

# [Commentary: effect of low-frequency repetitive transcranial magnetic stimulation ...](https://assignbuster.com/commentary-effect-of-low-frequency-repetitive-transcranial-magnetic-stimulation-on-impulse-inhibition-methamphetamine-in-abstinent-methamphetamine-patients/)

[Health & Medicine](https://assignbuster.com/essay-subjects/health-n-medicine/)

A Commentary on
Effect of Low-Frequency Repetitive Transcranial Magnetic Stimulation on Impulse Inhibition in Abstinent Patients With Methamphetamine Addiction: A Randomized Clinical Trial

*by Yuan, J., Liu, W., Liang, Q., Cao, X., Lucas, M. V., and Yuan, T. F. (2020). JAMA Netw Open 3, e200910. doi:* [*10. 1001/jamanetworkopen. 2020. 0910*](https://doi.org/10.1001/jamanetworkopen.2020.0910)

Drug addiction and relapse are characterized by compulsive drug seeking behavior and high impulsivity throughout different stages of addiction (e. g., formation and relapse) ( [1](#B1) ). Methamphetamine (MA) dependents exhibited high impulsivity, which act as important risk of relapse ( [2](#B2) ). Neuroimaging studies reported dopaminergic transmission and cortical-striatal circuitry mechanisms underlying the changes ( [3](#B3) ). It is conceivable that targeting these aberrant circuits might facilitate the behavioral control and reduce behavioral impulsivity in MA dependents ( [4](#B4) ) and, finally, prevent the patients from relapse. A recent study published on *JAMA Netw Open* proved the clinical potential of brain stimulation approach for impulsivity control in MA patients ( [5](#B5) ).

The authors firstly developed a two-choice oddball task that allows for quantification of behavioral impulsivity with improved sensitivity, in compared to the classical Go/Nogo task ( [6](#B6) ). The task contains both standard (frequently) and deviant (infrequently) trials; the subject needs to habituate for standard trial responses and response for deviant trial by press the button for inhibition. The behavioral results therefore provided both accuracy responses and reaction time (RT) differences between the two conditions. The authors found that the MA dependents reported lower accuracy and shortened response time, both of which reflecting the increased impulsivity associated with MA dependence.

Considering the importance of prefrontal cortex (PFC) in behavioral inhibition and risk decision making processes ( [7](#B7) ), the authors therefore designed a randomized controlled trial to investigate the effects of 1 Hz non-invasive repetitive transcranial magnetic stimulation (rTMS) on impulsivity of MA dependents, which is found to be effective in reducing impulsivity in other types of patients ( [8](#B8) ). Single session 1-Hz treatment at left PFC successfully improved accuracy and slowed down the response time, while repeated treatment with 10 sessions demonstrated lasting effects for at least 30 days. These findings suggest that 1 Hz rTMS could reduce behavioral impulsivity and improve the cautious decision making.

The study for the first time reported the effects of rTMS intervention on impulsivity of MA dependence. It is possible that this finding might be generalize to other substances of abuse as well and warrants future large trials investigating the effects of chronic rTMS on impulsive drug seeking behaviors and relapse. Recent studies emphasized the potency of rTMS treatment on drug intake behavior, improve sleep quality and cognition, and efficiency to reduced cue reactivity or craving in a variety of drug dependents ( [9](#B9) – [17](#B17) ). It should be noted that most of these results focused on high-frequency (e. g., 10 Hz) rTMS stimulation at left PFC region ( [18](#B18) ).

Previous studies reported that, for MA addicts, the craving rate decreased after high-frequency (10 Hz) rTMS at left PFC, and the rate increased after low-frequency (1 Hz) rTMS at the same cortex ( [19](#B19) , [20](#B20) ). There is a theory that the excitation of unilateral cortical regions leads to suppression of the contralateral side, so the high-frequency stimulation on the left can achieve the same therapeutic effect in the right position by low frequency ( [21](#B21) ). It is consistent with the results observed by Yuan et al. that no matter high-frequency rTMS at left PFC or low-frequency rTMS at right PFC effectively reduced craving rate for MA abusers ( [22](#B22) ). Whether the patient requires two different and separate treatment protocols for drug seeking and impulsivity is yet to be understood.

