Does rejection hurt?

Review of the most recent neurological literature concerning social exclusion

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Introduction

A report from the Foundation for People with Learning Disabilities and Lancaster University has found that children with learning disabilities (about 3,5 per cent) are six times more likely to have a diagnosable psychiatric disorder than other children in Britain. Studies undertaken in Great-Britain, Australia, Norway, Finland, the Netherlands and South Africa suggest that approximately 40% of children and adolescents with learning disabilities are likely to have a diagnosable mental health problem. The report, based on the experiences of over 18,000 children aged between 5 and 15 years old, says that nearly half are living in poverty (47 per cent). Children in Britain who have learning disabilities and a mental health problem are likely to face considerable social adversity.

Nearly two thirds of children with emotional disorders are living in poverty. Six out of ten have been exposed to two or more different types of adverse life events. Young people with learning disabilities also have fewer friends than other children living in Britain and are more likely to suffer abuse and be involved in serious accidents. According to The Mental Health of Children and Adolescents with Learning Disabilities in Britain, the increased risk of mental illness is not always caused by a young person's learning disability, but instead because of exposure to greater poverty and social exclusion than experienced by non-disabled children. (Eric Emerson & Chris Hatton, 2007)

It is generally acknowledged that poverty is often a deadlock. But the fact that social exclusion can have such far-reaching consequences as impairing learning abilities will seem a little surprising for a lot of people at first sight. Can you prove that? How does it work? Does rejection hurt? Does it leave scars?

Laboratory experiments in Social Psychology have confirmed the phenomenon before. Baumeister et al. confirmed that social exclusion impairs self-regulation. Six experiments showed that being excluded or rejected caused decrements in self-regulation:

> "Past work has shown that socially excluded individuals exhibit increased aggression, poorer intellectual performance, a loss of prosocial behavior, and a susceptibility to self-defeating behavior patterns. At the societal level, and at multiple points in history, groups and categories of people who have felt excluded by the dominant culture have shown sadly similar patterns as reflected in high crime rates, underperformance in schools and intellectual life, withdrawal from positive contributions to the general societal good, and elevated rates of substance abuse, suicide, and other self-destructive patterns. The present findings suggest what may be a common underlying process. Effective self-regulation allows individuals to control and alter their behavior so as to resist temptations, stifle socially undesirable impulses, follow rules, pursue enlightened self-interest despite short-term costs, and make positive contributions to society. As such, individual selfregulation is essential to one's own well-being as well as that of others" (Baumeister et al., 2005).

In this review of the most recent neurological literature I will try to catch the neurological underpinnings of social exclusion and it's consequences. I will start with a critical note on the use of research techniques, proceed with the description of two revealing experiments in which the second experiment was set up to contradict partly the first. Faced with this controversy I will try illuminate the problem depicting a plethora of researches on the Anterior Cingulate Cortex, the area involved, activated during rejection. When you are not familiar with neurological texts I won't blame you if you leave out this chapter. Finally I will describe a very recent conclusive experiment that has solved in my opinion the original controversy.

Critical remarks on neuro-imagining

Reading of neurological papers should be very critical: for all fMRI studies should be analysed with care. The production of papers is often a race. The more spectacular the results, the more resonance in the press they get, the more funds can be collected. When using the 'same circuit' paradigm, stating that in one and the same person the same brain region was active e.g. when remembering one's own pain and when remembering pain of others we see no problem. The paradigm says what it says. For a non-invasive scan, fMRI has moderately good spatial resolution. However, the temporal response of the blood supply, which is the basis of fMRI, is poor relative to the electrical signals that define neuronal communication. Therefore, some research groups are working around this issue by combining fMRI with data collection techniques such as electroencephalography (EEG) or magneto-encephalography (MEG), which have much higher temporal resolution but rather poorer spatial resolution.

