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Facial expressions of 5–6 month-old infants born preterm and at term were compared while tasting for the first time solid foods (two fruit and two vegetable purées) given by the mother. Videotapes of facial reactions to these foods were objectively coded during the first six successive spoons of each test food using Baby FACS and subjectively rated by naïve judges. Infant temperament was also assessed by the parents using the Infant Behaviour Questionnaire. Contrary to our expectations, infants born preterm expressed fewer negative emotions than infants born full-term. Naïve judges rated infants born preterm as displaying more liking than their full-term counterparts when tasting the novel foods. The analysis of facial expressions during the six spoonfuls of four successive meals (at 1-week intervals) suggested a familiarization effect with the frequency of negative expressions decreasing after tasting the second spoon, regardless of infant age, type of food and order of presentation. Finally, positive and negative dimensions of temperament reported by the parents were related with objective and subjective coding of affective reactions toward foods in infants born preterm or full-term. Our research indicates that premature infants are more accepting of novel foods than term infants and this could be used for supporting the development of healthy eating patterns in premature infants. Further research is needed to clarify whether reduced negativity by infants born prematurely to the exposure to novel solid foods reflects a reduction of an adaptive avoidant behaviour during the introduction of novel foods.

Keywords:
Food diversification
Weaning
Premature infants
Facial expression
Temperament
Emotion

1. Introduction

Food diversification occurs at the transition between exclusive breast- or formula feeding and the introduction to regular and significant quantities of non-milk foods. In Western or Westernized countries, parents are advised to begin food diversification between 5 and 7 months post-birth (depending on the type of food introduced), with age variations depending on country, region of birth, as well as cultures (Rigal, 2010; Schaal & Soussignan, 2008; Schwartz, Chabanet, Lange, Issanchou, & Nicklaus, 2011). In European countries, food diversification generally starts with the introduction of fruit/vegetable purées given on a spoon at one meal of the day (Maier, Chabanet, Leathwood, Schaal, & Issanchou, 2007). The timing of diversification is considered important both nutritionally and developmentally because it may instill not only healthy feeding habits at the start of life but also affect later acceptance of novel foods in infancy and beyond (Coulthard, Harris, & Fogel, 2014; Hetherington et al., 2015; Lumeng & Blass, 2008; Mennella & Trabulsi, 2012; Remy, Issanchou, Chabanet, & Nicklaus, 2013). Learning and acceptance of novel flavours are facilitated by breastfeeding (Hausner, Nicklaus, Issanchou, Mølgaard, & Møller, 2010; Maier, Chabanet, Schaal, Leathwood, & Issanchou, 2008), and may be related to the early exposure of the fetus to different taste and odor stimuli (e.g., Delaunay-El Allam, Soussignan, Patris, Marlier, & Schaal, 2010; Maier, Blossfeld, & Leathwood, 2008; Mennella, Jagnow, & Beauchamp, 2001; Schaal, Marlier, & Soussignan, 2000; Schaal, Soussignan, & Delaunay-El Allam, 2008).

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1.1. Food diversification in infants born premature

Feeding difficulties at the weaning stage are frequent in infants born preterm, with up to 70% of infants born before 33 weeks of gestation displaying feeding problems (e.g., Le Heuzey, Turberg-Romain, & Lelièvre, 2007; Linscheid, Budd, & Rasnake, 2003; Mellier, Marret, Soussignan, & Schaal, 2008; Mellier & Marret, 2013). Developmental difficulties in feeding concern distinct aspects of the weaning meal, such as access to a variety of foods (Pridham, Steward, Thoyre, Brown, & Brown, 2007), a disorganized sucking pattern (Töröla, Lehtimalmes, Yliherva, & Olsén, 2012; Wolthuis-Stiger, Luinge, da Costa, Krijnen, Van der Schans, & Bos, 2015), weaning from gastric intubation (Amaizu, Schulman, Schandler, & Lau, 2008; Lau, 2007), and acceptance of novel tasting foods (Delfosse, Soulignac, Depoortere, & Crunelle, 2006) at around 6 months of age.

