Table S1. A complete list of published papers on reinstatement/relapse to opioid seeking using operant-based reinstatement/relapse models and their major findings. The data are based on PubMed research. Note: Several reinstatement-related papers reported results with more than one reinstating stimulus and appear in more than one category. Abbreviations: Self-administration, SA.

Section 2. Extinction-based relapse models

2.1. Drug priming

Number	Paper	Major Finding
1	(Davis and Smith, 1976)	Priming injections of morphine and amphetamine reinstate morphine seeking.
2	(de Wit and Stewart, 1983)	Priming injections of heroin and morphine reinstate heroin seeking.
3	(Stewart, 1984)	Morphine injections into the VTA (but not periaqueductal gray or caudate nucleus (reinstate heroin and cocaine seeking. Systemic naltrexone injections decrease this reinstatement.
4	(Stewart and Vezina, 1988)	NAc core amphetamine, but not morphine, injections reinstate heroin seeking.
5	(Wise et al., 1990)	Systemic injections of bromocriptine (a Drd2 agonist) reinstate heroin seeking.
6	(Stewart and Wise, 1992)	Systemic injections of morphine but not naltrexone or nalorphine (MOR antagonist/KOR agonist) reinstate heroin seeking.
7	(Shaham et al., 1994)	Heroin priming reinstates heroin seeking after extinction.
8	(Shaham and Stewart, 1995)	Heroin priming reinstates heroin seeking and increases NAc dopamine release.
10	(Shaham and Stewart, 1996)	Systemic injections of naltrexone, flupenthixol (non-selective Drd1/Drd2 antagonist), raclopride (Drd2 antagonist), and SCH 23390 (Drd1 antagonist) decrease heroin priming-induced reinstatement.
11	(Shaham et al., 1997a)	Adrenalectomy after training and acute injection or chronic exposure to metyrapone (a corticosterone synthesis inhibitor) have no effect on heroin priming-induced reinstatement.
12	(Shaham et al., 1997b)	Reinstatement of heroin seeking in male rats is not induced by exposure to receptive females.
13	(De Vries et al., 1998)	Priming injections of heroin, amphetamine, or cocaine reinstate heroin seeking.
14	(Spanagel et al., 1998)	Systemic injection of acamprosate (glutamatergic modulator) has no effect on heroin priming-induced reinstatement.
15	(De Vries et al., 1999)	Heroin or GBR-12909 (dopamine reuptake inhibitor) reinstate heroin seeking. Apomorphine, quinpirole (Drd2 agonist), and SKF 82958 (Drd1 agonist) do not reinstate heroin seeking after prolonged extinction.
16	(Leri and Stewart, 2001)	In rats trained to self-administer both cocaine and heroin, heroin priming reinstates heroin but not cocaine seeking while cocaine priming reinstates cocaine but not heroin seeking.
17	(Shalev et al., 2001b)	Ventricular injections of leptin have no effect on heroin priming-induced reinstatement of heroin seeking.
18	(De Vries et al., 2002)	Quinpirole reinstates heroin seeking after short-term, but not long-term extinction.
19	(Fuchs and See, 2002)	BLA inactivation with tetrodotoxin (TTX) decreases heroin priming-induced reinstatement of heroin seeking.
20	(Leri and Stewart, 2002)	A lapse of a heroin SA session after extinction induces subsequent heroin seeking in a relapse test 24 h later.
21	(De Vries et al., 2003)	Injection of HU210 (a CB1 receptor agonist) reinstates heroin seeking while injection of SR141716A (a CB1 receptor antagonist) decreases heroin priming-induced reinstatement.
22	(Fattore et al., 2003)	Systemic injections of WIN 55,212-2 and CP 55,940 but not Δ9-THC (CB1 receptor agonists) reinstate heroin seeking. Systemic injection of SR 141716A decreases heroin priming-induced reinstatement.
23	(Leri et al., 2004)	In rats trained to self-administer cocaine and heroin methadone maintenance decreases cocaine priming- and heroin priming-induced reinstatement.
24	(Luo et al., 2004)	Blood oxygen-level dependent (BOLD) signal after heroin priming-induced reinstatement is decreased in the prefrontal and parietal cortex as well as the NAc and hippocampus, compared to saline-trained control rats injected with heroin.
25	(Fattore et al., 2005)	Priming injections of WIN 55,212-2 and CP 55,940 reinstate heroin seeking. Systemic injections of naloxone and SR 141716A decrease heroin priming-induced reinstatement and reinstatement after priming injections of WIN 55,212-2 or CP 55,940.