The study is limited by a short period of treatment and follow-up time window. It is still necessary to understand the lasting effects of rTMS on impulsivity improvement; it is also important to examine if rTMS also improves risk decision making, which partly relies on behavioral inhibition ability. In addition, it will be interesting to understand if targeting motor cortical areas (e. g., SMA, M1) would also modulate the motor impulsivity and provide a full picture of impulsivity treatment in substances of abuse.

Taken together, the recent study by Yuan et al. opened novel possibility of impulsive behavior intervention for drug dependence and potentially imply on relapse behavior. Neuroimaging studies are required to elucidate the underlying neuroplasticity and circuitry changes following rTMS treatment.

## Author Contributions

HW, CY, and XL contributed equally to this work. HW and CY drafted the manuscript. XL revised the manuscript. WL and FH provided funds. All authors contributed to the article and approved the submitted version.

## Funding

The study was supported by the Medical Science and Technology Project in Ningbo (2017A54 and 2018A31), Science and Technology Project in Yongkang (201634), and Ningbo Municipal Innovation Team of Life Science and Health (2015C110026).

## Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Acknowledgments

The authors thank Qi Zhou, Wenhao Zhuang, and Xiaoli Liu for help during manuscript writing.

## References

1. Jentsch JD, Ashenhurst JR, Cervantes MC, Groman SM, James AS, Pennington ZT. Dissecting impulsivity and its relationships to drug addictions. *Ann N Y Acad Sci* (2014) 1327: 1–26. doi: 10. 1111/nyas. 12388

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/24654857/) | [CrossRef Full Text](https://doi.org/10.1111/nyas.12388) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=JD+Jentsch&author=JR+Ashenhurst&author=MC+Cervantes&author=SM+Groman&author=AS+James&author=ZT+Pennington&publication_year=2014&title=Dissecting impulsivity and its relationships to drug addictions&journal=Ann+N+Y+Acad+Sci&volume=1327&pages=1)

2. Jones HW, Dean AC, Price KA, London ED. Increased self-reported impulsivity in methamphetamine users maintaining drug abstinence. *Am J Drug Alcohol Abuse* (2016) 42: 500–6. doi: 10. 1080/00952990. 2016. 1192639

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/27398730/) | [CrossRef Full Text](https://doi.org/10.1080/00952990.2016.1192639) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=HW+Jones&author=AC+Dean&author=KA+Price&author=ED+London&publication_year=2016&title=Increased self-reported impulsivity in methamphetamine users maintaining drug abstinence&journal=Am+J+Drug+Alcohol+Abuse&volume=42&pages=500-6)

3. Lee B, London ED, Poldrack RA, Farahi J, Nacca A, Monterosso JR, et al. Striatal dopamine d2/d3 receptor availability is reduced in methamphetamine dependence and is linked to impulsivity. *J Neurosci* (2009) 29: 14734–40. doi: 10. 1523/JNEUROSCI. 3765-09. 2009

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/19940168/) | [CrossRef Full Text](https://doi.org/10.1523/JNEUROSCI.3765-09.2009) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=B+Lee&author=ED+London&author=RA+Poldrack&author=J+Farahi&author=A+Nacca&author=JR+Monterosso&publication_year=2009&title=Striatal dopamine d2%2Fd3 receptor availability is reduced in methamphetamine dependence and is linked to impulsivity&journal=J+Neurosci&volume=29&pages=14734-40)

4. Adinoff B, Rilling LM, Williams MJ, Schreffler E, Schepis TS, Rosvall T, et al. Impulsivity, neural deficits, and the addictions: the “ oops” factor in relapse. *J Addict Dis* (2007) 26(Suppl 1): 25–39. doi: 10. 1300/J069v26S01\_04

