes comprehension task, we observed the following pattern of success in the 3-year-old children: joy, fear, anger, sadness and neutral expression (where the fear, anger and sadness scores were all statistically equivalent) thus following a similar trajectory to that observed in the previous task. The 4-year-olds showed the following decreasing pattern: joy, sadness, fear, anger and neutral expression (where the sadness, fear, and anger scores were all statistically equivalent). The 5-year-olds obtained the following pattern: joy, sadness, fear, anger, and neutral expression (where the sadness score was equivalent to the fear score, which in

turn was equivalent to the anger score, but where the sadness score was significantly higher than the anger score) following once again a similar trajectory to that observed in the previous task.

General discussion

One of the aims of the current study was to examine the development of three components of emotion comprehension in three preschool age groups. The targeted components were facial expression recognition (context-free facial recognition task) based on an emotional label and the comprehension of the causes of emotions by pointing and labelling (non-verbal and verbal causes comprehension tasks) the correct emotion. Globally, the results showed significant differences in the ability to understand emotions between age groups on the global score of emotion comprehension. 5-years-old performed better than 4- and 3-years-old, and 4-years-old had better emotion comprehension scores than 3-years-old. Therefore, we found an age-related effect, which was in line with the results obtained by Pons et al. (2004)¹⁶ who showed an improvement in the two components of emotion comprehension (context-free facial recognition and the identification of emotions resulting from situational or external causes) as a function of age. This finding is promising, as it provides some evidence for the validity of our large-scale assessment tool within a specific age group. It also advances our understanding of age-related differences in emotion comprehension among 3-, 4-, and 5-year-olds, corroborated by the replication of previous results (e.g. for the importance of reproducibility/replication of results, see Diaba-Nuhoho & Amponsah-Offeh, 2021⁴¹; Open Science Collaboration, 2015⁴²). This age range appears to be a critical period for the development of this competence, as age-group differences are not only statistically significant but also reflect a moderate effect size. Future research extending this study to older children would be valuable to determine the age at which these differences level off and the tool may no longer serve as a sufficiently discriminative measure.

Moreover, we examined the influence of these three specific tasks. In a second phase, we examined whether some tasks were more complex to perform depending on children's age. Regarding the success rate of each task, all ages combined, the context-free facial recognition task was the best realized followed by the non-verbal (pointing) causes comprehension task and the verbal (labelling) causes comprehension task in decreasing order. In other words, context-free recognition of facial expressions was better mastered compared to the ability to identify and label an emotion after presenting the visual context in which the emotion was expressed and orally stating the cause of the emotion. Labelling facial expressions remained the most complex task to perform at these ages. The results also revealed a significant interaction between success on the three tasks and age group. More precisely, at the age of three, the verbal (labelling) causes comprehension task was the most difficult to perform compared to the other two. On the other hand, for both 4-year-olds and 5-year-olds, there were no significant differences between the non-verbal and verbal (pointing and labelling) causes comprehension tasks. Only the context-free recognition task remained the most successful task for each age group. This result shows that as children get older (already at 4–5 years old) they are more able to associate a chosen facial expression with the corresponding emotional term in a context of free labelling.

These findings highlighted three elements. Firstly, it seems that the older the children are, the more emotional words they have in their vocabulary. This would enable them to better recognize an emotion in a context-free situation and label an emotion. Our findings are in line with other studies that showed an increase in a more precise emotional vocabulary across age^{23,26,30–32}.

Secondly, the younger the children are, the more difficult it would be to understand emotions by labelling them compared to designating emotions after experimenter verbalization. As they grow older, the discrepancy decreases. Emotion recognition after a verbal statement by the experimenter would reflect children's understanding of the emotion felt by the character and would precede emotion free naming by children. According to Nook et al. (2020)³¹, young children tend to use physiological markers, such as referring to specific cues like crying or smiling, compared to adults, whose lexicon for understanding emotion is more extensive. Moreover, some studies showed that word comprehension (unemotional) appears early in development (from 6 to 7 months⁴³). It is therefore likely that associating an emotional label with a facial expression is an exercise that is already well mastered from an early age.