26	(Leri and Burns, 2005)	Very low doses of naltrexone decrease oxycodone priming-induced reinstatement.
27	(Sorge et al., 2005)	Chronic buprenorphine decreases heroin priming-induced reinstatement and heroin-induced increases in NAc dopamine release.
28	(He and Grasing, 2006)	Chronic treatment with clorgyline (an inhibitor of monoamine oxidase-A (MAO-A)) or rasagiline (an inhibitor of MAO-B) decreases morphine priming-induced reinstatement of morphine seeking.
29	(Yao et al., 2006)	Systemic injections of MPX-3 (A2a adenosine receptor antagonist) or NAc injections of DMPX (A2a antagonist) decrease heroin priming-induced reinstatement. NAc injections of DPCX (A1 antagonist) have no effect on heroin priming-induced reinstatement.
30	(Ghitza et al., 2007)	Systemic PYY3-36 injections have no effect on heroin priming-induced reinstatement.
31	(Lenoir and Ahmed, 2007)	Long access but not short access heroin-trained rats show heroin priming-induced reinstatement.
32	(Spano et al., 2007)	Baclofen ($GABA_B$ receptor agonist) deceases heroin priming-induced reinstatement.
33	(LaLumiere and Kalivas, 2008)	Heroin priming-induced reinstatement is associated with increased extracellular glutamate in NAc core. Inactivation of NAc core or dmPFC decreases heroin priming-induced NAc core extracellular glutamate. NAc core CNQX (AMPA/kainite receptor antagonist) or flupenthixol injections decrease heroin priming-induced reinstatement.
34	(Rogers et al., 2008)	Muscimol+baclofen reversible inactivation into the following brain regions decrease heroin priming-induced reinstatement: dmPFC and vmPFC, BLA, CeA, BNST, NAc core and shell, DLS, VTA, SN, and VP.
35	(Zhou and Kalivas, 2008)	Chronic N-acetylcysteine administration decreases extinction responding and heroin priming-induced reinstatement. Heroin priming-induced reinstatement is decreased for up to 40 days after discontinuing chronic N-acetylcysteine injections.
36	(Zhou et al., 2008)	Systemic injection of SSR149415 (vasopressin V1b receptor antagonist) decreases heroin priming-induced reinstatement.
37	(See, 2009)	dmPFC SCH 23390 injections decrease heroin priming-induced reinstatement.
38	(Peng et al., 2010)	Systemic injection of methadone does not reinstate heroin seeking.
39	(Grella et al., 2011)	Oxycodone priming reinstates oxycodone seeking and the magnitude of this effect is dependent on the amount of drug SA during training.
40	(Fattore et al., 2011)	Systemic injections of naloxone or SR141716A decrease WIN 55,212-2 priming-induced reinstatement of heroin seeking; injections of both naloxone and SR141716A decrease CB1R agonist priming-induced reinstatement.
41	(Li et al., 2011)	Heroin priming-induced reinstatement is blocked with a morphine/heroin vaccine.
42	(Liu et al., 2011)	Daily vagus nerve stimulation decreases heroin priming-induced reinstatement, an effect associated with decreased FosB and increased phosphorylated cAMP response element-binding protein (pCREB) in NAc.
43	(Shen et al., 2011)	Heroin priming-induced reinstatement is associated with increases in field excitatory post synaptic potential in NAc medium spiny neurons (MSNs) following PFC stimulation, and dendritic spine enlargement and upregulated surface expression of GluN2B subunits in NAc MSNs. NAc core ifenpridil (GluN2B antagonist) injections decrease heroin priming-induced reinstatement and prevent spine remodeling and changes in synaptic strength.
44	(Lee et al., 2012)	Acupuncture decreases morphine priming-induced reinstatement, an effect blocked by systemic injections of bicuculine and SCH50911 (GABA receptor antagonists).
45	(Liu et al., 2012c)	Morphine priming-induced reinstatement is associated with Thr286 phosphorylation of alpha Ca(2+)/calmodulin-dependent protein kinase II (CAMKII) in NAc shell but not core.
46	(Liu et al., 2012d)	NAc shell injections of myrisotylated autocamtide-2 inhibitory peptide (myr-AIP; selective CAMKII inhibitor) decrease morphine priming-induced reinstatement of morphine seeking.
47	(Schippers et al., 2012)	High and low impulsive rats do not differ in heroin priming-induced reinstatement.
48	(Xue et al., 2012)	Brief cued retrieval of drug memories 10 min but not 6 h before daily extinction sessions decreases heroin priming-induced reinstatement.
49	(Yue et al., 2012)	Systemic injections of levo-tetrahydropalmatine (l-THP; a mixed Drd1/Drd2/Drd3 antagonist) decreases heroin-induced reinstatement.
50	(Lai et al., 2013)	Systemic injections of risperidone (5-HT2 and Drd2 antagonist) have no effect on heroin priming-induced reinstatement.
51	(Ma et al., 2014)	L-Stepholidine (L-SPD; mixed Drd1 agonist/Drd2 antagonist) decreases heroin priming-induced reinstatement.
52	(Lai et al., 2014)	Systemic injections of rolipram (phosphodiesterase-4 inhibitor) decrease heroin priming-induced reinstatement, an effect associated with increased pCREB expression in NAc.
53	(Yue et al., 2014)	L-SPD decreases heroin priming-induced reinstatement.
54	(Li et al., 2014)	Morphine-keyhole limpet hemocyanin (M-KLH) vaccine decreases heroin priming-induced reinstatement.
55	(Raleigh et al., 2014)	M-KLH decreases heroin priming-induced reinstatement.