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/19283972/) | [CrossRef Full Text](https://doi.org/10.1300/J069v26S01_04) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=B+Adinoff&author=LM+Rilling&author=MJ+Williams&author=E+Schreffler&author=TS+Schepis&author=T+Rosvall&publication_year=2007&title=Impulsivity%2C neural deficits%2C and the addictions%3A the “oops” factor in relapse&journal=J+Addict+Dis&volume=26&pages=25)

5. Yuan J, Liu W, Liang Q, Cao X, Lucas MV, Yuan TF. Effect of Low-Frequency Repetitive Transcranial Magnetic Stimulation on Impulse Inhibition in Abstinent Patients With Methamphetamine Addiction: A Randomized Clinical Trial. *JAMA Netw Open* (2020) 3: e200910. doi: 10. 1001/jamanetworkopen. 2020. 0910

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/32167568/) | [CrossRef Full Text](https://doi.org/10.1001/jamanetworkopen.2020.0910) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J+Yuan&author=W+Liu&author=Q+Liang&author=X+Cao&author=MV+Lucas&author=TF+Yuan&publication_year=2020&title=Effect of Low-Frequency Repetitive Transcranial Magnetic Stimulation on Impulse Inhibition in Abstinent Patients With Methamphetamine Addiction%3A A Randomized Clinical Trial&journal=JAMA+Netw+Open&volume=3&pages=e200910)

6. Yuan J, He Y, Qinglin Z, Chen A, Li H. Gender differences in behavioral inhibitory control: ERP evidence from a two-choice oddball task. *Psychophysiology* (2008) 45: 986–93. doi: 10. 1111/j. 1469-8986. 2008. 00693. x

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/18778319/) | [CrossRef Full Text](https://doi.org/10.1111/j.1469-8986.2008.00693.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J+Yuan&author=Y+He&author=Z+Qinglin&author=A+Chen&author=H+Li&publication_year=2008&title=Gender differences in behavioral inhibitory control%3A ERP evidence from a two-choice oddball task&journal=Psychophysiology&volume=45&pages=986-93)

7. Sabrini S, Wang GY, Lin JC, Ian JK, Curley LE. Methamphetamine use and cognitive function: A systematic review of neuroimaging research. *Drug Alcohol Depend* (2019) 194: 75–87. doi: 10. 1016/j. drugalcdep. 2018. 08. 041

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/30414539/) | [CrossRef Full Text](https://doi.org/10.1016/j.drugalcdep.2018.08.041) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=S+Sabrini&author=GY+Wang&author=JC+Lin&author=JK+Ian&author=LE+Curley&publication_year=2019&title=Methamphetamine use and cognitive function%3A A systematic review of neuroimaging research&journal=Drug+Alcohol+Depend&volume=194&pages=75)

8. Sokhadze EM, El-Baz A, Baruth J, Mathai G, Sears L, Casanova MF. Effects of Low Frequency Repetitive Transcranial Magnetic Stimulation (rTMS) on Gamma Frequency Oscillations and Event-Related Potentials During Processing of Illusory Figures in Autism. *J Autism Dev Disord* (2008) 39: 619–34. doi: 10. 1007/s10803-008-0662-7

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/19030976/) | [CrossRef Full Text](https://doi.org/10.1007/s10803-008-0662-7) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=EM+Sokhadze&author=A+El-Baz&author=J+Baruth&author=G+Mathai&author=L+Sears&author=MF+Casanova&publication_year=2008&title=Effects of Low Frequency Repetitive Transcranial Magnetic Stimulation (rTMS) on Gamma Frequency Oscillations and Event-Related Potentials During Processing of Illusory Figures in Autism&journal=J+Autism+Dev+Disord&volume=39&pages=619-34)

