Prenatal Exposure to Maternal Cigarette Smoking and Adolescents’ Reward Processing

Kathrin Müller, Tomas Paus, Michael N. Smolka and the Imagen Consortium

Introduction
Previous neuroimaging studies demonstrate that drug addiction is characterized by altered reward processing. For example, smokers show an increased reactivity to drug related stimuli in the reward circuitry compared to non-smokers (Due et al., 2002). On the other hand they demonstrate a decreased neural response to non-drug rewards in these areas (Bühler et al., 2010). Animal studies indicate that not only the smoking individual himself shows these changes but even prenatal exposure to nicotine during pregnancy alters the offspring’s reward circuitry and modifies the effect of drugs later in life (Franke et al., 2008). In humans, adolescents with prenatal exposure to maternal cigarette smoking (PEMCS) show structural changes in brain areas known to be part of the reward circuitry, like the ventral striatum (Lotfipour et al., 2010) and the orbitofrontal cortex (Toro et al., 2008). Exposed individuals also exhibit a higher incidence of drug use or addiction (Buka et al., 2003).

So far very no study investigated actual reward processing in subjects with prenatal exposure to maternal cigarette smoking. Here we address this issue by comparing reward anticipation in exposed and non-exposed adolescents.

Methods
120 exposed (mother smoked at least 1 cigarette per day throughout the pregnancy) and 120 non-exposed adolescents (mean age: 14.4 years, SD=.38) matched on age, gender and maternal education level performed a reward processing task during fMRI. Subjects were selected from a large European multi-center study of reinforcement-related behavior in adolescents (IMAGEN, Schumann et al., 2010).

We analyzed reward anticipation in a modified version of the Monetary Incentive Delay (MID) Task (Knutson et al., 2001). Subjects were instructed to respond with a button press while a white square target was displayed. Subjects could either win nothing, a small or a high amount of points as indicated by different cues presented before each target. A feedback whether subjects hit or missed the target and the amount of wins was presented afterwards. The model for single subject data analysis included anticipation and feedback for different amounts of rewards and for hits and misses respectively. Here we focused our analysis on the anticipation of rewards (i.e. contrast anticipation of either small or large reward – anticipation of no reward).

For the second level analysis adolescents’ smoking and alcohol drinking behavior during the last 30 days were included as covariates. We used a hypothesis-driven ROI approach to probe the functional activation in the ventral striatum. A mask from the Jerne Database (Nielsen & Hansen, 2002) was used. Data were analyzed with SPM8.

For a more detailed analysis we divided the exposed group in a low (1-10 cigarettes per day, N = 99) and a high (more than 10 cigarettes per day, N = 21) exposed group.

Results
During the anticipation of a reward exposed adolescents showed a reduced activation in the left (-9, 5, -2; t=3.9) and right (15, 11, -5; t=2.6) ventral striatum compared to non-exposed. Adolescents’ smoking and alcohol drinking behavior showed no influence on striatal activation.

When looking at the three different exposure groups we found a negative dose-response relationship between exposure status and BOLD activation in the ventral striatum.
Conclusions
Maternal smoking during pregnancy is known to be a risk factor for later substance use and abuse in the offspring. But the underlying mechanisms are still unclear. For the first time we could show that prenatal exposure to maternal cigarette smoking decreases the neural activation during reward anticipation in adolescents. This hypo-activation may increase liability to substance use and development of an addiction and thereby contribute the higher incidences in exposed adolescents and adults.

References