Another issue is inverse inference. When attributing cognitive processes to activation of certain brain regions or concluding that a cognitive process took place because a certain brain region was activated inverse inference is used. Brain maps are still far from perfect:

> "Given that these coarse categories are unlikely to map the organization of the mind very deanly, it seems that powerful reverse inference awaits the development of a detailed cognitive ontology, which will probably require the work of a consortium of cognitive scientists akin to the Gene Ontology consortium (http://www.geneontology.org) that has developed ontologies for genome informatics." (Poldrack RA., 2006)

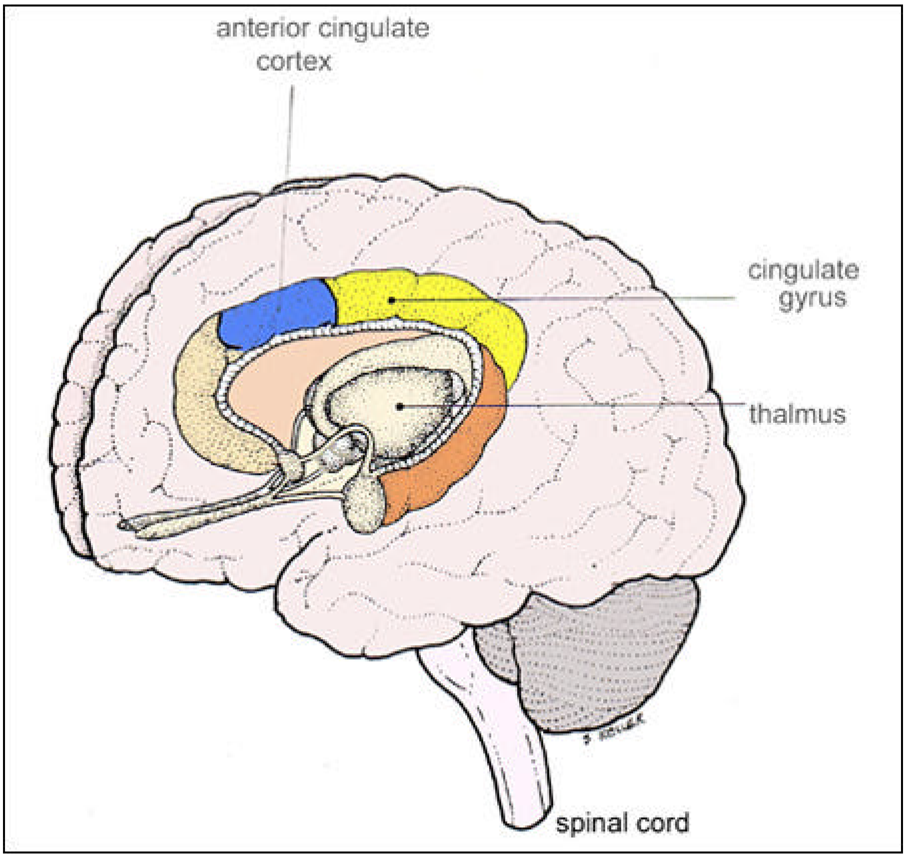
Reverse inference is not deductive valid. Mental states are explained based on activation of brain regions, which were activated also in other experiments. Only when one can demonstrate that a particular brain center is exclusive (if and only if) engaged in a particular process it can be attributed to that emotional or cognitive process. One way researchers can address this problem is the use of converging behavioral (response times, additional questionnaires etc.) evidence to provide stronger evidence of engagement of the process of interest. Additional evidence from TMS research is another way to address this problem. A noninvasive mapping technique such as fMRI allows researchers to see what regions of the brain are activated when a subject performs a certain task, but this is not proof that those regions are actually used for the task; it merely shows that a region is associated with a task. One reason TMS is important in neuroscience is that it can demonstrate causality. If activity in the associated region is suppressed with TMS stimulation and a subject then performs worse on a task, this is much stronger evidence that the region is used in performing the task. If any ambiguity might exist I will refer to both fMRI and single neuron recording or TMS or MEG research.