56	(Wager et al., 2014)	Systemic injection of PF-5006739 (casein kinase 1 delta/epsilon inhibitor) decreases fentanyl priming-induced reinstatement of fentanyl seeking.
57	(Montanari et al., 2015)	Heroin priming reinstates heroin seeking in resident rats but not in non-resident rats.
58	(Zhou et al., 2015)	Heroin priming-induced reinstatement results in similar reinstatement in both high footshock reinstatement responders and low footshock reinstatement responders.
59	(Chen et al., 2016b)	Systemic or ventricular injections of sodium butyrate (NaB; histone deacetylase (HDAC) inhibitor) increase heroin priming-induced reinstatement when administered 12 h but not 6 h before the reinstatement test. Levels of histone acetylation in the NAc core and shell are increased during reinstatement and further increased after ventricular injections of NaB.
60	(de Guglielmo et al., 2017)	Systemic injection of the pioglitazone (peroxisome proliferator-activated receptor gamma (PPARγ) agonist) decreases heroin priming-induced reinstatement.
61	(Porter-Stransky et al., 2017)	Systemic injection of SB-335867 (orexin-1 receptor (Ox1R) antagonist) has no effect on remifentanil priming-induced reinstatement of remifentanil seeking.
62	(Wager et al., 2017)	Systemic injection of PF-4363457 (Drd2/Drd3 antagonist) decreases combined fentanyl priming-induced and discrete cue-induced reinstatement of fentanyl seeking.
63	(You et al., 2017)	Systemic injection of CAB2-015 and BAK4-54 (Drd3 antagonist/partial agonist) decreases oxycodone priming-induced reinstatement of oxycodone seeking.