Feeding difficulties in infants born preterm are a major concern expressed by parents, and are frequently reported in questionnaire studies or interviews with parents until their infants reach the age of 18–42 months (e.g., Cerro, Zeunert, Simmer, & Daniels, 2002; Garel, Bahuaud, & Blondel, 2004). For instance, Delfosse et al. (2006) reported that the introduction of solid food was perceived by parents to be problematic for 27% of infants born very premature and was distressing for 44% of these infants.

Infant temperament has been considered as an important moderator of feeding behaviour in a number of studies (e.g., Doub, Moding, & Stifter, 2015; Moding, Birch, & Stifter, 2014). Temperament is indeed assumed to have a constitutional basis reflecting individual differences in psychobiological reactivity and self-regulation (Rothbart, 1981). Some studies have found that the acceptance and rejection of unfamiliar foods by infants is dependent upon both their temperament and previous exposure to solid foods (Doub et al., 2015; Moding et al., 2014). Furthermore, prematurity may affect temperament. While some studies reported that infants born prematurely show less regularity and adaptability to change, preference for less intense stimuli, higher social withdrawal, and more negative mood than term-born infants (e.g., Gennaro, Tulman, & Fawcett, 1990; Hughes, Shults, McGrath, & Medoff-Cooper, 2002; Langkamp, Kim, & Pascoe, 1998; Spittle et al., 2009), other studies found no such differences (e.g., Larroque, N'Guyen, Guédeney, Marchand, & Burguet, 2005; Oberklaid & Sanson, 1986). Thus, the effect of infants' prematurity status on their adaptability to the multidimensional novelty of the weaning situation remains unclear.

1.2. Aims and hypotheses of the study

Previous studies have mainly based their assessment of infant feeding ability on the parental reports of difficulties. Thus, studies examining directly the responsiveness of infants born preterm when initially exposed to a novel food, often with a novel mode of consuming food with a spoon, hand or chopstick, are lacking. In addition, there are no studies to date which have examined the link between facial expressions of infants born preterm when exposed to novel foods and temperamental variables potentially related to the (non-) acceptance of novelty in food stimuli.

The present study addresses these issues by investigating facial expressions in two groups of 5–6-month-old infants either born prematurely or at term, during first time exposure to four weaning foods (2 fruit and 2 vegetable purees). Infant facial expressions were coded using the Facial Action Coding System (FACS) during exposure to the first 6 consecutive spoons given by the mother. Infant responses to these foods were also assessed by naïve raters to examine whether they communicate reliable cues about their liking or disliking of the foods. In line with previous studies on emotional development and temperament of infants born preterm (e.g., Cismaru et al., 2016; Gennaro et al., 1990; Hughes et al., 2002; Langerock et al., 2013; Langkamp et al., 1998), we hypothesized that infants born prematurely would display more negative emotions when exposed to novel fruit and vegetable purées, observable both in the objective coding with FACS or the subjective coding by naïve judges giving an overall impression. Additionally, we expected that individual differences in terms of infant temperament would be related to negative emotional expressions in response to novel foods.

2. Participants and methods

2.1. Participants

Thirty seven infants, 21 born full-term (FT) (8 boys; 13 girls) and 16 born preterm (PT) (5 boys; 11 girls), were seen for the first time at the age of 5–6 months at the parents home one month before the onset of alimentary diversification from exclusive milk feeding. PT infants were recruited in the Neonatology Service in which they were born at Rouen University Hospital. Their average gestational age at birth was 30.26 weeks (SD = 1.7 weeks) with a mean birth weight of 1519 g (SD = 356 g). FT infants were recruited in the Belvédère maternity service of the Rouen University Hospital. They had an average gestational age of 39.1 weeks (SD = 0.86 weeks) with a mean birth weight of 3278 g (SD = 483 g). Exclusion criteria were retardation in neuro-motor development or any passed and current morbidity. Among the infants born PT, 37.5% were exclusively breast-fed and 62.5% were both breast-fed and formula-fed at the time of this study, while among the infants born FT, 41% were exclusively breast-fed and 47% were both formula-fed and breast-fed. To confirm their infant's participation in the study, the parents were contacted when the infants reached 5 months of age. They were informed about reasons for the study and procedure of the experiment, and gave written informed consent.