Thirdly, concerning the fact that children have more difficulties to understand the causes of an emotion compared to the recognition of emotions through an emotional term (context-free facial recognition), the results suggest that understanding the causes of an emotion (here visually and verbally presented) would require more abstract ability and probably presents a different developmental trend^{15,16} compared to the recognition of an emotion following the statement of an emotional label (context-free facial recognition). Indeed, when comparing the context-free facial recognition task to verbal (labelling) and non-verbal (pointing) causes comprehension tasks, the cognitive resources engaged by children are likely different. In the first task (context-free facial recognition), children must rely on their conceptual understanding of the emotional term (e.g., the fact that the spoken emotion is linked to specific behavioral characteristics) and simultaneously compare it to several facial expressions, sorting them according to their mental representation of the emotional term. In the other two tasks (non-verbal and verbal causes comprehension tasks), children must perceptually process the visual context along with the brief story told by the experimenter. They need to understand that these features represent the underlying cause of an emotion that is not expressed on the child's face (i.e. face without eyes, nose, mouth, or eyebrows). Then, while maintaining these various pieces of information in working memory, children need to compare different facial expressions and select the one that aligns with the visual context and the story. To achieve this, they must not only have developed knowledge about the types of situations that normally elicit a specific emotion and the corresponding emotional response (e.g. facial expression), but also be able to retrieve this information from long-term memory for use in choosing the appropriate facial expression (i.e. emotion script-based knowledge, which refers to complex categories formed by the combination of various components⁴⁴). When free labelling is added (verbal causes comprehension), children must also have an internalized bank of emotional terms and select the one that best matches what they perceive and understand^{45,46}. Consequently, the cognitive

processing required for the latter two tasks is likely more demanding and needs probably more developed mental functions, like executive functions. In a developmental perspective, preschool years are a particularly sensitive period for the evolution of executive functions^{47–49} (i.e. working memory, inhibition, flexibility). Indeed, it is during this period that core components develop rapidly^{50,51}, forming a crucial foundation that will set the stage for the development of higher cognitive processes (e.g. planification, reasoning, creativity, problem resolution) well into adulthood. For instance, although 3-year-olds are unable to inhibit a pre-potent behavioral response or cannot shift rule use, 4–5-year-olds demonstrate the ability to do so^{52,53}. These skills are essential, as accurately decoding emotions using embedded social rules (e.g., situational causes, behavioral consequences) requires children to develop executive functions (e.g., cognitive flexibility and inhibitory control). For instance, these abilities allow them to switch from one script to another and adjust their responses from one story to the next (e.g.^{46,54}). We can therefore better understand not only why there is a difference between the tasks but also the differences observed between three-year-old children and four- to five-year-old children in their performance to realize the tasks.

Finally, this study assessed the effect of these three age groups on the recognition and understanding of basic emotions, such as joy, anger, fear, sadness, and neutral emotions. Joy (total comprehension score) was the emotion best understood and neutral emotions (total comprehension) the most difficult to understand in the three age groups. In other words, the pattern of success of each emotion demonstrated that children recognize and understand the causes of the emotion of joy better already at an early age compared to the recognition and understanding of the causes of negatively valenced emotions (i.e. fear, anger, and sadness) which followed a progressive increase, in line with the existing literature^{3,21,28}. In a second phase, we examined whether there were significant differences in the understanding of these different emotions as a function of age and the type of emotion comprehension component. The results showed that for the last two tasks (i.e. non-verbal and verbal (pointing and labelling) causes comprehension tasks), when the visual and verbal causes that generate emotion were presented to 3- to 5-year-olds, joy tended to be the best-recognized emotion for each task. The other negatively valenced emotions tended to follow a similar pattern of success as a function of age and the type of task. In other words, for 3- and 4-years-old, there were no significant differences between fear, anger, and sadness scores for each task (non-verbal and verbal (pointing and labelling) causes comprehension tasks). On the other hand, at age 5, a significant distinction could be highlighted between sadness and anger for each task, with the sadness score being significantly higher than the anger score. This result is in line with the later developmental specific distinction between each emotion as in adults²³. Interestingly, for the recognition component (context-free facial recognition), even though this task was the one that children performed the best regardless of age, the pattern of success for some emotions was different from that of the two previous components involving a causal context (non-verbal and verbal causes comprehension tasks). Indeed, at the age of 3, on this recognition test without a causal context, anger and sadness were best recognized. Joy came in third place. It was only from age 5 that joy took first place. Fear remained the most difficult emotion to recognize in this task (significantly different from the other emotions), along with neutral for each age group. One hypothesis, that can explain why the facial expression of joy is more difficult to recognize at 3 year-old and that the fear and neutral expressions still remained difficult to identify, could be linked to the fact that the adults who are in charge of the child verbalize less often their own facial expression of joy, fear or when they are in a neutral or calm emotional state compared to emotions with a negative valence such as being angry or sad. This hypothesis seems consistent with the fact that between ages 2 and 3, expressions of anger peak⁵⁵. For instance, temper tantrums in young children (from 18 months to 5 years) are often expressed through crying⁵⁶. Tantrums in young children are both prevalent and frequent and involve two specific emotions: anger and sadness⁵⁷. Therefore, in reaction to the emotions expressed by young children, caregivers more often would express the fact that they are angry or sad about the child's behaviour than they are happy. Alternatively, they would more frequently name the emotions (angry and sad) the child is expressing. It is important to note that, in this task, children have no visual or verbal contextual cues to help them identify an emotion. Recognition is based solely on the emotional term given by the adult.

