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# The effect of face exploration on postural control in healthy children

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ABSTRACT

The objective was to explore how face exploration affects postural control in healthy children. The novelty here is that eye movements and posture were simultaneously recorded. Three groups of children participated in the study: 12 children of $7.8 \pm 0.5$ years old, 13 children of $10.4 \pm 0.5$ years old and 12 children of $15.7 \pm 0.9$ years old. Eye movements were recorded by video-oculography and postural stability was recorded by a platform. Children were invited to explore five emotional faces (neutral, happy, sad fear and angry). Analysis of eye movements was done on saccadic latency, percentage of exploration time spent and number of saccades for each specific region of interest (ROI): eyes, nose and mouth. Analysis of posture was made on surface area, sway length and mean velocity of the center of pressures (CoP). Results showed that visual strategies, exploration and postural control develop during childhood and adolescence. Indeed, after nine years-old, children started to look the eyes ROI firstly, then the nose ROI and finally the mouth ROI. The number of saccades decreased with the age of children. The percentage of exploration time spent in eyes ROI was longer than the others ROIs and greater for unpleasant faces (sad, fear and angry) with respect to pleasant emotional face (happy). We found that in front of sad and happy faces the surface area of the CoP was significantly larger compared to other faces (neutral and angry). These results suggest that visual strategies and postural control change during children's development and can be influenced by the emotional face.



## 1. Introduction

Many studies have explored the effect of performing a secondary task on postural sway, so called dual-task. Postural stability is not an automatically answer but it depends to environment [1] and different types of secondary tasks may influence postural stability in different ways: either increasing or decreasing postural sway depending on the attentional cost of the task [2]. The U-shaped non-linear interaction model described by Huxhold et al. [3] suggests that the performance of an easy secondary task can shift the focus of attention away from postural control, leading to a better postural stability relative to a single postural task. Olivier et al. [4] using dual task paradigm described that postural control in children decreased when a second cognitive task involved a high level of attention. Indeed, the increase of the difficulty of the secondary task can be responsible for a degradation of postural control. In everyday life postural control always needs to be performed at the same time as other tasks, in other words postural sway is naturally a part of dual or multiple tasks.

Darwin [5] had already proposed a relation between posture and emotional states. In the last decade, some studies have explored the effect of emotion on posture in adult subjects only. Hillman et al. [6] have reported in adults that postural control changes while viewing affective pictures: in front of unpleasant pictures, female increased postural movements in the posterior direction, while males increased postural movements in the anterior direction. In other words, female exhibited increased movement away from unpleasant pictures with respect to males. Furthermore, Azevedo et al. [7] have shown that in front of unpleasant stimuli, adult subjects decreased the surface area of the center of pressure, exhibiting a 'freezing' behaviour. They suggested that such behaviour has been reported in humans and other many animal species when faced with threatening stimuli activating neural circuits which promote defensive survival. The study of Ohno et al. [8] in healthy teenagers showed that anxiety state decreased postural stability. They made the hypothesis that the anxiety state involved a less efficiently use of visual inputs due to an increase of pupillary diameter. To our knowledge, no study exists exploring the effects of emotion on

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postural sway in children by recording at the same time, both eye movements and postural performance.

Several studies have been conducted describing facial emotion exploration in children. Children have a greater attraction for human faces and face processing capability in children changed and improved with aged. Batty et al. [9] showed that face processing depends on the nature of emotion and that there is a developmental aspect concerning face processing of unpleasant and pleasant emotions. The network for processing unpleasant emotion expands earlier than those for pleasant emotions, the latter most likely related to the activity of frontal region of the brain.

Based on such findings facial emotion processing in children could change during childhood and adolescence because the brain activation changed with age. Indeed, Forbes et al. [10] reported that brain activation during face exploration is different depending to the age of young subjects; for instance, pre-adolescents (mean age 11.80 years) and late-adolescents (mean age 12.46 years) showed a different activity in the amygdala and in the ventrolateral prefrontal cortex while they were viewing emotional faces. Moreover, Vuilleumier and Pourtois [11] in a fMRI and ERP study described that emotional face processing implicates an interactive network with several cortical structures (fusiform cortex, amygdala, occipital cortex, superior temporal sulcus, parietal areas). At the same time, it is also well known that eye movement performances are developing with age in relation to brain maturation and that the control of postural sway continues to improve during childhood until the adolescence [12].

In this context, the goal of this study was to record simultaneously postural and eye movement's performance in healthy children during a dual task. More precisely, we wonder to explore in children whether emotional faces exploration could affect postural stability. Based on previous knowledge, our driven hypothesis was that with age increasing, children could improve both postural and emotional faces exploration abilities. Secondly we made the hypothesis that emotional faces processing could also lead to a different saccade and fixation performance, which could affect in a different way postural stability.