2.2. Discrete cues

Number	Paper	Major Finding
1	(Davis and Smith, 1976)	Discrete cues reinstate morphine seeking.
2	(Alderson et al., 2000)	In rats trained to self-administer heroin under a second order schedule of reinforcement, discrete cues weakly reinstate heroin seeking.
3	(Highfield et al., 2001)	Daily injections of lofexidine (alpha-2 adrenoceptor agonist) have no effect on discrete cue-induced reinstatement of speedball (heroin-cocaine mixture) seeking.
4	(Fuchs and See, 2002)	BLA inactivation with TTX decreases discrete cue-induced reinstatement of heroin seeking.
5	(De Vries et al., 2003)	Systemic injections of SR141716A decrease discrete cue-induced reinstatement of heroin seeking.
7	(Bossert et al., 2005)	Systemic injections of LY379268 (an mGluR2/3 agonist that decreases evoked glutamate release) decrease discrete cue-induced reinstatement of heroin seeking.
8	(Grasing et al., 2005)	Daily intravenous delivery of selegiline (irreversible MAO inhibitor) has no effect on discrete cue-induced reinstatement of morphine seeking.
9	(Leri and Burns, 2005)	Co-SA of oxycodone and ultra-low-doses of naltrexone decrease discrete cue-induced reinstatement of oxycodone seeking.
10	(Schmidt et al., 2005)	Discrete cue-induced reinstatement of heroin seeking is associated with increased zif268 mPFC expression; muscimol+baclofen injections into the dmPFC increase discrete cue-induced reinstatement of heroin seeking.
11	(Zhang et al., 2005)	Discrete cue-induced reinstatement of heroin seeking is associated with increased Fos expression in the medial part of the lateral habenula.
12	(Zhou et al., 2005)	The magnitude of discrete cue-induced reinstatement is higher than the magnitude of discriminative cue-induced reinstatement.
13	(He and Grasing, 2006)	Chronic treatment with clorgyline (selective MAO-A inhibitor) or rasagiline (selective MAO-B inhibitor) decreases discrete cue-induced reinstatement of morphine seeking.
14	(Koya et al., 2006)	Reexposure to discrete cues after long-term extinction reinstates heroin seeking and is associated with increased expression of the immediate early gene expression *ania-3*, *MKP-1*, *c-fos*, and *Nr4a3* in mPFC and *ania-3* in OFC and NAc core.
15	(Bossert et al., 2007)	SCH 23390 injected in the NAc core, but not the lateral or medial shell, decreases discrete cue-induced reinstatement.
16	(Ghitza et al., 2007)	Systemic injections of PYY3-36 have no effect on discrete cue-induced reinstatement of heroin seeking.
17	(Zhou et al., 2007)	Systemic and NAc injections of physostigmine (acetylcholinesterase inhibitor) decrease discrete cue-induced reinstatement of heroin seeking. VTA physostigmine injections increase discrete cue-induced reinstatement of heroin seeking. TTX inactivation of NAc or VTA decreases discrete cue-induced reinstatement.
18	(LaLumiere and Kalivas, 2008)	Discrete cue-induced reinstatement of heroin seeking is associated with increased extracellular glutamate in NAc core. Inactivation of NAc core (TTX) or dmPFC, and NAc core injections of CNQX, flupenthixol, SCH 23390, or sulpiride decrease this reinstatement.
19	(Rogers et al., 2008)	Muscimol+baclofen inactivation of dmPFC and vmPFC, BLA, CeA, posterior BNST, NAc core, DLS, SN, and VP decrease discrete cue-primed reinstatement of heroin seeking.

