Tuning rapid brain response to rare emotional stimuli may calm down impulsivity

We may have experiences of doing something on impulse (e.g., impulse buying). Although impulsivity helps us to explore something new, and is important for establishing a prominent leadership to head up people in our communities. However, unusual impulsivity often causes socially problematic behaviors, such as violence, substance abuse, and suicide, which cause social and clinical economical loss. Abnormal impulsive behaviors are considered to result from the dysfunction of inhibitory control. Behavioral inhibition is an important brain ability to, for instance, brake cars, stop mouse-clicking unfavorable hyperlinks, and prevent from physically striking others with anger. Behavioral inhibition is supported by local brain areas including the medial prefrontal areas, and takes place about 0.3 second after we obtain inputs from sensory organs. On the other hand, automatic brain process before behavioral inhibition has been seldom examined upon impulsivity, while unattended visual processing may be affected by impulsivity, because people with more impulsivity tend to become more accustomed to novel stimuli.

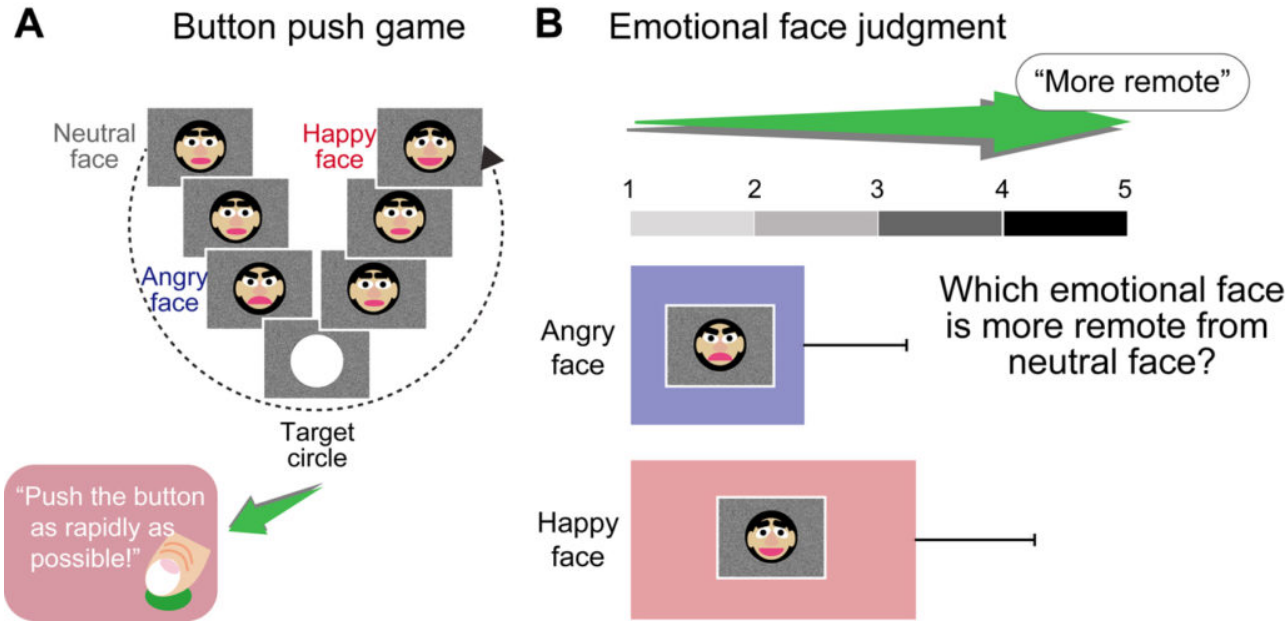

Fig. 1.

In the recent study using human brain electrical activities, we observed that impulsivity affects rapid brain activities for detection of novel emotional faces. A visual mismatch negative (vMMN) brain potential is a popular brain response to a rare visual input, which can be recorded from electrodes on the scalp. vMMN appears when rare visual images (e.g., happy and angry faces in Fig. 1A) are presented in the context of frequent visual images (e.g., neutral faces in Fig. 1A). vMMN is a rapid

brain response about 0.2 second after visual images, has origins from visual cortical areas, and is used as an index of automatic detection of rare visual images.

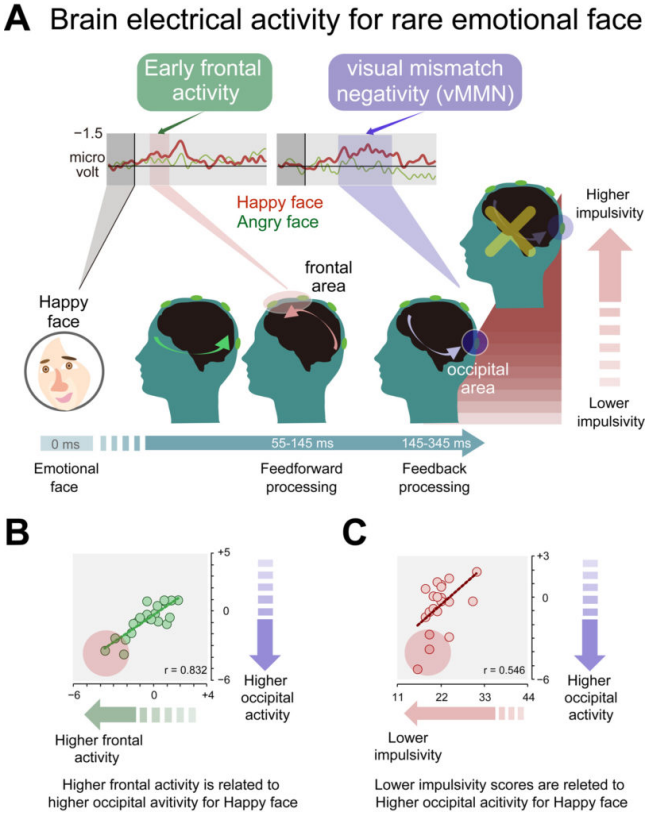

Fig. 2.

Twenty-one healthy adults conducted a game-like task, in which they pushed a button only when a white circle appeared (Fig. 1A). After the tasks, they answered questions about three types of their impulsive properties (attentional impulsivity, motor impulsivity, non-planning impulsivity). Participants also judged emotional faces used in the task with a 10 point scale, and felt that happy faces were more remote from neutral faces than angry faces (Fig. 1B).

Interestingly, the participants selectively yielded the vMMN to the rare happy faces (red line in Fig. 2). Greater vMMN was related to greater early frontal activity around 0.1 second after images appeared (Fig. 2A). Because the frontal activity reflects automatic arousal (attentional shift) to novel stimuli, the rare happy faces firstly evoked arousal response in the frontal cortical area, and subsequently promoted visual detection of the rare face stimuli. However, only vMMN activities decreased as motor impulsivity, such urgent responses, increased (Fig. 2B). That is, impulsivity weakens the frontal-occipital brain functional connection for detection of rare happy faces.

The present findings were based on the investigation of healthy people. In another study, on the other hand, clinical populations with unusual impulsivity reversely increased brain responses to rare emotional stimuli. These findings imply that development of abnormal impulsivity is related to shift to decreased to increased brain responses to rare emotional inputs. Early detection of such shift in brain responses may be important for the protecting development of abnormal impulsivity. To conclude, optimal adjustment of rapid brain responses to novel emotional stimuli may be effective to calm down our impulsivity, and to effectively prevent socially negative consequences.

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