More particularly, regarding comprehension of neutral emotions, the comprehension scores (on all three tasks) improved with age, but they were still more difficult to understand than the other emotions. An explanatory hypothesis could be linked to the role of culture and language. According to a constructionist approach, children learn to differentiate between emotion categories within their culture as emotion words and concepts are acquired throughout infancy and childhood⁵⁸. In this vein, cultural practices might guide the idea that one must feel some emotion rather than a neutral emotion. Neutral emotion might be more common in Eastern than Western cultures⁵⁹. Eastern cultures seem to place more importance on emotional balance than Western cultures⁶⁰. East Asian cultures, for instance, tend to value moderation and seeking the “middle-way”⁶¹. In our Western cultures, less attention is probably paid at school or at home to emotions that are not in the extremes of the two valences (pleasant or unpleasant) and whose arousal is not characterized by a low or high energy (in line with what we explained previously). Emotions like calm or pleasant (see the Mood Meter⁶², a four-quadrant grid based on the circumplex model of affect⁶) should also be taught. Particularly at school, where children are also expected to be able to express these kinds of emotions. This cultural hypothesis is important, as it highlights the importance of being aware not only of what we communicate to children on a physical level (such as facial expressions), but also of the terms we use to discuss more neutral emotional states.

However, certain limitations need to be highlighted. The main limitation of this study is its cross-sectional design. Without longitudinal data, we cannot clearly infer a causal link, particularly between the children's age and the results obtained on the different measures.

In this study, we limited the tasks used to certain basic emotions, partly due to the very young age of the participants and the constrained time available for teachers to conduct the assessments with each child. In future research, it would certainly be relevant to include at least disgust and surprise, which are among the basic

emotions described by Ekman. This would allow us to broaden our understanding of the development of basic emotions during the preschool years.

It was also challenging for us to create a situation that elicits a neutral emotion. It is possible that children's lower performance on tasks involving visual and verbal contexts for neutral emotions is actually due to the fact that they interpret the situation as not generating a neutral emotion. Gasper et al. (2019)⁵ also highlight the difficulty researchers face in assessing this type of emotion.

To conclude, our results also have strong implications at the applied level: A better understanding of how (1) some specific components of emotion comprehension are affected by age (from ages 3 to 5) and (2) some basic, neutral emotions are affected by age and the type of task will help refine the conception of school programs designed to support this competence during the preschool period. Indeed, according to Sprung's et al.⁶³ meta-analysis of training studies that targeted specifically emotion understanding and measure this construct, very few studies with preschool typically developing children have been realized and selected. Only four studies with typical children targeted in their training external causes and labellisation (3 to 6 years⁶⁴; 3 and 4 years⁶⁵); external causes, mixed emotions (study 1: mean age 6 years; study 2: mean age 6 years⁶⁶) and external causes, hiding and mixed emotions (5 to 8 years⁶⁷), and one dissertation with children from a low social economic environment targeting recognition and external causes (mean age 5 years⁶⁸). The external aspect of emotion understanding represents an essential foundation for the development of the other elements (mental and reflective). All of these studies give an important place of this element in their training and of the emotional labellisation. It is therefore essential to better understand how the external components of emotion comprehension and the labellisation of basic and neutral emotions evolve during this period to examine more precisely which aspects need to be really fostered in training studies.

Data availability

The authors confirm that all data generated or analysed during this study are included in this published article and are available in supplemental materials.

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Author contributions

S.R. wrote the introduction, a section of the methodology, and the general discussion, contributed to the creation of the measure used in the study and revised the manuscript. T.C. conducted the statistical analyses, wrote the methodology, the results section and revised the manuscript. N.D., S.A., L.A., A. L., and C.B. coordinated the task passation and collected data in schools. They also revised the manuscript. E.G. initiated the study, served as the supervisor, and contributed to the writing and revision of the manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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