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The neurology and evolution of humor, laughter, and smiling: the false alarm theory

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Abstract — Laughter (and humor) involves the gradual build-up of expectation (a model) followed by a sudden twist or anomaly that entails a change in the model — but only as long as the new model is non-threatening — so that there is a deflation of expectation. The loud explosive sound is produced, we suggest, to inform conspecifics that there has been a 'false alarm', to which they need not orient. The same logic may underlie tickling (menacing approach followed by a light non-threatening contact). Thus tickling may serve as 'play', a rehearsal for adult laughter. And lastly, when one primate encounters another, he may have always begun with a threat gesture — to bare his canines — but upon recognizing the individual as kin he may stop the grimace halfway and 'smile'.

When the insular cortex is damaged, patients giggle in response to pain, presumably because they can still sense the pain ('danger') but the pain is no longer aversive ('false alarm'), thereby fulfilling the two key requirements for laughter.

Introduction

Of all the mental traits that make us uniquely human, perhaps none is more enigmatic that laughter, that peculiar explosive sound that we make in response to jokes, humor, and tickling. Cultural factors undoubtedly have a profound influence on humor and what one finds funny; e.g., the English are thought to have a sophisticated 'sense of humor', whereas the Germans and Swiss rarely find anything amusing, and this difference is unlikely to have a genetic basis. But even if this is true, it does not itself negate the possibility that there might be some sort of 'deep structure' (1) underlying all humor. Indeed, theories on the biological origin of humor and laughter have a long history, going all the way to Schopenhauer (2) and Kant (3), two singularly humorless German philosophers.

It is generally agreed that, despite their surface diversity, all jokes and funny incidents have the following logical structure. Typically, one leads the listener along a garden path of expectation, slowly building up tension. At the very end, one introduces an unexpected twist that entails a complete reinterpretation of all the preceding data. It is critical that the new interpretation, although wholly unexpected, make as much 'sense' of the entire set of facts as the originally 'expected' interpretation. In this sense, jokes have much in common with scientific creativity; with what Thomas Kuhn (4) has called a 'paradigm shift' in response to a single 'anomaly'. The anomaly in the joke is, of course, the traditional punch line, and the joke is 'funny' only if the listener 'gets' the punch line; i.e. only if he is able to see *in a flash of insight* how a completely new interpretation of the same set

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of facts can incorporate the anomalous ending. The longer and more tortuous the garden path of expectation, the more 'funny' the punch line is when finally delivered. Good comedians make use of this principle by slowly taking their time to build up the tension of the story line. Nothing kills humor more surely than a premature punch line.

It is obvious, however, that although the introduction of a sudden twist at the end is necessary for the genesis of humor, it certainly is not sufficient. My plane is about to land in La Jolla, and I fasten my seat belt and get ready for touch down. The pilot suddenly announces that the 'bumps' that he (and I) had earlier dismissed as a air turbulence are really due to engine failure and that we need to empty fuel before landing. A paradigm shift has occurred in my mind, but this makes me *orient* and prepare for action; it certainly does not make me laugh! Or consider the time when I was staying at a hotel near the San Diego airport. It was late at night, and just as I was about to doze off, I heard a 'thump' noise from downstairs. 'Probably the wind' I thought, 'There are no burglars near the San Diego Airport'. After a few minutes there was another, louder, thud. Again I 'rationalize' it away and go back to sleep. Twenty minutes later I hear this extremely loud, resounding, 'bang'. What do I do? I 'orient' of course. My limbic system is activated. I grab my gun and flashlight and run down the stairs. Nothing funny so far.

Then, suddenly, I notice that a big flower vase has fallen down, and the cat I had seen earlier in the lobby is right next to it: the obvious culprit! this time I start laughing because I realize that the 'anomaly' I detected and the subsequent paradigm shift *is of trivial consequence* (all the facts now explicable in terms of the 'cat' theory rather than the more ominous 'burglar' theory). We can sharpen our definition of humor and laughter based on this example. When a person strolls up along a garden path of expectation and then there is a sudden twist at the end that entails a complete reinterpretation of the same facts, *and* the reinterpretation has trivial rather that ominous implications, then laughter ensues (5).

The false alarm theory

But why laughter? Why the explosive repetitive sound? Freud's view (6) that laughter serves to 'discharge' pent-up internal tension does not make much sense without recourse to an elaborate and farfetched hydraulic metaphor. To an ethologist, on the other hand, any stereotyped vocalization almost always implies that the organism is trying to communicate something to others in the social group. Now what might this be in the case of laughter? I suggest that the main purpose of laughter is for the individual to alert others in the social group (usually close relatives that are likely to share the same genes) that the anomaly detected by that individual *is of trivial consequence.* The laughing person is, in effect, announcing his discovery that there has been a false alarm; that 'the rest of you chaps need not waste your precious energy and resources responding to the spurious anomaly' (5). This would explain also why laughter is so notoriously contagious, for the value of any such signal would be amplified progressively as it is 'spread' through the social group. (It might also explain why one is reluctant to laugh in the presence of people who are *not* close kin or relatives.)

The 'false alarm' theory of humor being proposed here would also explain slapstick humor. You watch a man — preferably portly and self-important — walking down the street. Suddenly, he slips on a banana peel and falls down. If his head hits the pavement and breaks his skull, you do not laugh as you see blood spill out. You rush to his aid or to the nearest telephone to call the ambulance. But if he gets up casually, wipes the remains of fruit from his face, and continues walking, you would probably burst out laughing, thereby letting others in your group know that they *need not rush to his aid.* Of course, when watching a slapstick movie (e.g. Laurel and Hardy or 'Mr Bean') we are usually willing to tolerate 'real' harm or injury to the unfortunate victim because we are aware, all the time, that 'it is only a movie'.

