Is heroin addiction related to a dysfunctional processing of reward and hedonism in the brain? Insights from neuroimaging studies

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Summary

The functioning of reward in drug addicts is a major issue both in terms of pathophysiology and in a rehabilitative view. We used a PET imaging device to assess the hedonic functioning of methadone maintained heroin addicts, compared to control subjects, by two modalities: 1) the elicitation of interest by anticipated monetary reward; 2) the neuroimaging correlates of visually elicited pleasure. In heroin addicts fewer brain regions showed activated during tasks implying known monetary reward in comparison to tasks without any reward. On the other hand, the processing of subjectively pleasant videoclips resorted to different brain pathways in heroin addicts. Heroin addicts seem to show a lower level of anticipatory sensitivity to monetary reward, whereas the topography of pleasure-feeling seems to be different from normal subjects. Such results show a different reward-seeking and reward-feeling status of methadone maintained heroin addicts, although it is to be clarified whether such a status was also fore-running heroin use, or developed as a correlate of addiction.

Key Words: Reward - Heroin Addiction - Methadone Maintenance - PET

Introduction

A large body of empirical evidence indicates that the reinforcing properties of psychoactive drugs are mediated by the mesostriatal and meso-corticolimbic dopamine system. Studies have shown that most psychoactive drugs, including heroin, cocaine, nicotine and alcohol, increase the dopaminergic transmission within this system, especially in the ventral striatum. This system, in its turn, is involved in the processing of reward information (1).
Reward has an important motivational function and is also involved in learning. It can elicit approach and consummatory behaviour. Obtaining reward is associated with pleasant feelings, which give a positive motivational value to the goal-object. The neural bases of reward processes have been investigated with various experimental approaches, including brain lesions, psychopharmacology, electrical self-stimulation, single neuron recording and neuroimaging. Most of these studies indicated that dopamine neurons were involved in the processing of reward information. Furthermore, specific regions of the mesolimbic dopamine system, like the midbrain, the striatum and the orbitofrontal cortex have been shown to be involved in several aspects of reward processing, suggesting that these regions belong to a cortico-subcortical loop that mediates motivational processes. It is not clear, however, whether dopamine is involved in the mediation of the pleasant feelings associated with rewards or is, rather, involved in learning processes.

Because drugs of abuse and rewards are associated with similar neural processes, it can be hypothesized that drug addiction is a dopamine-dependent disorder in which the positive reinforcing value of the drug is mediated through the activation of the mesolimbic dopamine system. On the other hand, the possible role of dopamine in processing pleasant feelings suggests that drug addiction could be related to a dysfunctional processing of hedonic information. We will present here the results of two PET (Positron Emission Tomography) studies that have investigated the neural processing of reward and of pleasant information in heroin addicts.

**Reward processing in heroin addiction**

It is well known that drugs have a rewarding value, but very little is known about the processing of natural rewards in the addicted brain. We have used PET to investigate activation related to the processing of monetary reward in a group of former heroin addicts on methadone maintenance and in a group of healthy controls. The subjects performed a visuo-spatial recognition task during PET acquisition under three different feedback conditions: feedback comprised no reinforcement, a non-monetary reinforcement, or a monetary reward. The tasks were exactly identical except for the reinforcer used. Under the condition involving no reinforcement, the subjects received a nonsense feedback for every response. Under the reinforcement condition, no reinforcement appeared if the response was wrong. As to monetary reward, the subjects were instructed before the scans that they would receive the sum shown at the end of the session. The maximum which could be won was 320 Swiss Francs (approximately 210 Euros). The subjects were thoroughly instructed before the scans, and they performed the task once under all three conditions during a training phase.

Our results showed that fewer regions were activated in response to reward in the brains of dependent subjects. Typical reward-related regions were activated by monetary reward, but not by non-monetary reinforcement, in contrast to the healthy subjects. These results corroborated previous findings obtained in a smoker group showing a similar
pattern of activation as that of the heroin addicts in response to reward. Taken together, these results show that there is a common pattern of reward-related activation in the two forms of dependence. This pattern could indicate that non-monetary reinforcement has insufficient motivational value to activate reward-related regions, suggesting that specific reward regions require more stimulation in addicts’ brains (3).

The processing of hedonic information in heroin addiction

In a second study, we investigated the processing of hedonic information in a group of healthy control subjects and a group of former heroin addicts on methadone maintenance. The cerebral blood flow was measured with PET, while the subjects were shown pleasant and neutral film clips. Our results showed that the presentation of pleasant film clips was associated with activation in the striatum and in other typical reward regions in the heroin addicts, but not in the control subjects. These results suggest that hedonic information is processed in a different way in the brain of heroin addicts.

Conclusion

In conclusion, we were able to show at a neural level that there is a dysfunctional processing of reward information in heroin addicts. Furthermore, the reward-related brain activation was similar in two major forms of dependence (heroin addiction and tobacco dependence) and differed noticeably from the activation observed in healthy subjects. Thus, typical reward-related regions were activated only by the highest rewards in dependent subjects. Furthermore, the passive viewing of pleasant information was associated with the activation of typical reward regions in the brain in heroin addicts, but not in healthy control subjects. These findings could indicate that the brains of dependent subjects interpret and react to motivational and emotional stimuli in a different way from the brains of healthy, non-addicted, subjects.

References

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