

Haptic perception in the human foetus

Peter G. Hepper

Introduction

Recent years have seen increased exploration of the sensory development of the foetus [1]. All five senses, auditory, visual, cutaneous, olfactory and gustatory and been demonstrated to begin functioning in the prenatal period. It is the aim of this chapter to review the evidence of haptic perception in the human foetus. The development and function of other senses is briefly presented. However before reviewing this evidence it is necessary to pause to consider some general issues which must be borne in mind when evaluating the evidence presented by these studies.

Sensory and perceptual development in the foetus

First, it is important to distinguish between sensation and perception [1]. Often researchers reporting studies in this area use the two terms interchangeably but this is an error as the two are different. Sensation refers to the transduction of the physical signal by the sensory receptor and turning this physical signal into neural impulses. Thus a sound stimulates the hair cells of the inner ear and neural impulses are generated by the hair cell and transmitted to the cochlear nerve for onward neural transmission to the brain. Sensation refers simply to the act of transducing the physical stimulus into neural stimuli within the nervous system. Perception is the process which adds meaning to these neural impulses as they interact with the various centres and pathways in the brain. Thus if the sound stimulus were

the voice of the infant's mother, the sensation experienced would be the various parameters of the sound, for example its frequency, duration, intensity. The perception experienced would include, for example, recognition of the voice as mother, the meaning of the words spoken by the mother, and potentially the urgency or otherwise of the information conveyed. Caution must thus be exercised in interpreting the results of studies examining foetal sensory and perceptual development. Although the foetus may respond to the sound of its mother's voice, whether the foetus perceives this stimulus as its mother's voice or is responding to a sensation due to the presence of a sound, needs careful experimentation and consideration.

A second issue concerns the onset of the development of sensory abilities. To determine whether the foetus detects a particular stimulus we have to rely on observation of a change in its behaviour, e.g., a sudden behavioural jump to the onset of a loud sound. Observation of the foetus's movement may be achieved through ultrasound [2, 3] or recording its heart rate [4, 5].

With appropriate methodology and controls the presence of a response following presentation of a stimulus can reliably be used to assume that the foetus has detected the stimulus presented. The inverse however is not true. In the absence of a response, great care must be exercised in drawing the conclusion the foetus cannot sense the stimulus. To respond the foetus requires both the neural apparatus to detect the stimulus and elicit a response (the one we are looking for) and the appropriate connections between sensory and motor pathways. Lack of any one may result in a lack of response. This is particularly important to bear in mind when con-



FIGURE 1. HUMAN FOETUS IN THE 21ST WEEK OF GESTATION.

Picture from Prof. Holger Stepan, Department of Obstetrics, University of Leipzig.

sidering the age of onset of sensory responding in the foetus.

The final issue concerns the natural foetal environment. It is very easy to elicit a response to sound in late gestation foetuses by playing sound through a loud speaker placed on the mother's abdomen. However this is not natural. If we are to consider the role of sensory stimulation for normal development it is important to consider whether, in the normal course of pregnancy, the foetus will be naturally exposed to these stimuli. It may be very easy in the experimental scenario to present a wide range of stimuli to the foetus, but these may not be experienced by the foetus in the normal course of pregnancy.

Sensory development in the foetus

Before considering the development of cutaneous sensation and perception in the foetus a brief overview of the sensory development of the other sensory systems will be provided.

By far the most studied sensory system in the foetus is that of audition [6]. This undoubtedly

reflects the ease with which auditory stimuli can be presented to the foetus. Responses to auditory stimuli have been observed using movement [7], heart rate [8] and most recently in late gestation using fMRI techniques [9]. Evidence indicates that the foetus begins to respond to sound around 24 weeks of gestation [10] but in a very restricted range of frequencies and at high intensity. As the foetus develops the sensitivity of its hearing increases and the range of frequencies responded to expands [11].

Studies which have played specific stimuli to the foetus (e.g., music, voices) have observed that the newborn responds to these sounds differently compared to other, unfamiliar sounds [12, 13]. This strongly suggests that these stimuli sound similar when 'heard' *in utero* to the way they sound outside of the womb, providing strong evidence for continuity of auditory experience before and after birth. The mother's skin attenuates sounds outside the womb but around the fundamental frequency of the human voice there is little attenuation and speech sounds will pass relatively unaltered into the foetus's environment [10, 14]. As well as the external environment providing a rich source of sounds the mother's physiological systems also provide noise, e.g., heart beat, digestive system [14]. Thus the foetus responds to sound and is naturally stimulated by sound in the womb.

The same cannot be said of vision. It is possible to elicit a motor response, observed on ultrasound, or a change in heart rate, by discharging a camera flash light over the mother's bare abdomen [15–17] from 26 weeks of gestation. However it is unlikely in the natural course of pregnancy that visual stimuli will penetrate the womb in such a distinct and discrete fashion. At best there may be a generalised glow if the women exposed her abdomen to sunlight but not a specific point source of stimulation. Thus while the foetus can respond to visual stimuli it may be unlikely that it will be naturally stimulated during pregnancy [1].

Studies have found that the foetus appears responsive to both smell and taste stimuli [18]. It is difficult to separate smell and taste *in utero* and both senses are usually considered together.