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# The effect of postnatal age on the early tactile manual abilities of preterm infants

Fleur Lejeune [a,*], Frédérique Berne-Audéoud [b], Leïla Marcus [b], Thierry Debillon [b], Edouard Gentaz [c,d]

[a] Child Clinical Neuropsychology Unit, University of Geneva, Switzerland
[b] Intensive and Regular Neonatal Care Unit, CHRU Grenoble, France
[c] Psychology and NeuroCognition Laboratory, University of Grenoble, CNRS, Grenoble, France
[d] Sensorimotor, Affective and Social Development Unit, University of Geneva, Switzerland

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ABSTRACT

*Background:* Although preterm infants possess early tactile manual abilities, the influence of the postnatal experience has not yet been systematically examined.
*Aims:* To investigate whether early tactile manual habituation, discrimination and recognition (following interference) of shape in preterm infants are modified by postnatal age.
*Study design:* Prospective study.
*Subjects:* Forty preterm infants were assessed from the post-conceptional age (PCA) of 34 weeks. Two groups were made up according to postnatal age (PNA): low PNA (PNA ≤ 10 days of life) and high PNA (PNA ≥ 12 days of life).
*Outcome measures:* An object (prism or cylinder) was presented repeatedly in the left hand, and holding times of the object were recorded during each trial.
*Results:* Holding time was shorter for all preterm infants following successive presentation of the same object irrespective of postnatal age range. In the discrimination phase, the mean holding time for the novel object was longer than holding times in the last two habituation trials, in both PNA groups. Finally, the mean holding time of the familiar object presented in the recognition phase was shorter than the holding time of the novel object presented previously, but only in the low PNA group.
*Conclusions:* Tactile manual habituation and discrimination of shape information is present in preterm infants at a post-conceptional age of 34 weeks, independently of postnatal age. However, tactile manual recognition of familiar shapes following interference is affected by length of postnatal experience. The significance of this last result is discussed in detail.



## 1. Introduction

The first sense to develop *in utero* is the somatosensory system. Researchers who have taken an interest in aborted foetuses' response to tactile stimulation on different parts of the body [1–3] have found that cutaneous receptors are present at a very early stage in embryogenesis. They appear around the mouth from the 7th week of gestation, and develop throughout the body by cephalocaudal maturation until 20 gestational weeks (GW). In addition, pressure exerted by an object on the palm of the hand (grasping reflex) causes the fingers to close around the stimulus and is observed from 18 GW [1]. However, grasping at birth is not only a pure reflex. Tactile manual exploration of objects allows the full-term newborn to gather information about their weight, substance, texture, and shape [4–9].

Recent studies have investigated tactile manual abilities in preterm infants using habituation and reaction to novelty procedures. The infants in question had a post-conceptional age of between 33 and 34 + 6 GW and a mean postnatal age of 20 days (ranging from 3 to 50 days). Results revealed that from a post-conceptional age of 33 weeks, preterm infants were able to memorise tactile information about specific shape features (prism or cylinder), and to detect differences between the two shapes with either the right or left hand [10]. These abilities were not influenced by hand, shape, medical history, birth weight, gestational age, post-conceptional age, and postnatal age. These results were also replicated in younger preterm infants and similar skills were observed from a post-conceptional age of 28 weeks [11]. Moreover, these preterm infants were also able to recognize familiar shapes following interference (prior presentation of the novel shape), suggesting the existence of a functional

* Corresponding author at: Unité de psychologie clinique et neuropsychologie de l'enfant, Faculté de Psychologie et de Sciences de l'Education, Université de Genève, Bd du pont d'Arve, 40-1211, Geneva, Switzerland. Tel.: +41 22379 9287.
*E-mail address:* Fleur.Lejeune@unige.ch (F. Lejeune).

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short-term haptic memory from 28 GW. The infants in this study [11] were assessed before the post-conceptional age of 34 GW, during the first 10 days of life, in order to minimize postnatal experience. Postnatal experience refers to the period comprised between the birth and the day of the evaluation. Therefore, preterm infants do possess early tactile manual abilities, but the influence of postnatal experience has not yet been systematically investigated.

Postnatal experience is of great interest because preterm infants are exposed to a particular environment—the neonatal intensive care unit (NICU). They are physiologically immature and therefore need the daily medical care provided by the NICU to survive. A preterm birth means a brutal and premature change for the neonate. They come from a protected environment with muted sound, dimmer lighting, and limited tactile stimulation compared with the NICU, which can be bright and noisy, and involves frequent nursing and medical intervention including numerous tactile demands and painful procedures [12]. These environmental conditions, in relation to medical factors, lead to behavioural and physiological stress responses [13], which in turn affect the preterm infant's immature nervous system [14–17]. The impact of NICU on cerebral development is also supported by studies on developmental care (for example, massage therapy, Neonatal Individualized Developmental Care and Assessment Program), which aim to minimize neonatal discomfort by controlling sensory stimuli. Studies have shown that developmental care has beneficial effects on brain development [18,19]. Some studies have also revealed that postnatal experience can modify (enhancement or alteration) specific aspects of audition and vision in preterm infants, indicating the vulnerability of their immature sensory systems (for details, see discussion [20–22]). In addition, hospitalized infants experience up to 14 painful procedures per day and up to 53 different procedures during their first 15 days of life [23]. Knowing that preterm infants in their incubators receive lots of repetitive and stereotyped tactile stimulation (daily care, alimentation, medical examinations, etc.), could longer exposure to the NICU modify early tactile manual abilities?