Another remark about the specific experiments reviewed here that must be kept in mind and that preserves its importance through the text: these experiments were set up in virtual environments; none of the attendants were a true victim of social exclusion. It was their perception of social exclusion, albeit conscious either unconscious, implicit either explicit, that caused all kinds of distress that will be mentioned. Thus social exclusion is defined if and only if it is perceived that way but not necessarily noted by the excluded him self. I don't see a real problem here, my experience is that people are very sensitive about these matters and of course there are plenty of obvious cases defined in the social realm. Neurological research, being mainly a medical discipline, takes enough distance of its subject when investigating these subjective processes.

Does rejection hurt?

Is it only hurting metaphorically speaking or does one that is excluded really feel pain? Eisenberger et al. were able to create a social context believable enough to replicate behavioral effects and gain insights into the neural correlates of the phenomenon of exclusion. Participants were scanned while playing a virtual ball tossing game in which they were ultimately excluded.

Specifically, they found that social rejection in the game (not having the ball thrown to you by the other two animated players) activated areas of the anterior cingulate cortex (ACC) and the right ventral prefrontal cortex, areas activated in neuroimaging studies of physical pain.



A pattern of activations in the anterior cingulate cortex (ACC) very similar to those found in studies of physical pain emerged during social exclusion, providing evidence that the experience and regulation of social and physical pain share a common neuro-anatomical basis. Dorsal ACC activity is primarily associated with the affectively distressing rather than the sensory component of pain. This study suggests that social pain is analogous in its neurocognitive function to physical pain, alerting us when we have sustained injury to our social connections, allowing restorative measures to be taken, (Eisenberger et al., 2003).

The authors claim that ACC activity was strongly correlated with perceived distress after exclusion. But aren't these researchers jumping into conclusions based on inverse inference? What does activation of the ACC mean exactly? Does it work as an alarm system or does it reflect underlying distress due to exclusion?

Leah Somerville et al. combined two tasks in the same study to discriminate between pain distress and alarm function. Their results suggest that the Eisenberger et al. ACC findings were more about the violation of a social expectancy about being included in the ball tossing game, and not about the "pain" of rejection:

> "Taken together, these findings support a general role for dACC in the processing of cognitive conflict and demonstrate a more specific role for vACC in social and emotional evaluation—both of which are consistent with current theories of ACC functioning. To the extent that people expect consistency in social exchange dACC activity reported in the present study and elsewhere may well reflect violations of the fundamental expectation of social inclusion." (Somerville et al., 2006)

Before I take a definitive stand in this controversy, both based on fMRI research I would like to find out more about ACC in studies that used a different technique.

Unfolding the ACC function

Hutchison et al. have identified single neurons in the ACC that respond selectively to painful thermal and mechanical stimuli, supporting a role for the ACC in pain perception. Single-neuron recordings and microstimulation with tungsten microelectrodes (during cingulotomy procedures for the treatment of psychiatric disease) were carried out in patients under local anesthesia, without analgesics or sedatives. The study of Hutchison provided direct support for a role of the ACC in pain sensation by identifying cortical neurons responsive to painful stimuli in humans. (Hutchison et al., 1999).

A first attempt to define and summarize the role of the ACC was undertaken by Allmana et al. in 2001:

> “We propose that the anterior cingulate cortex is a specialization of neocortex rather than a more primitive stage of cortical evolution. Functions central to intelligent behavior, that is, emotional self-control, focused problem solving, error recognition, and adaptive response to changing conditions, are juxtaposed with the emotions in this structure. Evidence of an important role for the anterior cingulate cortex in these functions has accumulated through single-neuron recording, electrical stimulation, EEG, PET, fMRI, and lesion studies. The anterior cingulate cortex contains a class of spindle-shaped neurons that are found only in humans and the great apes, and thus are a recent evolutionary specialization probably related to these functions. The spindle cells appear to be widely connected with diverse parts of the brain and may have a role in the coordination that would be essential in developing the capacity to focus on difficult problems. Furthermore, they emerge postnatally and their survival may be enhanced or reduced by environmental conditions of enrichment or stress, thus potentially influencing adult competence or dysfunction in emotional self-control and problem-solving capacity.” (Allman et al., 2001)

In the years that followed several experiments on pain perception were set up to find out how empathy is correlated in the brain, (Avenati et al, 2005; Tania Singer and Claus Frith, 2005; Jean Decety et al., 2006; Claus Lamm et al., 2007). All these studies show that anterior insula and anterior cingulated cortex are involved in receiving pain as well as in seeing pain in others. This shared circuit phenomenon is known as mirror neuron system. It is the neuronal base of our capacity to ‘put ourselves in the shoes of others’, i.e. empathy.

