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Emotions and voluntary action: What link in children with autism?

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HIGHLIGHTS

- The organization of voluntary movement involves cognitive and automatic processes.
- This organization depends on the emotion conferred to the goal of the action.
- A positive emotional valence promotes the cognitive processes in autism.
- An aversive emotional valence blocks or disturbs it.
- No emotions effect is observed on the automatic processes.

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ABSTRACT

This research focuses on the impact of emotions – defined as "motivational states" – on the organization of goal directed locomotion in children with autism. Walking toward a goal involves both cognitive processes responsible for movement planning and automatic processes linked to movement programming. To these processes, motivation leading to achieving the goal is added. For some authors, a deficit of planning and/or programming processes is highlighted in autism. Others stand for some impairment of the emotional system. The aim of this research is to link these two viewpoints and to determine if, in children with autism, the organization of locomotion is affected by a positive/aversive emotion conferred to an object to fetch. Twenty-nine children participated in the study (11 children with autism – mean age 122 months; 9 mental age-matched controls – mean age 36 months; and 9 chronological age-matched controls – mean age 122 months). They were instructed to go and get a positive or aversive emotional valence object located straight ahead, at 30° to the right or straight ahead then moved at mid-distance to the right. Gait analysis was performed using the Vicon system. The main results suggest that a positive emotional context promotes the cognitive processes involved in movement planning while an aversive emotional context blocks it or disturbs it in children with autism. No emotions effect is observed on movement programming. It is suggested that emotions triggered off and modulated movement planning and that the deficit observed was related to a developmental impairment rather than to a developmental delay.

1. Introduction

The human emotional nature is complex and this probably explains the many theories which have been elaborated so far to try and define the emotions in their behavioral, physiological or cognitive and subjective components without consensus on general definition of the term "emotion" [1–4]. It is then crucial to define what we understand by "emotions". According to Frijda, emotions would correspond to "motivational states"; motivation being responsible for the release, the maintenance and the cessation of an intended behavior as well as the appetitive or aversive value conferred on the goal of the action and/or to the elements of the environment on which this behavior is exerted [5]. Within this framework, the affectivo-motivational models of the behavior indicate that these motivational states induce the approach of positive experiences and the avoidance of aversive experiences [6–8]. In this way, goal directed locomotion is a particularly interesting

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movement because it is the primary motor behavior used by many living beings. Thus they interact with the environment by moving their whole body in order to either reach a precise point of space or, on the contrary, avoid it.

Goal directed locomotion and more generally voluntary movements are organized by the central nervous system in three hierarchical steps [9–11]. The first one is movement planning. It corresponds to cognitive processes allowing the emergence of the act intent, the identification of the goal of the task, the decision-making leading to action. Moreover according to Bernstein [12] there would exist, at higher levels of the nervous system, a "higher engram" which would be strongly geometrical and which would represent a very abstract motor image of space (topological and not metric coding). Cognitive processes are therefore involved in the representation of an abstract movement trajectory linked to an estimate of the spatial and postural contexts on the environment and body states. Then the second step corresponds to movement programming. It involves automatic processes corresponding to the motor programs. Not only do they include the movement parameters (amplitude, duration, velocity) but also the kinematic strategies controlling balance throughout the movement, *i.e.* the balance strategies without which a movement becomes ineffective. They also include the muscles involved both in movement and balance control. These programs profit from automatic regulations conferring on their execution a limited flexibility of expression according to the circumstances and the risks of the environmental conditions. The whole of the genetically wired programs constitutes the basic repertoire available to organize motor behaviors. Movement programming is itself dependent on the movement planning of the higher level which selects, triggers and modulates the motor programs. It can be considered as an interface between movement planning and the third step: movement execution. Thus, the goal oriented movement execution is the objective result of the two previous steps.

