Aha! I got it! Engagement of dopaminergic pathways during insight moments
Sladky R 1, Tik M 1, Luft CDB 2,3, Willinger D 1, Hoffmann A 1, Banissy MJ 3, 
Bhattacharya J 3, Windischberger C 1
1MR Center of Excellence, Center for Medical Physics and Biomedical Engineering, 
Medical University of Vienna, Austria. 2Biological & Experimental Psychology Division, 
School of Biological & Chemical Sciences, Queen Mary, University of Lon- 
don. 3Department of Psychology, Goldsmiths, University of London

Background: An Aha!-moment is a unique feeling of excitement, joy, and certainty asso- 
ciated with suddenly finding a creative solution through insight. Currently, one hypothe- 
sis suggests the involvement of the neurotransmitter dopamine in Aha!-moments by 
facilitating novelty seeking and creative drive (Flaherty, 2005). The link between dopa- 
mime and creativity is supported by (1) studies in Parkinson’s disease patients that show 
dopamine-related changes in artistic expression (Kulisevsky et al., 2009), (2) abuse of 
dopamine agonists to increase artistic performance (Schwingenschuh et al., 2010), and 
(3) reductions in creativity following reduction of dopamine agonist use (Lhommee et al., 
2014). Yet there is no direct evidence for the involvement of the dopaminergic midbrain 
in the emergence of the Aha!-moment, a key component of creative insight.

Methods: While undergoing 7 Tesla fMRI (Siemens MAGNETOM, TR=1.4 s, TE=23 
ms, 1.5×1.5×1 mm³ resolution), 25 healthy volunteers performed the compound word 
remote associates task (RAT), which has been validated and used in previous neuroima- 
ging studies on insight problem solving (Jung-Beeman et al., 2004; Sandkühler and 
Bhattacharya, 2008).

Results: Aha!-moments are associated with an increased activation in a subcortical brain 
network that includes nucleus accumbens (NAcc), posterior hippocampus (Hipp), and 
ventral tegmental area (VTA) (Figure A). Using DCM we show that connectivity from 
VTA to NAcc and from VTA to Hipp was substantially increased for Aha!-moments 
compared to solution-moments without Aha! (p=0.010 and p<0.001) and no solution 
(p=0.010 corrected and p=0.023 uncorrected), which strongly suggests that activations in 
NAcc and Hipp are mediated by the dopaminergic system (Figure B).

Conclusions: Here we show that the underlying insight-related mechanisms occur within 
a neural network comprising dopaminergic midbrain structures as well as nucleus ac- 
cumbens and hippocampus. These results present the first direct evidence of the involve- 
ment of the dopaminergic system in the Aha!-moment.