A review of recent research in pain perception of Apkarian mentions:

> “The evidence for and the respective incidences of brain areas constituting the brain network for acute pain are presented. The main components of this network are: primary and secondary somatosensory, insular, anterior cingulate, and prefrontal cortices (S1, S2, IC, ACC, PFC) and thalamus (Th).” (Apkarian et al, 2005)

What is the specific role of the ACC? The anterior cingulate cortex (ACC) is believed to act as a neural “alarm system” or conflict monitor, detecting when an automatic response is inappropriate or in conflict with current goals. Converging neuroimaging and clinical findings suggest that ACC function mediates context-driven modulation of bodily arousal states, (Critchley et al., 2005).

ACC is also known to activate in decisions between conflicting response tendencies. ACC activity has also been connected to violation of expectancy. Evidence for the role of the ACC as having an error detection function comes from consistent observations of Error Related Negativity (ERN) uniquely generated within the ACC upon error occurrences. The ERN then, serves as a beacon to highlight the violation of an expectation. The anterior cingulate cortex is involved in a form of attention that is referred to as attention for action. (Luu & Pederson, 2004).

This result is congruent with the role attributed to the anterior cingulated cortex by the review of literature of Phan Luu and Stacey M. Pederson:

> “That is, contributions from the ACC are required when ongoing actions are inadequate or do not match up with current demands. The concept of attention for action is used to describe the cognitive processes that are engaged under situations that require control, although cognitive control may not be implemented by the ACC (Garavan, Ross, Murphy, Roche, & Stein, 2002; MacDonald, Cohen, Stenger, & Carter, 2000). The results from ERP studies of action monitoring reviewed in this chapter reveal that this concept is still appropriate for describing ACC functions, particularly because it emphasizes the role of action in cognition. It is likely that the ACC has evolved to regulate behaviors such that they are adaptive to sudden changes in the environment and should be important to early stages of learning.” (Luu & Pederson, 2004).

A comprehensive and recent theory describes the ACC as an active component and poses that it detects and monitors errors, evaluates the degree of the error, and then suggests an appropriate form of action to be implemented by the motor system. The dorsal and rostral areas of the ACC both seem to be affected by rewards and losses associated with errors. During one study, participants received monetary rewards and losses for correct and incorrect responses respectively. The dorsal part of the ACC seems to play a key role in reward-based decision making and learning. The rostral part of the ACC, on the other hand, is believed to be more involved with affective responses to errors.

In an experiment of Polli and al. participants performed a version of the Eriksen Flanker Task using a set of letters assigned to each response button instead of arrows.Targets were flanked by either a congruent or incongruent set of letters. Using an image of a thumb (up, down, or neutral) participants received feedback on how much money they gained or lost. The researchers found greater rostral ACC activation when participants lost money during the trials. The participants reported being frustrated when making mistakes. Because the ACC is intricately involved with error detection and affective responses, it may very well be that this area forms the bases of self-confidence. Taken together, these findings indicate that both the dorsal and rostral areas are involved in evaluating the extent of the error and optimizing subsequent responses. A study that confirming this notion explored the functions of both the dorsal and rostral areas of the ACC involved using a saccade task.