The effect of emotions on the initiation of gait or during walking is beginning to be studied in the healthy adult. Indeed Stins and Beek [13] show that this effect is especially impacted by negative emotions, thus unpleasant images caused an initial "freezing" response and a tendency to move away from the stimuli during whole-body movements such as voluntary stepping. On another side a study of gait initiation toward pleasant or unpleasant images showed that negative pictures viewing increased reaction time (delay between the beginning of picture viewing and the beginning of the dynamic phenomena on the anteroposterior axis) and decreased the amplitude of the early postural component associated to gait initiation. This was done without a modification of the length of the first step [14]. Lastly, Naugle et al. [15] showed that pollution or mutilation pictures viewing during launched locomotion led to a decrease of length and velocity of the first two steps. Nevertheless, if these studies give us very useful information about the effect of emotions on the initiation and/or execution of a voluntary movement, the emotional value conferred on the goal of this action remains unclear. In fact, in daily life, voluntary movements can be defined as movements which answer the intent linked to the motivation to realize a goal oriented task in a specific context [16]. Initiating a gait or walking toward a picture only corresponds to answering the order to walk toward it, whatever its emotional load. It is different from the realization of a goal directed locomotion which depends on the motivation at the origin of the movement. This motivation depends on the positive or negative emotional value conferred on the goal of this action; "Emotion feelings constitute the primary motivational component of mental operations and overt behaviour" [4].

But what is happening when the movement organization and the emotional system are impaired the way it is in autism? Indeed, autism is classically defined as a disorder characterized by a triad of impairments including social difficulties, communication trouble and restricted interests together with repetitive behavior (American Psychiatric Association, 2000). But some authors highlight a deficit of the executive functions including the whole cognitive processes allowing the control and the execution of finalized activities [17–20] and then movement planning [21,22]. Others point the impairments of the movement itself, assuming a disturbance of the automatic processes linked to a deficient movement programming [22–27]. Others still stand for an impairment of the emotional system. Indeed, children with autism are able to feel the four basic emotions (fear, anger, enjoyment and sadness), to establish links between them and to identify different valence emotions. However, they should be more sensitive to an aversive stimulus. They badly identify their own emotions and feel more often aversive emotions than the children of the same age [28–33]. Moreover, the children with autism have difficulties not only as far as the perception of social-emotional signals is concerned but also with regards to the regulation of their behavior in response to these signals [34,35]. This impairment of the emotional system allows an inability to interact in an emotional way with other people and it would be an original cause of autism [36,37].

If these three components of the voluntary movement organization: emotions, cognitive and automatic processes are clearly impaired in autism, their link has never been studied. Yet, determining if cognitive and/or automatic processes are directly impaired in autism or if their impairment is the result of an impaired emotional system, seems to be fundamental not only for the diagnosis but for the therapy too. In a recent study, we showed that planning was mainly disturbed in an emotionally negative situation when children with autism were walking in a straight line to retrieve a positive or aversive emotional valence object. Movement programming was consequently impaired. Then, this finding suggests that cognitive and/or automatic processes are not directly impaired in autism since they are preserved in an emotionally positive situation [38]. But up to now, it only concerns a motion toward an object located opposite the children. What is happening if the object is not located in front of them or is being shifted while they walk? Thus, the present study emphasizes the link between emotional system and movement planning by analyzing the effect of a positive emotion or an aversive one conferred to an object to fetch, object located in three different positions in space. Each position would induce a particular locomotor trajectory, while the goal of the task remains unchanged (fetching the object). The first corresponds to an object located opposite the children inducing a straight line trajectory (control condition). The second corresponds to an object located sideways inducing, from scratch, a deflected trajectory with respect to the straight line. The last corresponds to an object shifted while walking inducing a reorganization of movement planning in the midst of the action in order to determine the new trajectory with respect to the moved object.

2. Methods

This research was the subject of a collaboration between researchers in neurosciences and psychology of the laboratory "Research Centre on Sports and Movements" of the University Paris Ouest Nanterre La Défense and some practitioners of the hospital complex Théophile Roussel, supervised by Dr. Orève, in Montesson, France.

2.1. Participants

Eleven children with autism (mean age: 119 months, range 78–158 months) were recruited at the Hospital Complex Théophile Roussel for this experiment. They were selected by an experienced clinician (Hospital MD, specialized in psychiatry), according to the criteria of ICD-10 and evaluated by the Childhood Autism Rating Scale: CARS [39]. Total CARS scores range from 15 to 60, with a minimum score of 30 serving as the cutoff for a