20	(Van den Oever et al., 2008)	Discrete cue-induced reinstatement of heroin seeking results in downregulation of GluR2 AMPA receptor subunit, upregulation of clarthrin-coat assembly protein AP2m1 in synaptic membranes of mPFC, and decreased mPFC AMPA/NMDA current ratio. Systemic or vmPFC, but not dmPFC injections of TAT-GluR23Y (peptide inhibiting GluR2 endocytosis) decrease discrete cue-induced reinstatement of heroin seeking.
21	(Zhou and Kalivas, 2008)	Daily N-acetylcysteine administration decreases extinction responding and discrete cue-induced reinstatement. Discrete cue-induced reinstatement is decreased for up to 40 days after discontinuing daily N-acetylcysteine injections.
22	(Doherty et al., 2009)	Discrete cue-induced reinstatement of morphine seeking is weaker in rats that began morphine SA during adolescence vs. adulthood.
23	(See, 2009)	vmPFC SCH23390 injections decrease discrete cue-induced reinstatement of heroin seeking.
24	(Banna et al., 2010)	Systemic injection of yohimbine increases discrete cue-induced reinstatement of heroin seeking.
25	(Van den Oever et al., 2010)	After extinction of heroin SA, extracellular matrix (ECM) proteins are downregulated in mPFC and NAc, and expression returns to baseline following discrete cue-induced reinstatement of heroin seeking. ECM proteins in the mPFC are condensed in the perineuronal nets that surround GABAergic interneurons, and the tone of inhibitory synaptic inputs to mPFC pyramidal neurons increases following discrete cue-induced reinstatement. Ventricular injections of FN-439 (matrix metalloproteinase inhibitor) decrease cue-induced reinstatement of heroin seeking.
26	(Liu et al., 2011)	Vagus nerve stimulation decreases discrete cue-induced reinstatement of heroin seeking and is associated with a decrease in FosB and an increase in pCREB expression in NAc.
27	(Liu et al., 2012a)	Systemic injection of galantamine (acetylcholinesterase inhibitor) decreases discrete cue-induced reinstatement of heroin seeking. This effect is reversed by systemic pretreatment with scopolamine (muscarinic type 2 (M2) receptor antagonist) but not mecamylamine (nicotinic receptor (nAChR) antagonist) or scopolamine methobromide (M2 receptor antagonist with low blood brain barrier penetrance). Lateral dorsal tegmental nucleus (LDTg) injections of galantamine decrease discrete cue-induced reinstatement while microinjection of scopolamine in LDTg reverses this effect.
28	(Schippers et al., 2012)	High and low impulsive rats do not differ in discrete cue-induced reinstatement of heroin seeking.
29	(Smith and Aston-Jones, 2012)	Systemic injection of SB-334867 (orexin/hypocretin receptor antagonist) decreases discrete cue-induced reinstatement of heroin seeking.
30	(Guo et al., 2012)	Daily deep brain stimulation (DBS) given bilaterally or unilaterally into the right NAc during abstinence decreases discrete cue-induced reinstatement. These effects are associated with increased expression of pCREB and decreased expression of ΔFosB in NAc.
31	(Lai et al., 2013)	Systemic injections of risperidone decrease cue-induced reinstatement of heroin seeking.
32	(Lai et al., 2014)	Systemic injections of rolipram (selective PDE4 inhibitor) decrease discrete cue-induced reinstatement of heroin seeking, an effect correlated with increased pCREB expression in NAc.
33	(Shen et al., 2014)	Impaired NAc core glutamate elimination after extinction of heroin SA leads to spillover of increased extracellular glutamate. Systemic injections of ceftriaxone (a GLT-1 activator) restore NAc core glutamate uptake and decrease discrete cue-induced reinstatement of heroin seeking, an effect reversed by GLT-1 knockdown.
34	(Smith et al., 2014)	Discrete cue-induced heroin reinstatement increases matrix metalloproteinase (MMP) activity in NAc core.
35	(Yue et al., 2014)	L-SPD decreases discrete cue-induced reinstatement of heroin seeking.
36	(Galaj et al., 2015)	Systemic injections of SR 21502 (Drd3 antagonist) decrease discrete cue-induced heroin reinstatement.
37	(Chen et al., 2016a)	vmPFC injections of PEPA (an allosteric AMPA receptor potentiator) decrease discrete cue-induced reinstatement of heroin seeking and increases ventral mPFC and NAc expression of GLuR1.
38	(Galaj et al., 2016)	Environmental enrichment during extinction and reinstatement tests decreases discrete cue-induced reinstatement of heroin seeking.
39	(de Guglielmo et al., 2017)	Systemic injections of pioglitazone have no effect on discrete cue-induced reinstatement.
40	(Neelakantan et al., 2017)	Lorcaserin (5-HT2C receptor agonist) decreases discrete cue-induced reinstatement of oxycodone seeking.
41	(Porter-Stransky et al., 2017)	SB-335867 decreases discrete cue-induced reinstatement of remifentanil seeking in rats that self-administer low but not high levels of the drug during SA training.
42	(Wager et al., 2017)	PF-4363457 decreases combined fentanyl priming-induced plus discrete cue-induced reinstatement of fentanyl seeking.