Other cognitive functions of laughter

I hasten to add that although this model accounts for the evolutionary origin of laughter, it certainly doesn't purport to explain all the functions that humor may serve in modern humans. Once the mechanism was in place, however, it could easily have been exploited for other purposes. For instance, even though the mechanism originally had the form 'Thank God it's a false alarm; I can now feel good and announce it to everyone', it may have been subsequently coopted and refined to motivate the playful juxtaposition of incongruous conceptual categories that would otherwise have remained quite separate in the brain. And that, in turn, would have allowed one's ancestors to 'see' familiar ideas from novel vantage points, serving as an antidote to mental 'conservatism' and a catalyst to creative thinking. Laughter and humor, in other words, may be a form of 'play' or rehearsal for creativity. If so, perhaps jokes, puns and other forms of humor should be introduced very early into our elementary schools as part of the formal curriculum.

Notice, also, that although our theory explains the logical structure of humor, it does not explain why humor itself is sometimes used as a psychological 'defense mechanism'. One possibility is that jokes are an attempt to trivialize what would otherwise be genuinely disturbing anomalies. In other words, when an anomaly is detected, it is ordinarily dealt with by orienting, or — when small — by denial or repression, but an alternative strategy would be to pretend that it is a trivial anomaly by using a joke (i.e. you set off your own 'false alarm' mechanism). Thus, a mechanism that originally evolved specifically as an ethological signal to appease others in the social group has now become internalized to deal with cognitive anomalies in the form of a new type of psychological defense mechanism (hence the phrase 'nervous laughter'). We have suggested elsewhere that such psychological defenses evolved mainly for stabilizing behavior (for you would not want to 'orient' to every trivial anomaly that threatened the status quo). They should be seen as part of a general mechanism for the coherencing of consciousness that helps avoid indecisive vacillation and ensures optimum resource allocation given the ever-present need for rapid action (5).

Evolution of smiling

The smile, too, may have similar evolutionary origins; indeed it should essentially be regarded as a 'weaker' form of laughter. When an ancestral primate encounters another individual he may have always begun with a threatening grimace to bear his canines. Upon recognizing the individual as 'friend' or 'kin', however, he may stop the grimace halfway — thereby producing a smile. This may have subsequently evolved into a ritualized greeting: 'I know you pose no threat and I reciprocate'. Thus a smile, in this scheme, in an aborted orienting response in much the same sense that laughter is.

Interestingly, there is a neurological disorder called catalepsy in which there appears to be a pathological exaggeration of this 'stop orienting' reflex; patients with this disorder become completely paralyzed, often in response to merely listening to a joke!

Neurology of laughter and tickling

What are the neural mechansims underlying humor? Undoubtedly, understanding the subtle nuances of wordplay and humor must involve several widely disseminated regions of the brain. But, again, it does not follow that there is no specialized circuitry in the brain that is mainly concerned with informing others in the social group that there has been a false alarm. There is strong clinical evidence that the relevant circuitry must be in the limbic system, since limbic seizures (7) (and lesions in certain parts of the limbic system such as the mammilary bodies (8–11) and tuber cinereum) can lead to uncontrollable laughter; indeed one patient 'laughed himself' to death (12).

It is also known that a certain proportion of patients with damage to the insular cortex suffer from a curious disorder called 'pain asymbolia' (also seen in some ventromedial frontal patients). You jab the patient's finger with a needle, and he will tell you that he 'feels the pain but it doesn't hurt' — the aversive emotional component of the pain is gone. This is presumably because the sensory component of pain is mediated by the thalamus and partly by the insula itself — but it fails to get relayed to the cingulate and other limbic strutures to generate appropriate affect and arousal. Even more surprising, though, is the observation that some of these patients will report that the stimulus feels funny and actually start laughing (13)! Oddly enough, the authors of this report do not consider the implication of this observation for understanding the neural basis of humor, but it makes perfect sense from the point of view of our 'false alarm' theory. In particular, I suggest that these patients laugh because of a disconnection between somatosensory and limbic structures so that the two key ingredients we postulated are both present: a potentially dangerous 'anomaly' (the sensory output signaling: pain) followed by a deflation of expectation (it doesn't hurt after all). Perhaps the only resolution of this is to regard the pain as a false alarm and laugh.

The same line of responding can be invoked to explain why people laugh when tickled. The adult approaches the child menacingly with his hand stretched out. 'Will he shake me or poke me or hurt me in any way?' asks the child's mind, only to learn no, the finger makes only light intermittent contact with my belly. Again, the two key ingredients are present and the child laughs as if to inform the other children, 'He doesn't mean harm; he is only playing!'. By doing so, the child may also be engaging indirectly in a form of 'play' — a rehearsal of the brain programs required for sophisticated adult humor. This idea is consistent with the recent observation (C. Johnson, personal communication) that one can be tickled even by an inanimate machine; it is entirely possible that even though the reflex originally evolved in a social context, once it is in place it can be elicited by other 'nonsocial' stimuli as well. Furthermore, our suggestion that there is a close operational analogy between the logic of tickling and the response of pain asymbolia patients to noxious stimuli, leads to the interesting prediction that if a PET scan is done

while a subject is being tickled there should be strong activation of the insular cortex (in addition to the expected limbic activation).

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