Participants were shown a cue that indicated whether they had to make either a post saccade or an anti-saccade. An anti-saccade requires suppression of a distracting cue because the target appears in the opposite location causing the conflict. Results showed differing activation for the rostral and dorsal ACC areas. Early correct anti-saccade performance was associated with rostral activation. The dorsal area, on the other hand, was activated when errors were committed, but also for correct responses. Whenever the dorsal area was active, fewer errors were committed providing more evidence that the ACC is involved with effortful performance. The second finding showed that during error trials, the ACC activated later than for correct responses clearly indicating a kind of evaluative function. Incorporating the findings of the previously discussed studies, the rostral and dorsal areas of the ACC seem to be monitoring for errors and, when they occur, evaluate their severity. The ACC can then send a form of affective response based on the severity of the error and so provides feedback about what just happened and what to do next (Polli et al., 2005).

A clinical study of Mayberg et al. in 2005 confirms the active role of the ACC and enlightens how the functioning of the ACC can be paralyzed. During depression it seems that some neurons in area 25 (rostral ACC) are hyper-activated. After years of researching the mechanics of depression, Emory University Neurologist Helen Mayberg noticed something unusual. If you looked at fMRI scans of depressive's brains next to scans of healthy people's brains, the depressed people's showed two things: reduced activity in the frontal cortex, and hyperactivity in rACC.

Mayberg grew curious, so she did some scans of depressed people pre- and post-treatment. As she predicted, once the patient's medications took effect, normal frontal cortex activity was restored, and area 25 in acc showed decreased activity.

> "Reciprocal pathways linking Cg25 to orbitofrontal, medial prefrontal, and various parts of the anterior and posterior cingulate cortices form the neuroanatomical substrates by which primary autonomic and homeostatic processes influence various aspects of learning, memory, motivation and reward—core behaviors altered in depressed patients." (Mayberg et al., 2005)

I think the merit of Mayberg is that she treats depression as a dynamic system:

> "Converging clinical, biochemical, neuroimaging, and postmortem evidence suggests that depression is unlikely to be a disease of a single brain region or neurotransmitter system. Rather, it is now generally viewed as a systems-level disorder affecting integrated pathways linking select cortical, subcortical, and limbic sites and their related neurotransmitter and molecular mediators." (Mayberg et al., 2005)

Mayberg's began to suspect that area 25 served as gateway of sorts--the bridge between the part of the brain responsible for negative rumination (the frontal cortex) and the seat of anxiety and fear (the limbic system). She wondered whether psychiatric drugs worked because they unintentionally reduced activity in area 25. To test her thesis, she decided to perform an experiment on 12 subjects whose chronic depression had stubbornly withstood drugs, talk therapy, and frequent bouts of electroconvulsive therapy.

The only way to test her theory was to bore two holes into the skulls of her subjects and insert electrodes directly into their brains—a stark reminder that neuroscience is still in its infancy. Yes, it sounds barbaric, but Mayberg's hope was that delivering a small jolt of electricity to this site would effectively reboot it. And it looks like she was right. Eight of her 12 subjects experienced relief, some instantaneously. Their melancholy evaporated as if by magic and it has yet to return. A quick shock to area 25 appears to lower the gateway between negative thoughts and painful feelings, effectively eliminating both the emotional and physiological components of depression. (Mayberg et al., 2005, David Dobs, 2006). Repeated rejection may lead to such a hyper-activation of area 25 and ACC, causing attention deficit and depression. Major depression is the most common of all psychiatric disorders.

The negative dynamic of rejection

The systems approach of Mayberg reduces the importance of the original controversy we started with. The huge degree of connectivity within ACC with other brain regions, serving as a gateway between the frontal cortex and the seat of anxiety and fear in the limbic system makes it a key region in our brain[1]. The frontal lobes have been found to play a part in impulse control, judgment, language production, working memory, motor function, problem solving, sexual behavior, socialization, and spontaneity. The frontal lobes assist in planning, coordinating, controlling, and executing behavior. The ACC and its connections to both the frontal lobe and the limbic system appears to play a role in a wide variety of autonomic functions, such as regulating blood pressure and heart rate, as well as rational cognitive functions, such as reward anticipation, decision-making, empathy and emotion. Seen as a dynamic, active, very complex and vulnerable system having various crucial coordination tasks, we must reduce beforehand any possible risk it gets messed up. Most likely Somerville et al. made a point: during exclusion the ACC is working as an alarm system. But their approach is too limited. It isn't a simple bad regulated car alarm that starts hooting when a cat is hiding under it, it's an intelligent and very sophisticated calculator regulating the 'fight or flight response', making work our cortex and our limbic system in accordance. It helps to take vital and intelligent decisions for survival.

