SENSATION AND PERCEPTION IN VIRTUAL REALITY

SENSAZIONI E PERCEZIONI NELLA REALTÀ VIRTUALE

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Abstract

Over the past few years, virtual reality has become a tool used in so many areas of research, from social sciences, psychology, medicine to neuroscience. In particular, in the latter area, there has been much debate about the role this tool can play in measuring perception parameters, particularly of the tactile, auditory or visual type. Indeed, this tool makes it possible to create an environment in which the variables analyzed can be manipulated and controlled with greater accuracy. In particular, by using virtual reality in a learning context, it is important to take into account how the control and modification of perception parameters can be an alternative way to favor the customization of the virtual environment. Virtual reality customization allows a better and less annoying experience at the perceptual level, but also it favors the inclusion and use of digital tools for those who want to use them.

Negli ultimi anni, la realtà virtuale è diventata uno strumento utilizzato in moltissimi ambiti di ricerca, dalle scienze sociali, alla psicologia, alla medicina fino alle neuroscienze. Proprio in quest'ultimo ambito si è dibattuto molto il ruolo che questo strumento possa avere nella misurazione dei parametri di percezione in particolare di tipo tattile, uditiva o visiva. Questo strumento infatti permette di creare un ambiente in cui le variabili da analizzare possono essere manipolate e controllate con maggiore accuratezza. In particolare, utilizzando la realtà virtuale in contesti didattici e di apprendimento è importante tener conto di come il controllo e la modifica dei parametri di percezione possa essere una modalità alternativa per favorire, non solo la customizzazione dell'ambiente virtuale a seconda dell'individuo, ma anche quella di favorire l'inclusione e l'uso di strumenti digitali per soggetti con bisogni educativi speciali.

Keywords

Virtual Reality; Perception; Movement; Neuroscience.

Realtà Virtuale; Percezione; Movimento; Neuroscienze.

Introduction

In the world of neuroscience, perception means the interpretation of information from the environment that enables us to process these signals and their meaning. Sensation, on the other hand, involves the capacity of awareness produced by an external or internal stimulus. There are two processes in particular that help the brain to decode stimuli: one is the bottom-up process, that is the set of processes aimed at identifying the stimulus by analyzing the information available in the external environment; the other is the top-down process, which decodes information using a priori knowledge depending on the context. In general, we are subjected to a great deal of sensory input every day; electromagnetic radiation in particular carries fundamental information such as color, depth, contrast and spatial frequency. Contrast is defined as the percentage difference between the maximum luminance of the bright line and the minimum luminance of the dark line, while spatial frequency is defined as the number of lines per unit visual angle (cycles/degree). High spatial frequencies correspond to thinner lines and low spatial frequencies to wider lines. These stimuli are translated into electrical signals by the photoreceptors in the retina. We could define the perceptual process as a filter that allows us to see the world through specific features that act as a bridge.

There are several perceptual parameters to refer to, in addition to vision, we also find hearing, touch and proprioception involved, the perception of one's own body involving the encoding of space and movement. According to the ecological approach of Van der Meer et al., 1999, perception and action go hand in hand: not only must we perceive in order to move, but we must move in order to perceive. The distinction between perception and movement should by now be outdated according to Berthoz (1997) because, as Lee (1976) already pointed out, perception and action are two inseparable sides of the same coin.

Perception is, therefore, 'not only an interpretation of sensory messages: it is conditioned by action, it is an internal simulation of it, it is judgement, it is a choice, it is anticipation of the consequences of action' (Berthoz, 1997), 'in fact, it is not only a simulated action, but also, and above all, a decision. Perceiving is not only combining and pondering. It is to select; it is to choose from the mass of available information those relevant to the action under consideration. It is to eliminate ambiguities, and thus it is to decide. To decide is to link the present to the past and the future' (Berthoz, 2003).

Perception and action are closely linked processes, with the interaction of sensory input and motor output fundamental to the calibration of fine or gross motor skills. Accurate perception of body movements is fundamental to fine motor skills. However, there are many studies with examples of dissociation between perception and action (e.g., Goodale and Milner, 1992; Merfeld et al., 2005). Consequently, the perception of one's movement and orientation can also be altered using virtual reality.

Virtual reality (VR), in fact, could be defined as an additional filter of reality, as perception is totally subject to manipulation of the variables from which the virtual environment is composed. This possibility of modification is certainly a way of adapting the internal parameters of the virtual environment depending on the individual using it, for example the ambient light, the color or the perception of movement. Just think of the difference between actually moving with the visor worn in a real physical space and moving in a three-dimensional space while physically sitting in a chair.

How VR affects motor output was investigated in a study by (Wright, 2014). It appears that the brain primarily refers to the visual system and that it calibrates the perceptual-motor system, consequently the motor system acquires a compensatory role with respect to various perceptual discordances. It has also been observed that exposure to a VR environment automatically causes sensorimotor adaptation. Inaccurate automatic motor responses due to the recalibration of visual, vestibular and somatosensory co-ordination certainly could become a risk. However, for those with a perceptual or motor deficit, immersion in VR can move them from a maladaptive state to an adaptive one. Thus, it has been demonstrated the ability of this digital tool to stimulate brain plasticity and consequently stimulate a modification of the brain in response to external stimuli. Precisely in relation to this opportunity, the use of VR also finds application in the medical-clinical sphere, whereby attempts are made to enhance any perceptive deficits through its controlled use.

