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Research report

Validation of laughter for diagnosis and evaluation of depression

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ABSTRACT

Background: In the medical field, laughter has been studied for its beneficial effects on health and as a therapeutic method to prevent and treat major medical diseases. However, very few works, if any, have explored the predictive potential of laughter and its potential use as a diagnostic tool.
Method: We registered laughs of depressed patients ($n=30$) and healthy controls ($n=20$), in total 934 laughs (517 from patients and 417 from controls). All patients were tested by the Hamilton Depression Rating Scale (HDRS). The processing was made in Matlab, with calculation of 8 variables per laugh plosive. General and discriminant analysis distinguished patients, controls, gender, and the association between laughter and HDRS test.
Results: Depressed patients and healthy controls differed significantly on the type of laughter, with 88% efficacy. According to the Hamilton scale, 85.47% of the samples were correctly classified in males, and 66.17% in women, suggesting a tight relationship between laughter and the depressed condition.
Limitations: (i) The compilation of humorous videos created to evoke laughter implied quite variable chances of laughter production. (ii) Some laughing subjects might not feel comfortable when recording. (iii) Evaluation of laughter episodes depended on personal inspection of the records. (iv) Sample size was relatively small and may not be representative of the general population afflicted by depression.
Conclusions: Laughter may be applied as a diagnostic tool in the onset and evolution of depression and, potentially, of neuropsychiatric pathologies. The sound structures of laughter reveal the underlying emotional and mood states in interpersonal relationships.

1. Introduction

Laughter has been virtually absent from the international research scene until last two decades (Provine, 2000). Notwithstanding the important research progress and the new insights gained, fundamental aspects of the phenomenon are not clarified yet. More than in the biomedical field itself or in pathological laughter, it is spontaneous laughter – or technically, *Duchenne* laughter – which continues to present the greatest unsolved questions: in terms of stimuli, production causes, circuit detection, acoustic structures, neurocognitive correlates, relationships with emotions, social context, etc. In this paper we are going to explore whether laughter production may correlate or not with an important neuropsychiatric pathology, depression, and how the results of this correlation may have a potential application to clinical diagnostic.

Laughter is an innate reaction of human behaviour, of Anthropoid provenance, which is elicited by the concurrence of certain external stimuli and some internal reactions, mostly related to social interactions (Provine, 2000; Bachorowski and Owren, 2002). Both the external interaction and the inner background of the individual conspire together for the occurrence of laughter, which apparently is a kind of social signal of individual wellness in front of apparently inconsistent or problematic situations (Marijuán and Navarro, 2011; Hurley et al., 2011). However, some physical and chemical stimuli may also directly elicit the spontaneous behaviour of laughter (Provine, 2000).

Currently there are three main theories explaining the causes of laughter and the conjunction of external and internal phenomena that elicit it (Rozengurt, 2011). *Theories of relief* come from Freud (1928) suggesting that laughter can release tension and "psychic energy" that are built up for inhibiting taboo feelings such as sex or

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death. *Superiority theories* argue that laughter expresses the subject's superiority over other people in the social interaction (Martin, 2006; Portmann, 2000). And *incongruity theories* conceive laughter as a result of simultaneous occurrence of incompatible elements in the current interactions (Martin, 2006; Suls, 1972; Attardo, 1994). The latter approach has also been formulated within a "computational turn", presenting laughter as an information-processing tool in charge of debugging the inconsistencies of cortical databases (Hurley et al., 2011). A further "neurocomputational hypothesis" has been proposed by some of the present authors (Marijuán and Navarro, 2011), where laughter is considered as a behavioural outcome caused by sudden neurodynamic information gradients, actually arising in a variety of physical, behavioural, and social problem-solving circumstances, which become positively finalized—and are thus spontaneously expressed as a signal of the subject's wellness and social competence.

Indeed the above plurality of theories accommodates well with the complexity of the phenomenon and the basic unsolved questions that remain; it also denotes the multifarious stimuli and variegated inner and social circumstances that may produce laughter along the daily life of the individual. Laughter closely accompanies human relationships: of babies and toddlers with their parents, children play, adolescent groups, courtship, parenthood, group coalitions, social small-talk, friendship, etc. Quite possibly, laughter as a pervasive phenomenon in human societies is centred on the formation and maintenance of the neural engrams subtending "social bonds" (Marijuán and Navarro, 2011). It is understandable that in mental pathologies that seriously affect the relational capabilities of individuals, laughter also becomes severely affected both in its production circumstances and in its acoustic expressive contents—as we are going to study here.