43	(Rubio et al., 2018)	dmPFC is activated by both heroin and cocaine-associated cues in rats that self-administered cocaine and heroin.

2.3. Discriminative cues

Number	Paper	Major Finding
1	(McFarland and Ettenberg, 1997)	Systemic injections of haloperidol (a preferential Drd2 receptor antagonist) decrease discriminative cue-induced reinstatement of heroin seeking in the runway model.
2	(Gracy et al., 2000)	Discriminative cues reinstate heroin seeking after extinction of heroin SA.
3	(Zhou et al., 2005)	The magnitude of discrete cue-induced reinstatement of heroin seeking is higher than the magnitude of discriminative cue-induced reinstatement.
4	(Alvarez-Jaimes et al., 2008)	mPFC and NAc (but not BLA) SR141716A injections decrease discriminative cue-induced reinstatement of heroin seeking.

2.4. Context

Number	Paper	Major Finding
1	(Bossert et al., 2004)	Systemic or VTA (but not SN) injections of the mGluR2/3 agonist LY379268 decrease context-induced reinstatement of heroin seeking.
2	(Bossert et al., 2006)	NAc shell (but not core or DS) injections of LY379268 decrease context-induced reinstatement of heroin seeking.
3	(Bossert et al., 2007)	Medial or lateral NAc shell (but not core) SCH23390 injections decrease context-induced reinstatement of heroin seeking.
4	(Bossert et al., 2009)	DLS (but not DMS) SCH23390 injections decrease context-induced reinstatement of heroin seeking. Neither functional disconnection of DLS and lateral NAc shell (SCH23390 injections into both areas) nor DLS injections of MK212 (5-HT2CR agonist) have an effect on this reinstatement.
5	(Bossert et al., 2011)	Muscimol+baclofen inactivation of vmPFC (but not dmPFC) decreases context-induced reinstatement of heroin seeking. Selective inactivation of context-activated vmPFC neurons (using Daun02) also decreases this reinstatement.
6	(Bossert et al., 2012)	Context-induced reinstatement of heroin seeking is associated with activation (Fos) of vmPFC-to-NAc shell pathway. Functional disconnection of vmPFC (muscimol+baclofen) and NAc shell (SCH23390) either contralaterally or ipsilaterally decreases this reinstatement.
7	(Bossert and Stern, 2014)	Muscimol+baclofen inactivation of vSub but not dorsal subiculum decreases context-induced reinstatement of heroin seeking.
8	(Bossert et al., 2016)	Context-induced reinstatement of heroin seeking is associated with activation (Fos) of vSub-to-NAc shell and vSub-to-vmPFC pathways. Functional disconnection of vSub (muscimol+baclofen inactivation) and NAc shell (SCH23390) either contralaterally or ipsilaterally decreases this reinstatement. Disconnection of vSub and vmPFC (muscimol+baclofen inactivation in both areas) has no effect on this reinstatement.
9	(Ge et al., 2017)	Context-induced reinstatement of heroin seeking is associated with activation (Fos) of entorhinal cortex (EC)-to-dorsal dentate gyrus (dDG) pathway. Functional disconnection of the pathway using muscimol+baclofen (into both areas) or viral delivery of inhibitory DREADD into cell bodies (EC) and CNO injections into terminals (dDG) decreases context-induced reinstatement of heroin seeking. Inhibition of this pathway depends on GluN2B-ERK-mediated signaling.
10	(Wang et al., 2018)	Context-induced reinstatement of heroin seeking is associated with activation (Fos) of vSub-to-vmPFC pathway and LTD induction in this pathway. Functional disconnection of the pathway using muscimol+baclofen (into vSub) and blockade of internalization of ionotropic glutamate receptor-2 (GluA2) (into vmPFC) or viral delivery of inhibitory DREADDs into cell bodies (vSub) and CNO into terminals (vmPFC) decreases context-induced reinstatement of heroin seeking and reverses LTD induction and molecular changes induced by this reinstatement.
11	(Bossert et al., 2018)	Systemic injections of naltrexone, but not naltrindole or LY2456302 (the δ-opioid receptor (DOR) or KOR antagonists, respectively) decrease context-induced reinstatement of oxycodone seeking.