In the current sample, the average age at the beginning of the weaning period was 5 months 22 days (±16.6 days) for FT infants, and 6 months and 16 days (±32.7 days) for PT infants. Infants' age was not corrected for prematurity in this study for several reasons. First, our study focused on infants' facial expressions following the very first exposure to non-milk foods. Thus, PT and FT infants were matched in terms of age when they were first exposed to the weaning foods. The present sample confirmed previous studies (e.g., Le Heuzey et al., 2007) showing that FT infants tend to be introduced earlier to food diversification than infants born PT (5 months and 22 days vs. 6 months and 16 days, respectively; $t(31) = 2.46$, $p = 0.024$). Second, the senses of taste and smell are functional and reliably elicit facial responses in both FT (e.g., Rosenstein & Oster, 1988; Schaal, 1988; Schaal et al., 2000; Soussignan, Schaal, Marlier, & Jiang, 1997) and PT newborns (e.g., Eckstein, 1927; Goubet, Rattaz, Pierrat, Bullinger, & Lequien, 2002; Martin du Pan, 1955; Pihet, Mellier, Bullinger, & Schaal, 1997; Rotstein et al., 2015; Schaal, Soussignan, & Hummel, 2004; Steiner, 1977). In addition, studies comparing odor or taste responsiveness between PT and FT newborns showed no fundamental differences in sensitivity or reactivity (e.g., Sarnat, 1978; Shimada, Takahashi, Imura, & Baba, 1987). Thus, chemosensory functioning, especially as assessed through facial expressions, is expected not to be strongly dependent on age within the developmental window considered. Finally, age correction is controversial (Kavšek & Bornstein, 2010) and recent epidemiological research (Wilcox, Weinberg, & Basso, 2011) has shown that adjusting for gestational age at birth in infants born PT may act as a collider and lead to bias when estimating direct effects as we do here.

2.2. Food stimuli

The infant foods were pilot-tested by a panel of 18 adults (10 women). They evaluated different brands of commercial baby-foods by smell, taste and texture to decide those which were most typical. The types of foods and flavours were chosen to conform to local practices. Fruit/vegetable purées of commercial origin are offered to infants in 84.9% of French families (Lepicard-Thiebault, 2008) and the present flavours are often given to infants to initiate weaning. The odors of the different cooked foods were representative of two fruits (peer and banana) and two vegetables (carrot and green beans). While the taste of the former was clearly sweet, the one of the latter was slightly salted and rather starchy. They conveyed globally equivalent ratings of subjective intensity. The different foods were used without further addition of any compound (e.g., salt or butter) and delivered at room temperature using a standard spoon.

2.3. Procedure

Infants were assessed during four food trials run at home following their normal meal schedule. These trials were conducted at weekly intervals over a period of four weeks. Conditions were standardized across participants. Infants were seated in a high-chair facing the mother in the room where the infant's meals generally occur (without any other persons present than the experimenter L.L.). To standardize maternal behaviour and provide infants with similar facial cues potentially fostering imitation, mothers were instructed to open their own mouth when approaching the child's mouth with the filled spoon. Each infant was videotaped in close-up view of chest and face with a camera placed at about 3 m. The order of presentation of the four food types was discussed with the mother. Although the preferred first choice was fruit or carrot purees, there was no significant difference in the order of presentation of the four foods between both groups of infants.

The percentage of video-recordings for the different test foods varied between 81 and 100% for FT infants, and 75 and 100% for PT infants (for carrot, green beans, peer and banana, we obtained 21, 21, 18, and 17 video-recordings for FT, and 12, 16, 15, and 15 for the PT infants, respectively). This unequal number of recordings per foods resulted from the fact that 8 families left the study before full completion.

2.4. Temperament

At the age of 5 months, parents were asked to complete the French version of the Infant Behaviour Questionnaire (IBQ, Rothbart, 1981). The IBQ is composed of 94 items which parents had to judge on Likert scales ranging from 1 (never) to 7 (always). Conceptual and item analyses (Rothbart, 1981) have provided adequate psychometric properties (reliability and stability) for temperamental dimensions such as activity level, fear, distress to limitations, soothability, smiling and laughter, and duration of orienting.