9. Shen Y, Cao X, Tan T, Shan C, Wang Y, Pan J, et al. 10 Hz repetitive transcranial magnetic stimulation of the left dorsolateral prefrontal cortex reduces Heroin cue craving in long-term addicts. *Biol Psychiatry* (2016) 80(3): e13–4. doi: 10. 1016/j. biopsych. 2016. 02. 006

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/26995024/) | [CrossRef Full Text](https://doi.org/10.1016/j.biopsych.2016.02.006) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=Y+Shen&author=X+Cao&author=T+Tan&author=C+Shan&author=Y+Wang&author=J+Pan&publication_year=2016&title=10 Hz repetitive transcranial magnetic stimulation of the left dorsolateral prefrontal cortex reduces Heroin cue craving in long-term addicts&journal=Biol+Psychiatry&volume=80&pages=e13-4)

10. Li X, Hartwell KJ, Owens M, Lematty T, Borckardt JJ, Hanlon CA, et al. Repetitive Transcranial Magnetic Stimulation of the Dorsolateral Prefrontal Cortex Reduces Nicotine Cue Craving. *Biol Psychiatry* (2013) 73: 714–20. doi: 10. 1016/j. biopsych. 2013. 01. 003

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/23485014/) | [CrossRef Full Text](https://doi.org/10.1016/j.biopsych.2013.01.003) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=X+Li&author=KJ+Hartwell&author=M+Owens&author=T+Lematty&author=JJ+Borckardt&author=CA+Hanlon&publication_year=2013&title=Repetitive Transcranial Magnetic Stimulation of the Dorsolateral Prefrontal Cortex Reduces Nicotine Cue Craving&journal=Biol+Psychiatry&volume=73&pages=714-20)

11. Bolloni C, Panella R, Pedetti M, Frascella AG, Gambelunghe C, Piccoli T, et al. Bilateral Transcranial Magnetic Stimulation of the Prefrontal Cortex Reduces Cocaine Intake: A Pilot Study. *Front Psychiatry* (2016) 7: 133. doi: 10. 3389/fpsyt. 2016. 00133

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/27551268/) | [CrossRef Full Text](https://doi.org/10.3389/fpsyt.2016.00133) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=C+Bolloni&author=R+Panella&author=M+Pedetti&author=AG+Frascella&author=C+Gambelunghe&author=T+Piccoli&publication_year=2016&title=Bilateral Transcranial Magnetic Stimulation of the Prefrontal Cortex Reduces Cocaine Intake%3A A Pilot Study&journal=Front+Psychiatry&volume=7&)

12. Liu T, Li Y, Shen Y, Liu X, Yuan TF. Gender does not matter: Add-on repetitive transcranial magnetic stimulation treatment for female methamphetamine dependents. *Prog Neuropsychopharmacol Biol Psychiatry* (2019) 92: 70–5. doi: 10. 1016/j. pnpbp. 2018. 12. 018

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/30605708/) | [CrossRef Full Text](https://doi.org/10.1016/j.pnpbp.2018.12.018) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=T+Liu&author=Y+Li&author=Y+Shen&author=X+Liu&author=TF+Yuan&publication_year=2019&title=Gender does not matter%3A Add-on repetitive transcranial magnetic stimulation treatment for female methamphetamine dependents&journal=Prog+Neuropsychopharmacol+Biol+Psychiatry&volume=92&pages=70-5)

13. Liang Y, Wang L, Yuan TF. Targeting Withdrawal Symptoms in Men Addicted to Methamphetamine With Transcranial Magnetic Stimulation: A Randomized Clinical Trial. *JAMA Psychiatry* (2018) 75: 1199–201. doi: 10. 1001/jamapsychiatry. 2018. 2383

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/30208372/) | [CrossRef Full Text](https://doi.org/10.1001/jamapsychiatry.2018.2383) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=Y+Liang&author=L+Wang&author=TF+Yuan&publication_year=2018&title=Targeting Withdrawal Symptoms in Men Addicted to Methamphetamine With Transcranial Magnetic Stimulation%3A A Randomized Clinical Trial&journal=JAMA+Psychiatry&volume=75&pages=1199-201)