## 2. Experimental procedures

### 2.1. Subjects

Thirty seven healthy children participated in the study in Robert Debré hospital. The investigation adhered to the principles of the Declaration of Helsinki and was approved by our Institutional Human Experimentation Committee (Comité de Protection des Personnes CPP Ile de France V, Hôpital Saint-Antoine), written consent was obtained from the children's parents after an explanation of the experimental procedure).

Children were divided into three groups depending on their age: 12 children between 7 and 8 years (with mean age: $7.8 \pm 0.53$ years 10 males and 2 females), 13 children aged between 9 and 11 years (with mean age: $10.4 \pm 0.51$ years 9 males and 4 females) and 12 children aged between 14 and 17 years (with mean age: $15.7 \pm 0.86$ years 4 males and 8 females).

ANOVA performed on mean age showed that groups were significantly different from each other ($F_{(5,73)} = 262.84$, $p < 0.0001$). Children had to fulfill the following criteria to be included in the study: no known neurological or psychiatric history, without autistic spectrum disorder, no orthopedic, anatomical or scoliotic anomaly and no visual impairment or difficulty with near vision.

Children underwent complete sensorial and motor ophthalmologic examinations (mean values showed in Table 1). All children had normal binocular vision (mean value of 51 s of arc), which was evaluated with the TNO random test. Visual acuity was normal ($\geq$20/20) for all children. The near point of convergence was normal for all children (mean value of 2 cm). Heterophoria at near distance (i.e. latent deviation of one eye when the other eye is covered, using the cover-uncover test) was normal for all children tested (exophoria $\leq$ 3.5 pD). Moreover, an evaluation of vergence fusion capability using prisms was done at near distance. The divergence and convergence amplitudes were also normal for all children. All children tested had also normal vestibular function.

### 2.2. Material

#### 2.2.1. Visual stimuli

Stimuli were presented on a PC screen of 22 inches, with a resolution of $1920 \times 1080$ and a refresh rate of 60 Hz. Five Ekman's emotion pictures, extensively validated in Ref. [13], were randomly presented to children during postural measure (25.6 s). One pleasant happy face and three unpleasant faces expressing sad, fear and angry. Furthermore a neutral face was also presented as control. All faces measure $11.8^\circ \times 15.2^\circ$ and are shown in Fig. 1. The specific choice of these emotional faces is based on the fact that they are non-violent pictures and can be explored by young children. All emotional faces were presented once during 25.6 s and between trials a rest time of few seconds was given to the child in order to reduce possible fatigue effect.

#### 2.2.2. Eye movement recordings

Eye movements were recorded with the Mobile Eyebrain Tracker (Mobile EBT®, e(ye)BRAIN), an eye-tracking device CE marked for medical purposes. The Mobile EBT® benefits from a high frequency camera that allows it to record both the horizontal and vertical eyes positions independently and simultaneously for each eye. Recording frequency was set up to 300 Hz. The precision of this system is 0.5°. The recording system does not obstruct the visual field, and the calibrated zone covers a horizontal visual angle of ±22°.

#### 2.2.3. Platform

A platform (principle of strain gauge) consisting of two dynamometric clogs (Standards by Association Française de Posturologie 1985, 1986, produced by TechnoConcept®, Céreste, France) was used to measure postural stability.

The position of the feet was the following, on the footprints: heels distant by 2 cm and feet spread out in a symmetric way with respect to the sagittal axis of the child at a 30° angle. Arms were placed vertically along the body. The excursions of the center of

**Table 1**
Clinical characteristics of all children tested. Mean and standard deviation values for binocular vision (stereoacuity test, TNO measured in seconds of arc), near point of convergence (NPC measured in cm), vergence fusional amplitudes (convergence and divergence) in prism diopters measured at near distance and heterophoria at near distance, measured in prism diopters.

| Groups | TNO (s of arc) | PPC (cm) | Convergence (pD) | Divergence (pD) | Heterophoria (pD) |
|---|---|---|---|---|---|
| 7–8 years | 67 ± 7 | 3 ± 1 | 41 ± 2 | 18 ± 0.6 | 4 ± 1 |
| 9–11 years | 63 ± 8 | 3 ± 1 | 34 ± 3 | 17 ± 0.9 | 5 ± 1 |
| 14–17 years | 55 ± 3 | 3 ± 0.8 | 32 ± 3 | 14 ± 0.9 | 3 ± 0 |