2.5. Behavioral coding

Infants' facial responses during the food tasting sessions were analyzed in two ways. First, accredited, trained observers used the infant version of the FACS to directly code infants' facial movements to the first six videotaped spoonfuls of each of the four foods. These first 6 spoons were chosen retrospectively as corresponding to the minimum number of spoonfuls accepted by all the infants (the maximum number being 9).

Second, naïve judges rated the degree of pleasure/displeasure expressed at global level from the video-clips of the 3rd spoonful. The FACS analyses indicated that this 3rd spoonful was representative of the emotional expressions over the whole set of 6 spoonfuls of a meal. This aim of this second analysis was to further examine whether infants' facial reactivity to novel foods could be identified by untrained observers and whether infants were able to communicate accurate information about the hedonic experience.

In both tests, one spoonful was defined as exposure to one complete sequence of ingestion including the approach of the spoon, oral acceptance of spoon, tasting/chewing the food, and swallowing.

2.6. Baby FACS coding

Black and white video-clips of infants' facial responses were independently scored with the Baby-FACS (Oster, 2007) by two certified coders (R.S. and N.R.) who were blind to the infant status (PT vs. FT) and the type of food they consumed. Baby-FACS is an anatomically based instrument in which the action units (AUs) are minimally distinguishable movements of the facial muscles. Each AU is given a specific numeric code and scored on the basis of precise criteria of transitory and subtle changes in the shape and movement of facial muscles. Table 1 presents the list of negative AUs coded in infants' facial expressions based on previous studies of facial responsiveness to odorants and tastes in infants and children (Rosenstein & Oster, 1988; Soussignan & Schaal, 1996; Soussignan et al., 1997). An index of negatively-valenced facial expressions was defined involving the following AUs: 4 (the brows are lowered); 1 + 3, 1 + 4 (the inner portions of the brows are raised and pulled together); 3 + 4 (the brows are knotted and knitted); 1 + 2 + 3/4 (the entire brows are raised); 9 (the nose is wrinkled); 10 (the upper lip is raised); 11 (the nasolabial furrow is deepened); 15 (the lip corners are pulled down); 20 (the lower lips are stretched). We also coded facial expressions of disgust involving AU 9 and/or AU 10. Because the frequency of smiles (AU 12) in response to food tasting was low, it was not included in the analysis. The inter-observer reliability for AUs was calculated based on the infants' facial behaviour during the 810 videotaped spoonfuls (135 meals $\times$ 6 spoonfuls). Inter-observer reliability provided a Cohen's kappa coefficient of 0.81 which is higher than the accepted minimum value.

2.7. Subjective evaluation of liking/disliking facial expressions

A panel of 45 naïve raters (23 women; mean age $\pm$SD: 24.5 $\pm$ 3.54 years; without expertise in coding facial expressions, and unfamiliar with the infants) evaluated the degree of liking/disliking expressed by the participants on tasting the test foods. The analysis of their rating performance according to their experience

Table 1
List of facial action units (AUs) from the Baby-Facial Action Coding System (FACS) used to code infants' negative emotional responses to the introduction of novel foods.

AU number	Baby FACS name (muscular basis)
1	Inner brow raiser (*medial frontalis*)
2	Outer brow raiser (*lateral frontalis*)
3	knitting action (*corrugator*)
4	Brow lowerer (*procerus*)
9	Nose wrinkle (*levator labii superioris alaequi nasi*)
10	Upper lip raise (*levator labii superioris*)
11	Nasolabial furrow deepener (*zygomatic minor*)
15	Lip corner depressor (*depressor anguli oris*)
20	Lip stretcher (*risorius*)