14. Ernestina Politi MD, Eugenia Fauci MD, Santoro A, Enrico Smeraldi MD. Daily Sessions of Transcranial Magnetic Stimulation to the Left Prefrontal Cortex Gradually Reduce Cocaine Craving. *Am J Addict* (2008) 17: 345–6. doi: 10. 1080/10550490802139283

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/18612892/) | [CrossRef Full Text](https://doi.org/10.1080/10550490802139283) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=MD+Ernestina Politi&author=MD+Eugenia Fauci&author=A+Santoro&author=MD+Enrico Smeraldi&publication_year=2008&title=Daily Sessions of Transcranial Magnetic Stimulation to the Left Prefrontal Cortex Gradually Reduce Cocaine Craving&journal=Am+J+Addict&volume=17&pages=345-6)

15. Camprodon JA, Martínez-Raga J, Alonso-Alonso M, Shih MC, Pascual-Leone A. One session of high frequency repetitive transcranial magnetic stimulation (rTMS) to the right prefrontal cortex transiently reduces cocaine craving. *Drug Alcohol Depend* (2007) 86: 91–4. doi: 10. 1016/j. drugalcdep. 2006. 06. 002

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/16971058/) | [CrossRef Full Text](https://doi.org/10.1016/j.drugalcdep.2006.06.002) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=JA+Camprodon&author=J+Martínez-Raga&author=M+Alonso-Alonso&author=MC+Shih&author=A+Pascual-Leone&publication_year=2007&title=One session of high frequency repetitive transcranial magnetic stimulation (rTMS) to the right prefrontal cortex transiently reduces cocaine craving&journal=Drug+Alcohol+Depend&volume=86&pages=91-4)

16. Madeo G, Terraneo A, Cardullo S, Gomez Perez LJ, Cellini N, Sarlo M, et al. Long-Term Outcome of Repetitive Transcranial Magnetic Stimulation in a Large Cohort of Patients With Cocaine-Use Disorder: An Observational Study. *Front Psychiatry* (2020) 11: 158. doi: 10. 3389/fpsyt. 2020. 00158

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/32180745/) | [CrossRef Full Text](https://doi.org/10.3389/fpsyt.2020.00158) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=G+Madeo&author=A+Terraneo&author=S+Cardullo&author=LJ+Gomez Perez&author=N+Cellini&author=M+Sarlo&publication_year=2020&title=Long-Term Outcome of Repetitive Transcranial Magnetic Stimulation in a Large Cohort of Patients With Cocaine-Use Disorder%3A An Observational Study&journal=Front+Psychiatry&volume=11&)

17. Lin J, Liu X, Li H, Yu L, Shen M, Lou Y, et al. Chronic repetitive transcranial magnetic stimulation (rTMS) on sleeping quality and mood status in drug dependent male inpatients during abstinence. *Sleep Med* (2019) 58: 7–12. doi: 10. 1016/j. sleep. 2019. 01. 052

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31042621/) | [CrossRef Full Text](https://doi.org/10.1016/j.sleep.2019.01.052) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J+Lin&author=X+Liu&author=H+Li&author=L+Yu&author=M+Shen&author=Y+Lou&publication_year=2019&title=Chronic repetitive transcranial magnetic stimulation (rTMS) on sleeping quality and mood status in drug dependent male inpatients during abstinence&journal=Sleep+Med&volume=58&pages=7)

18. Ekhtiari H, Tavakoli H, Addolorato G, Baeken C, Bonci A, Campanella S, et al. Transcranial electrical and magnetic stimulation (tES and TMS) for addiction medicine: A consensus paper on the present state of the science and the road ahead. *Neurosci Biobehav Rev* (2019) 104: 118–40. doi: 10. 1016/j. neubiorev. 2019. 06. 007