When it comes to tactile perception in VR, it has to be taken into account that each subject has a different tactile sensitivity. The Chinese team (City University of Hong Kong) in the article 'Encoding of tactile information in hand via skin-integrated wireless haptic interface', published in Nature Machine Intelligence, describes the realization of a skin-embedded interface capable of delivering current through electrodes placed on the palm of the hand, thus provoking tactile sensations in the wearer and recreating the perception related to the physical touch of a virtual object.

On the basis of pain threshold data customized for each user, electro tactile signals are sent to command to each point on the fingers and palm of the hand with intensity and at intervals such that they do not cause discomfort but are perceived.

Thus, the amount of current delivered by the electrodes contained in the patch also elicits different tactile sensations at different points of each person's palm. There are future possible applications in immersive reality of the wearable VR skin system, in addition to the world of video games and sports training, think also of remote surgery. Users wearing the wireless 'second skin' will be able to feel, on their hand, the touch of a sharp object or the perception related to grasping an object such as a tennis racket; in the case of use by a surgeon, the haptic feedback will relate to the grip of the scalpel and the patient's body, refining the operation.

Another important perceptual parameter for a VR environment is hearing. Sounds can come from all directions, flow and give information even if we do not pay attention to them. In this, hearing differs from the vision: to interrupt the flow of information it is sufficient to close one's eyes; as far as hearing is concerned, it is not always possible to block the flow of information by just plugging one's ears.

In recent years, more and more realistic virtual reality interfaces have been developed, but the sound aspect has remained an imprecise element.

The biggest challenge is not so much the technical limitations (today the field of music technology and software is very advanced) but to make the human-instrument interaction intuitive, sensible and consistent with everyday reality. The aim is to achieve with greater precision the integration of all sounds that can be heard simultaneously, their direction and the synchrony with which they can be perceived. There are many technologies that could be reach out this type of goal such as specific headphones or audio system as the 5.1.

With regard to visual perception, there are a number of studies that have investigated how the perception of certain visual parameters (e.g., spatial frequency, contrast, visual acuity) in groups of persons with atypical development may differ from a control group.

In a study by Ffion et al. (2004), visual acuity and contrast sensitivity were measured in subject group comprised 58 children with Down syndrome and 44 control subjects, aged 3 months to 14.15. It was verified that in subjects with Down's syndrome the threshold of visual acuity and contrast sensitivity was significantly lower than in the control group.

In contrast, in a study by Koh et al. (2010), they measured the contrast sensitivity of seven spatial frequencies (0.5-20 cycles/degree) in a total of 13 adolescents with autism spectrum disorder and 29 control group of adolescents participated in the study. No group differences were observed on any of the measures of the function that measures sensitivity to different spatial frequencies is called the contrast sensitivity curve (CSF), demonstrating that there are no differences in differential spatial frequency processing in autism spectrum disorder. It appears that detail-oriented visual perception in individuals with autism may be the result of a different sensitivity to low spatial frequencies than to high spatial frequencies, the present study unfortunately does not demonstrate enough evidence to support this hypothesis.

In a study by Fuermaier et al. (2018), it was found that individuals with ADHD have greater discomfort with sensory stimuli at a lower level than individuals with typical development. It has been shown that alterations in perceptual function in individuals with ADHD are moderated by various factors, such as drug treatment, cognitive function and symptom severity.

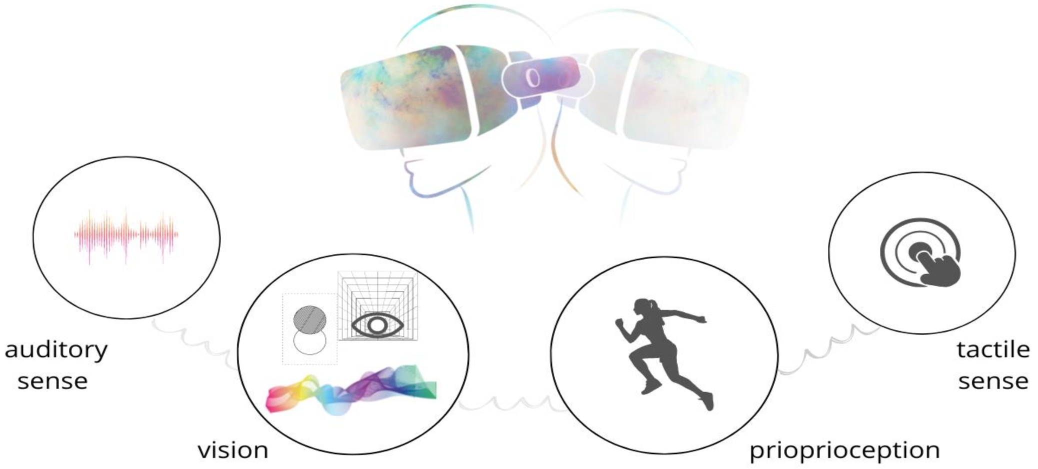

Figure 1: Infographic representation of some perceptual parameters (hearing, contrast vision, spatial frequency, colors, proprioception and tactile sense) that may be important during a virtual reality experience.

Thus, VR is becoming an increasingly used tool in many different research fields. In particular, the perception of external stimuli is an extremely complex process and needs to be understood in the best possible way so that even with the use of virtual reality there are benefits and improvements for the user.

In conclusion, some individuals with special educational needs may need additional calibration of visual, auditory or tactile perception parameters for the use of VR. In general, one may need to customize vision, hearing or movement parameters to one's liking in order to have a better and less perceptually disturbing experience.

Studies on the use of virtual reality increasingly aim to personalize the virtual experience, with an inclusive perspective vision, in order to make the experience more immersive for anyone who wants to use virtual reality.

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