with feeding infants (never: 47%; rarely: 44%; regularly: 9% of the raters were parents) did not indicate any statistical effect of experience on their judgements. There was also no evidence that ratings of male differed from those of female judges. The raters saw each video clip individually on a 17-inch screen and reported their assessment of the infant's like/dislike using a visual-analogue scale displayed directly on the screen. The raters were told that each clip lasted about 10 s, and that they should position a cursor on a 17.5-cm line to indicate their evaluation of the degree of liking expressed by the infant. Extreme dislike and like ratings were positioned on the left and right ends of the scale, respectively, and the middle position corresponded to neutral rating. As soon as the rater's response was recorded, the software showed the next clip with the cursor automatically repositioned to the neutral point. The hedonic expression of the infant was measured between a score of 0 (maximal disliking) and a score of 100 (maximal liking). This scale allows thus to assess the *hedonic polarity* (negative: score <50, positive: score >50) and the level of *hedonic intensity* of infants' responses.

Each video clip was played in black and white, was muted, and the order of their presentation alternated the foods and the status of the infant (PT or FT). During the rating task, no information concerning the nature of the foods tasted was provided, nor was the status of the infant (PT or FT) known. The 135 clips were distributed in 4 equal blocks which were presented in random order to the judges.

3. Results

3.1. Infant facial responses through Baby-FACS coding

An analysis of variance (ANOVA), with the group of infants (PT vs. FT) as the between-subjects factor and the foodstuffs tasted (carrot, green bean, pear, and banana) as the within-subjects factor, was carried out on the rate of infants' facial expressions. The facial expression rate was defined as the ratio between the number of negative facial expressions and the total number of facial expressions (negative and non-negative facial expressions) per infant. A main effect of gestational term on the rate of facial expressions was reached for the rate of negative responses ($F(1133) = 12.38$, $p = 0.001$) and for disgust ($F(1,133) = 11.45$, $p = 0.001$). For all four foods grouped together, infants born PT displayed about two times fewer negative expressions than infants born FT (Fig. 1). There was no statistically significant effect concerning the type of food.

A second analysis examined the temporal profile of the percentage of infants displaying facial reactions over the course of the first 6 spoonfuls for each food (Fig. 2). A Cochran test comparing the number of infants showing negative responses for the first spoon versus the five following spoons revealed a significant difference

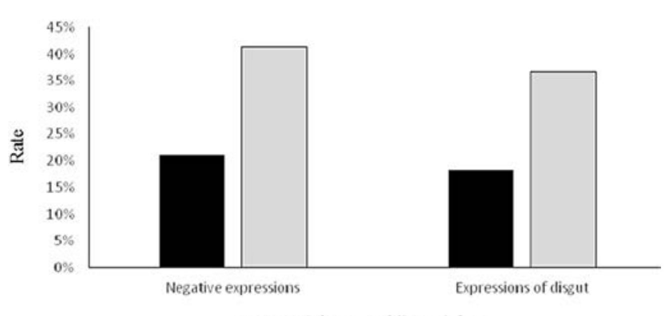

Fig. 1. Rate of infants' negative facial expressions and disgust expressions according to the term of birth.

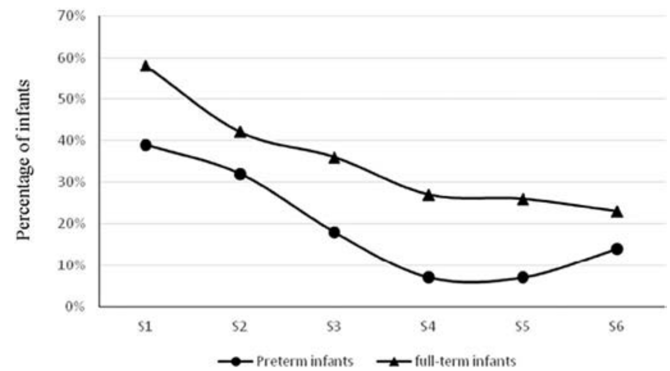

Fig. 2. Percentage of infants displaying negative emotional expressions when exposed to 4 novel foods as a function of gestational age at birth (preterm vs. full-term infants) and the course of the meal [S1 to S6: spoon 1 (S1) to spoon 6 (S6)]. The 6 spoonfuls were videotaped during consecutive time intervals and corresponded to spoons accepted by the infants (spoon in the mouth followed by chewing).