Medically, the study of pathological laughter (Poeck, 1985) has pioneered the field respect other behavioural and cognitive approaches to spontaneous laughter. Lesion studies for instance (i.e. damage to frontal cortex areas), have pinpointed the participation of many specific areas in humour perception and laughter production, and have also dispelled too simple neurological and cognitive assumptions. Unlike in emotional responses relatively confined to specific cerebral localizations, it has been authenticated that laughter is associated with activation of numerous areas: left, front, right, and rear of the cortex, as well as motor areas, cerebellum, limbic system, subcortical nuclei, hypothalamus, etc. According to Wild et al. (2003) the neuro-anatomical command system for laughter production includes two pathways: the voluntary, involving the premotor opercular areas, the motor cortex, and pyramidal tract; and the involuntary, involving amygdala, thalamic, hypothalamic and subthalamic nuclei. Both pathways are controlled by a single centre located in the dorsal upper pons. Further, in the overall occurrence of laughter three main neural systems would be involved: a cognitive area, mainly frontal cortex, which comprehends the high level processing of stimuli; the motor area that generates a series of muscle movements producing sounds and facial expressions, identified as the supplemental motor cortex; and the emotional area that provides joy and happiness feelings, mainly the nucleus accumbens (Ariniello, 2001; Hasan and Hasan, 2009; Parvizi et al., 2001). See the flow chart in Fig. 1.

Laughter has also been studied for its effects on health and as a therapeutic method to prevent, detect, and treat major medical diseases (Penson et al., 2005). For instance, it is well authenticated that major depression affects humour appreciation in patients with symptoms such as feelings of anhedonia, hopelessness, guilt thoughts or inability to concentrate; schizophrenia patients exhibit a humour deficit too—as already pointed by Corcoarns et al. (1997). An important population study of the relationship between laughter production and the occurrence of certain autoimmune and mental health diseases has been conducted by Hasan and Hasan (2009), additionally suggesting that laughter history of patents should be incorporated into the general practice of medical history taking. A major clinical review has been performed by Gelkopf (2011), highlighting the therapeutic potential of laughter and humour in a variety of clinical settings and treatments: pain relief, immune function, stress, interpersonal processes, psychotherapy frameworks, etc. Overall, there is clinical evidence that "serious mental illnesses" may benefit from the use of humour and laughter, facilitating medication adherence, therapeutic alliance, psychotherapy work and patient empowerment.

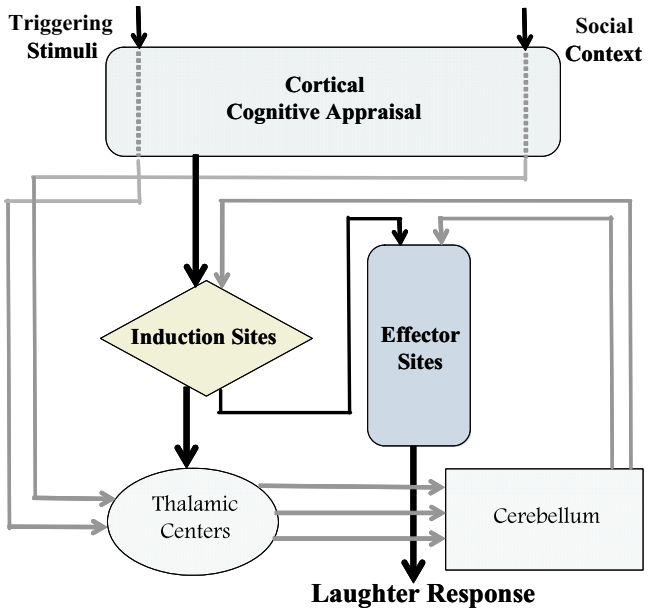

Fig. 1. Main neural systems and pathways involved in laugther. The initial stage is the cognitive appraisal (cognitive system), which mainly corresponds to the frontal cortex, together with the sensory and multimodal areas related to the kind of triggering stimuli (visual, auditory, tactile, linguistic). At this stage, the intensity, emotional content, and duration of laughter are not well gauged yet, as they should be in accord not only with the triggering stimuli, but also with the social context and with the reaction produced in the whole memory contents of the subject. Further, the emotionally-laden induction sites (emotional system) comprehend the amygdala, ventral striatum, and anterior cingulated cortex. The motor or effector sites (motor system) include motor cortices, hypothalamus, and cranial nerve nuclei. The three previous systems (cognitive, emotional, motor) relay to the telencephalic structures, and from there to the cerebellum, which computes the different influences that shape the final laughter response conveyed through the motor system. See Parvizi et al. (2001) for a careful discussion of all these pathways and systems.

A number of research findings and contributions to recent literature suggest that laughter reflects the whole mental and physical condition of individuals (Gelkopf, 2011; Bennett and Lengacher, 2008; Adams, 2008; Walter et al., 2007). In the extent to which that assumption holds, a better understanding of the *sound structures* of laughter, in their close relationship with the emotional and mood states of the subjects, could imply a potential use of laughter as an indicator of well-being and mental health, helping to distinguish the presence of neuropsychiatric pathologies. Very few works have been addressed in that direction, trying to explore the predictive potential of laughter (Uekermann et al., 2008). Specifically, detecting the differences of laughter between healthy subjects and depressed patients will be addressed in the present study.

Therefore, this study investigates whether one of the most important neuropsychiatric conditions, depression, can be detected using laughter as a screening test. In the extent to which this attempt is successful, its results would provide new neuroscientific