The main purpose of the present study was to investigate whether early tactile manual abilities in preterm infants were modified by postnatal experience. We used a classic habituation/discrimination procedure followed by a recognition phase. In order to evaluate the effect of postnatal experience, we compared two groups of preterm infants based on their postnatal age, but at the same developmental stage (from the post-conceptional age of 34 GW). One group had a low postnatal age (≤10 days of life, based on a previous study [11]) and the other had a high postnatal age (≥12 days of life). Firstly, we expected that all preterm infants' holding times would decrease following successive presentation of the same object, independently of postnatal age range. Secondly, we defined discrimination as having occurred when the mean holding time for the novel object was significantly longer than the mean holding time in the last two habituation trials. Thirdly, recognition was defined as having occurred when the mean holding time for the familiar object presented in the recognition phase was significantly shorter than the mean holding time for the novel object presented previously in the discrimination phase. We expected that preterm infants in the low postnatal age group would display the same tactile manual discrimination and recognition abilities as those previously observed at a younger post-conceptional age [11]. We also investigated whether these abilities were modified by a longer postnatal experience in the high postnatal age group.

## 2. Method

### 2.1. Participants

Participants were 40 preterm infants (19 girls and 21 boys), hospitalized in the intensive and neonatal care units in Grenoble Hospital (France) between March 2009 and February 2013. We excluded from the study preterm infants with polymalformative syndrome, cystic periventricular leukomalacia, grade III or IV intraventricular hemorrhage based on their cranial ultrasound, and those who received sedatives or anticonvulsive treatment during the experiment. An additional 14 preterm infants were excluded from the study because of crying (2), drowsiness (6), or sleeping (6).

All preterm infants were assessed once between the post-conceptional age (PCA) of 34 weeks and their discharge. We decided to create two distinct groups based on postnatal age (PNA): low PNA (PNA ≤ 10 days of life, based on a previous study [11]), and high PNA (PNA ≥ 12 days of life). The infants were randomly assigned to these two groups by the nurse in charge of the neonatal unit. Each PNA group was composed of 20 preterm infants. We compared general and medical characteristics in the two groups. Significant group differences were found in general characteristics: the low PNA group had a greater gestational age ($t(38) = 7.13$, $p < .001$) and higher birth weight ($t(38) = 3.81$, $p < .001$), and a lower postnatal age ($t(38) = 5.76$, $p < .001$) than the high PNA group (Table 1). They did not, however, differ significantly on post-conceptional age and weight at time of test. There was no significant difference in the medical characteristics between the two groups regarding gender, mode of delivery, hypotrophy, Apgar scores at 5 and 10 minutes, or the presence of nasal cannula (Table 2). However, more infants in the high PNA group needed antenatal steroid treatment ($\chi^2 = 11.12$, $p = .001$), intubation ($\chi^2 = 10.16$, $p = .001$), nasal continuous positive airway pressure ($\chi^2 = 11.49$, $p = .001$), or catheterization ($\chi^2 = 12.91$, $p < .001$) than in the low PNA group.

Parents gave written consent for infants to participate. The present study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee of the LPNC (CNRS and University of Grenoble 2). Testing was classified as purely behavioral and involved no discomfort or distress to the infants.

### 2.2. Display and apparatus

Each infant was wrapped comfortably and assessed in his incubator just before or just after care, in an arousal state of 4 on the Brazelton scale (quiet wakefulness) [24], and more than 1 hour after being fed. Testing was conducted without visual control: the first experimenter positioned the infant's head to the opposite side of the hand being tested and if the infant turned his head, the experimenter placed her hand between the infant's eyes and the object. We tested the left hand, as it was mostly free of any prosthesis and no hand differences have been found in previous studies [10,25]. In addition, the experimenter held the infant's forearm gently throughout the entire experiment in order

**Table 1**
Preterm infants' general characteristics according to postnatal age range: mean (standard deviation), [range].

| Characteristics | Low PNA | High PNA | *P* |
|---|---|---|---|
| Gestational age (weeks) | 34 + 1 (.77), [32 + 4–35 + 4] | 30 + 5 (2), [26–34 + 1] | <.001 |
| Birth weight (g) | 1,819 (338), [1,170–2,510] | 1,415 (332), [900–1,905] | <.001 |
| Post-conceptional age (weeks) | 35 + 1 (.75), [34–36 + 4] | 35 + 1 (1.2), [34 + 1–38 + 3] | NS |
| Postnatal age (days) | 6.8 (2.8), [2–10] | 31.2 (18.7), [12–87] | <.001 |
| Weight at test (g) | 1,801 (343), [1,340–2,580] | 1,911 (451), [1,300–2,940] | NS |

*Note*: NS, no significant difference.