both for the infants born FT ($Q(5) = 42.01$, $p < 0.001$, n = 66) and for the infants born PT ($Q(5) = 41.70$, $p < 0.001$, n = 56). The difference in the number of infants displaying negative responses for the second spoon compared to the 4 following spoons was also significant both for the FT infants ($Q(4) = 16.74$, $p < 0.002$, n = 66) and for the PT infants ($Q(4) = 24.14$, $p < 0.001$, n = 56). Infants' negative responses were significantly more frequent for the first two spoons than for the rest of the meal. However, negative facial expressions did not vary significantly between the third and later spoons for both FT infants ($Q(3) = 5.84$, $p = 0.12$, n = 66) and PT infants ($Q(3) = 7.71$, $p = 0.052$, n = 56).

In sum, PT infants displayed a generally lower rate of negative facial expressions than FT infants in response to present test foods. Although the different test foods did not elicit discriminative responsiveness, some differential reactivity was found for the green bean purée for which negative facial responses were overall less frequent than for the other foods. The infants reacted with fewer negative responses to the first spoon than to the following ones when comparing green beans purée to the other purées in both the infants born FT (vs. Carrot: $Q(5) = 19.05$, $p = 0.002$, n = 19; pear: $Q(5) = 24.83$, $p < 0.001$, n = 16; banana: $Q(5) = 10.83$, $p = 0.05$, n = 15) and infants born PT (vs. Carrot: $Q(5) = 11.73$, $p = 0.039$, n = 12; pear: $Q(5) = 12.80$, $p = 0.025$, n = 15; $Q(5) = 16.43$, $p = 0.006$, n = 15). As in the preceding analysis, the number of infants displaying a negative response to the 3rd spoonful was not statistically different from subsequent spoonfuls.

We also calculated the percentage of infants displaying negative facial responses from spoons 1 to 6 according to the experience of spoon-feeding as measured by the number of weeks on this regime. The present food trials with vegetable/fruit purées were filmed at 1-week intervals, allowing for at least one spoon-fed meal per day between two sessions (i.e., around 20 meals at the 4th session, 15 meals at the 3rd session and 8 meals at the 2nd session). In FT infants, a significant decrease in the number of infants displaying negative responses was found beyond the first spoon for the 2nd session ($Q(5) = 19.74$, $p = 0.001$, n = 18) and for the 4th session ($Q(5) = 16.33$, $p = 0.006$, n = 16). In PT infants, the decrease in negative responses was clearly noted in sessions 1 ($Q(5) = 20.29$, $p = 0.001$, n = 14) and 4 ($Q(5) = 20.10$, $p = 0.001$, n = 13).

3.2. Infant facial responses as rated by naïve adults

Given the results obtained with the Baby FACS, naïve adults were only required to decode and rate the 3rd spoon given to the infants. A 2−way ANOVA was conducted on the liking/disliking scores rated by the judges with the group of infants (PT vs. FT) as the between-subjects factor, and the test food (carrot, green bean, pear, and banana) as the within-subjects factor. Facial expressions of infants born PT were rated more strongly on the positive side of the scale than those of infants born FT (Fig. 3). The index of hedonic intensity indicated a mean value of 57.27 ($SD = 15.06$) for PT infants and 46.86 ($SD = 19.44$) for FT infants ($F(1,133) = 12.78$, $p < 0.001$).

The comparison of both FT and PT groups by Chi^2 test on the hedonic rating by the raters (rating in the range [0–50] vs. rating in the range [50–100]) indicated that PT infants were more often evaluated than FT infants as displaying facial expressions indicative of pleasure while eating these test foods (ratings >50) ($\chi^2(1) = 7.04$, $p = 0.008$).

3.3. Relationships between the FACS coding and subjective rating

The intensity of negative facial responses as evaluated by the hedonic scores lower than 50 attributed by naïve raters on the 3rd spoonful of each of the 4 meals was correlated with the intensity of expressions coded as the sum of negative AUs across the first 6 spoonfuls of the 4 meals. Both of these evaluations are negatively correlated ($r = -0.76$; $p < 0.001$) in FT ($r = -0.77$, $p < 0.001$) and PT infants ($r = -0.68$, $p < 0.001$).