A MEG research shows that social exclusion messes with our brain:

> "Self-control was assessed by having participants solve 180 moderately difficult math problems while measuring how quickly they identified a supplied answer as correct or incorrect. Magneto-encephalography (MEG) was used to assess neural activity during this task. Socially excluded participants showed lesser activity in occipital and parietal cortex from 100-350 ms after the presentation of the math problems. When presented with the answers, socially excluded participants showed lesser activity in several regions, including occipital, parietal, and right prefrontal cortex from 100-300 ms post-stimulus. Furthermore, activation in the parietal and right prefrontal cortex mediated exclusion-control performance differences on math problems. The findings suggest that social exclusion interferes with the executive control of attention, and this effect is manifest in specific aspects of cognitive performance and brain function." (Campell et al., 2006).

[1] I don't say a central region because i still do not believe there is one center in the brain that regulates all the rest, i believe in interplay, not in autocracy but i am aware that this might be an ideological stand, thus i should answer rather that i am an agnostic in that matter

In a new research, reported in the journal Social Neuroscience, researchers from the University of Georgia and San Diego State University report for the first time that social exclusion actually causes changes in a person's brain function and can lead to poor decision-making and a diminished learning ability. The magneto encephalography (MEG) technique was used. MEG is an imaging technique that measures the magnetic fields produced by electrical activity in the brain. One of the advantages of the MEG technique is that brain changes can be recorded in milliseconds, not in seconds, as some research of this kind may take. MEG actually has more advantages than other brain-imaging methods when it is used to look at real-time activity during a task.

The MEG data revealed that those in the social-exclusion group had clear differences in activity in the brain's occipital, parietal and prefrontal cortex regions. Those in the social-exclusion group also performed more poorly on the math questions. The inference is that social exclusion actually affects the brain's neural circuitry. The parietal cortex is involved in attention; while the prefrontal cortex helps support so-called "executive functioning" processes such as working memory and other behaviors that may support self-control.

> "These findings, therefore, may indicate that social rejection can have a powerful influence on topdown regulation of stimulus processing during relatively demanding cognitive tasks. This research also provides additional information about the nature of cognitive deficits that underlie responses to social exclusion and enhances our understanding of the mechanisms that underlie self-control failure." (Campell et al., 2006).

Researchers have known for a long time that there is a link between social exclusion and the failure of self-control. For instance, people who are rejected in social situations often respond by abusing alcohol, expressing aggression or performing poorly at school or work.

Conclusion

When social exclusion is defined based on the perception, noted either not noted, of the excluded himself, social rejection impairs the socialization capacity of the excluded thus aggravating the situation of exclusion by impairing the social adaptation capacity of the excluded, who gets caught in a negative spiral of mental disaster. I want to stress that I did not find that the harm it causes is irreversible. Though since an important function: namely to alarm us and to warn us for the damage caused to our social relations produces such puzzling effects, social exclusion should be considered as a form of mental violence. Its effects harm our brain circuits. The significance of these injuries will, in my opinion, depend on the persistence and repetition of rejection and the vulnerability of the brain circuit at stake.

On a philosophical level it makes me wonder if I wouldn't prefer a blow of the cudgel above social rejection. I might have a swollen red ear for some days, but this is only temporary damage. Perpetual and renewed social exclusion might be a lot more and a lot longer devastating and maybe irreversible in the long run. Another thought springs up also. The struggle for emancipation cannot be won when you stand-alone. The risk for mental disorder is lurking around the corner or as Baumeister puts it:

> "Though our findings are hardly adequate for prescribing social change, they do lend support to the view that promoting a more widely inclusive society, such that fewer groups or individuals feel left out, would reduce the extensive harm and heartbreak that often follow from self-regulation failure." (Baumeister et al., 2005).

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