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31271802/) | [CrossRef Full Text](https://doi.org/10.1016/j.neubiorev.2019.06.007) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=H+Ekhtiari&author=H+Tavakoli&author=G+Addolorato&author=C+Baeken&author=A+Bonci&author=S+Campanella&publication_year=2019&title=Transcranial electrical and magnetic stimulation (tES and TMS) for addiction medicine%3A A consensus paper on the present state of the science and the road ahead&journal=Neurosci+Biobehav+Rev&volume=104&pages=118-40)

19. Li X, Malcolm RJ, Huebner K, Hanlon CA, Taylor JJ, Brady KT, et al. Low frequency repetitive transcranial magnetic stimulation of the left dorsolateral prefrontal cortex transiently increases cue-induced craving for methamphetamine: a preliminary study. *Drug Alcohol Depend* (2013) 133: 641–6. doi: 10. 1016/j. drugalcdep. 2013. 08. 012

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/24028801/) | [CrossRef Full Text](https://doi.org/10.1016/j.drugalcdep.2013.08.012) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=X+Li&author=RJ+Malcolm&author=K+Huebner&author=CA+Hanlon&author=JJ+Taylor&author=KT+Brady&publication_year=2013&title=Low frequency repetitive transcranial magnetic stimulation of the left dorsolateral prefrontal cortex transiently increases cue-induced craving for methamphetamine%3A a preliminary study&journal=Drug+Alcohol+Depend&volume=133&pages=641-6)

20. Su H, Zhong N, Gan H, Wang J, Han H, Chen T, et al. High frequency repetitive transcranial magnetic stimulation of the left dorsolateral prefrontal cortex for methamphetamine use disorders: A randomised clinical trial. *Drug Alcohol Depend* (2017) 175: 84–91. doi: 10. 1016/j. drugalcdep. 2017. 01. 037

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/28410525/) | [CrossRef Full Text](https://doi.org/10.1016/j.drugalcdep.2017.01.037) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=H+Su&author=N+Zhong&author=H+Gan&author=J+Wang&author=H+Han&author=T+Chen&publication_year=2017&title=High frequency repetitive transcranial magnetic stimulation of the left dorsolateral prefrontal cortex for methamphetamine use disorders%3A A randomised clinical trial&journal=Drug+Alcohol+Depend&volume=175&pages=84)

21. Kirton A, Chen R, Friefeld S, Gunraj C, Pontigon AM, Deveber G. Contralesional repetitive transcranial magnetic stimulation for chronic hemiparesis in subcortical paediatric stroke: a randomised trial. *Lancet Neurol* (2008) 7: 507–13. doi: 10. 1016/S1474-4422(08)70096-6

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/18455961/) | [CrossRef Full Text](https://doi.org/10.1016/S1474-4422%2808%2970096-6) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=A+Kirton&author=R+Chen&author=S+Friefeld&author=C+Gunraj&author=AM+Pontigon&author=G+Deveber&publication_year=2008&title=Contralesional repetitive transcranial magnetic stimulation for chronic hemiparesis in subcortical paediatric stroke%3A a randomised trial&journal=Lancet+Neurol&volume=7&pages=507-13)

22. Liu Q, Shen Y, Cao X, Li Y, Chen Y, Yang W, et al. Either at left or right, both high and low frequency rTMS of dorsolateral prefrontal cortex decreases cue induced craving for methamphetamine. *Am J Addict* (2017) 26: 776–9. doi: 10. 1111/ajad. 12638

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/29134789/) | [CrossRef Full Text](https://doi.org/10.1111/ajad.12638) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=Q+Liu&author=Y+Shen&author=X+Cao&author=Y+Li&author=Y+Chen&author=W+Yang&publication_year=2017&title=Either at left or right%2C both high and low frequency rTMS of dorsolateral prefrontal cortex decreases cue induced craving for methamphetamine&journal=Am+J+Addict&volume=26&pages=776-9)