3.4. Temperament and facial responses to novel foods

The scores on the various dimensions of temperament reported by mothers through the IBQ did not differ significantly between both groups of infants.

However, Pearson correlation coefficients indicated significant relationships between negative facial responses (as measured by the Baby-FACS) to the present foods and the dimensions “laughs and smiles” and “soothability” in FT infants (laughs and smiles × negative AUs: $r = -0.35$, $p = 0.004$, n = 65; soothability × negative AUs: $r = -0.346$, $p = 0.005$, n = 65). Further, in FT infants, significant correlations were found between liking to the foods as rated by the judges and these two same positive dimensions of temperament (laughs and smiles × pleasure: $r = 0.32$; $p = 0.009$, n = 65; soothability × pleasure: $r = 0.34$, p = 0.005, n = 65). Finally, in PT infants, a significant correlation was detected between the “distress to limitations” dimension and the infants' liking of foods as rated by the judges (frustration × pleasure: $r = -0.45$, $p = 0.0001$, n = 58).

4. Discussion

The results of both objective coding and subjective ratings of the facial responses indicate that infants born preterm display fewer negative reactions than infants born full-term when exposed at weaning for the first time to novel foods. This outcome is contrary to our expectation that infants born PT would show more negative emotional responses than infants born FT when exposed to food novelty during diversification from non-milk foods. First, coding of facial movements by trained experts (using the Baby-FACS) reveals that both vegetable (carrot and green beans) and fruit (pear and banana) purées resulted in more negative facial expressions by FT compared with PT infants. Second, naive rating of infants' facial expressions to these novel foods indicates that PT infants communicate more liking, or less disliking, than FT infants. This confirms our second hypothesis which predicted a significant correlation between objective coding of infant facial movements and the overall impression of emotional expressions by naïve raters. However, these naïve raters judged the infants facial expressions more positively than the trained coders. This suggests that naïve raters may have taken into account information beyond the mere hedonic expression of the face, in including additional cues from the infants' posture or motor tonicity. It is also possible that the more positive score reported by the raters for PT infants (score of 57.27) reflects indifferent and neutral reactions to the test foods (as compared to FT infants who scored 48.86 and displayed negative reactions). This latter interpretation is in line with previous studies unrelated to eating contexts where PT infants were described as less responsive to stimuli than FT infants when their behaviour was assessed using the Bayley Scales of Infant Development (Meisels, Plunkett, & Cross, 1987) or were less reactive toward fear-eliciting situations (Langerock et al., 2013). From this account, although food neophobia is usually considered as minimal in young infants when solid foods are being introduced (Lafraire, Rioux, Giboreau, & Picard, 2016), a higher rate of negative facial expressions in FT infants might be interpreted as an initial attempt of food rejection. Such responses might have an adaptive significance in protecting infants when exposed for the first time to foods that convey multiple unfamiliar cues (odor, taste, texture).

Our analysis of infants' emotional expressions over the course of the first meals given with a spoon revealed that negative reactions were more pronounced at the beginning of the meal, and in particular for the first two spoons, regardless of birth status, the type of food offered and the order of flavour presentation (vegetable vs. fruit purée). The 3rd spoon appeared to mark the onset of a familiarization phenomenon to the novel foods (texture, temperature, taste, smell), to being fed with a spoon, or to both types of events. Thus, infants indicate their ability to process the sensory qualities conveyed by novel foods and to become familiarized with it from the 3rd spoon onwards. In the conditions of the present study, even 5–6 month-old infants born preterm do not need any longer time to get used to novel, non-milk foods and may be able to familiarize to the multisensory context created by novel foods. Therefore, we argue that early developing sensory modalities (here, oral and nasal chemosensation, and oral somesthesis), in the same way as palmar somesthesis (e.g., Lejeune & Gentaz, 2013), allow for an effective perceptual treatment of corresponding stimuli in 5–6 month-old infants born PT. In contrast, late developing sensory modalities (vision) appear less effective in PT infants than in FT infants (e.g., Kavšek & Bornstein, 2010). This difference in chemosensation and somesthesis between PT and FT infants may be explained by Gottlieb's (2002) theory on the sequential ordering of perceptual development. This theory predicts that, at early stages of development, the earlier maturing sensory modalities may dominate in the control of behaviour as compared to later maturing modalities (vision). Accordingly, earlier developing sensory functions (such as chemoreception and oral somesthesis) may prevail so as to protect the formation of adaptive perceptual abilities.

We did not find any difference in infants' reactions to the four

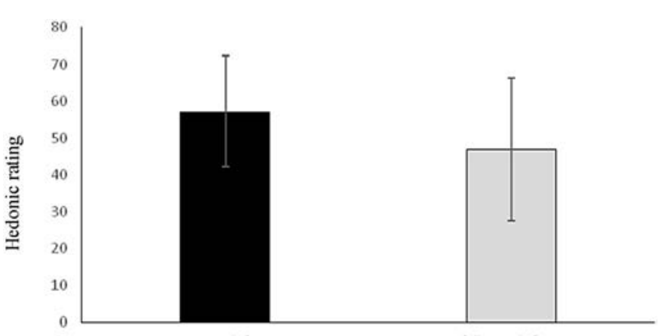

Fig. 3. Mean hedonic scores (±SD) rated by judges (scores ranging from 0 to 100) according to gestational age at birth in infants exposed to novel foods.

types of vegetable/fruit purées as a function of their gestational age at birth. Thus, at least within the limits of the 4 flavours selected here, and specifically the sweet vs non-sweet foods, no differentiation of facial responses did appear. The only notable effect appeared not to be food-dependent and concerned the substantial decrease of negative expressions in PT infants starting in the 1st week of eating a novel food from a spoon, i.e. without any previous experience of spoon-feeding. In contrast, this decrease of negative reactions was shown during the 2nd week for FT infants. Given that the 4 types of foods were presented randomly over a 4-weeks period, we can conclude that the responses to the variable qualities of the foods were not confounded with the effects of habits or practices of feeding.

The data on infant temperament reported by the parents one month before the onset of the study did not indicate any differences according to the term of birth as previously reported (Larroque et al., 2005; Oberklaid & Sanson, 1986). We have nevertheless found individual differences within each group of infants as revealed by significant correlations between some dimensions of infants' temperament and their facial responses to novel foods. On the one hand, a negative dimension of temperament (distress to limitations) was moderately associated with fewer expressions of liking in PT infants. This dimension of temperament reflects infant's fussing, crying or showing distress in diverse situations (a confining place or position; caretaking activities; inability to perform a desired action) (Rothbart, 1981). This suggests that infants born PT who were perceived by their parents as more fussy and difficult at 5 months of age were those who communicated less pleasure for foods by their facial expressions. On the other hand, two positive dimensions of infants' temperament (laughs and smiles and soothability) were correlated with both the objective coding and subjective ratings of emotional expressions of FT infants. This may reflect that the infants born FT who were rated by their parents as displaying more often positive expressions (at age 5 months in caretaking and play situations) and a reduction of fussing/crying (when soothed) were those who displayed the lower scores of negative facial expressions and communicated more pleasure toward foods. Thus, our data confirm that infant temperament is a possible moderator of affective reactions to unfamiliar foods (Doub et al., 2015; Moding et al., 2014).

The current research has several limitations. First, it does not take into account the rhythm of ingestion, the total duration of the meal, the total quantity of ingested food, and the cues that parents may use to make overall judgement as to whether their infant has "eaten well". Second, our analysis does not take into account the "social dimension" of the meal; rather, we specifically analyzed the sensory and hedonic responses in close relation to the sensory-motor expressions during the 1st spoons of a meal, while minimizing potential differences based on maternal initiated variations during feeding interactions. Future research should take these sources of variation into account in filming both the infant and the mother during the feeding interaction. Finally, future research might investigate the role played by the adults' representations of the infant's gestational term (e.g., video-clips of eating infants analyzed by raters with full knowledge vs. without knowledge of the infants' gestational term) to evaluate their impact on the perception of emotional expressions of preterm infants.

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