2.5. Stress

Intermittent footshock

Number	Paper	Major Finding
1	(Shaham and Stewart, 1995)	Footshock stress reinstates heroin seeking and increases dopamine release in NAc.
2	(Shaham et al., 1996)	Chronic delivery of heroin via osmotic minipumps has no effect on footshock stress-induced reinstatement of heroin seeking.
3	(Shaham and Stewart, 1996)	Systemic injections of flupenthixol, but not naltrexone, SCH23390, or raclopride, decrease footshock-induced reinstatement of heroin seeking.
4	(Shaham et al., 1997a)	Acute ventricular injections of CRF reinstate heroin seeking, and acute ventricular pretreatment with the CRF antagonist alpha-helical CRF decreases footshock-induced reinstatement of heroin seeking. Adrenalectomy increases footshock-induced reinstatement and acute injections of the corticosterone synthesis inhibitor metyrapone reinstate heroin seeking.
5	(Shaham et al., 1998)	The selective non-peptide CRF1 receptor antagonist CP-154,526 decreases footshock-induced reinstatement of heroin seeking.
6	(Spanagel et al., 1998)	Systemic injections of acamprosate have no effect on footshock-induced reinstatement of heroin seeking.
7	(Shaham et al., 2000)	Systemic or ventricular injections of the alpha-2 adrenergic receptor agonist clonidine decrease footshock-induced reinstatement of heroin seeking. Neither clonidine nor its charged analogue ST-91 decreases footshock reinstatement when injected into LC. 6-hydroxydopamine (6-OHDA) lesions of the ventral NE bundle decrease this reinstatement.
8	(Highfield et al., 2000)	Electrical stimulation of medial septum decreases footshock-induced reinstatement of heroin seeking. TTX inactivation of medial (but not lateral) septum reinstates heroin seeking.
9	(Shalev et al., 2000)	Footshock in the drug environment and electrical stimulation of medial septum reinstate heroin seeking. Restraint stress or intermittent footshock exposure in a novel environment do not reinstate heroin seeking.
10	(Shalev et al., 2001b)	Ventricular injections of leptin have no effect on footshock-induced reinstatement of heroin seeking.
11	(Shalev et al., 2001a)	Footshock-induced reinstatement of heroin seeking after extinction occurs after late, but not early withdrawal from heroin. Footshock-induced reinstatement of heroin seeking after late withdrawal is associated with increases in CRF mRNA in dorsal BNST, but not ventral BNST or CeA.
12	(Highfield et al., 2001)	Repeated or acute injections of lofexidine decrease footshock-induced reinstatement of speedball seeking.
13	(Leri et al., 2004)	Chronic delivery of methadone via osmotic minipump does not decrease footshock-induced reinstatement of heroin seeking.
14	(Leri and Burns, 2005)	Co-SA of oxycodone and ultra-low-doses of naltrexone decrease footshock-induced reinstatement of oxycodone seeking.
15	(Sorge et al., 2005)	Chronic delivery of buprenorphine via osmotic minipumps does not decrease footshock-induced reinstatement of heroin seeking.
16	(Zhou et al., 2008)	Systemic injections of SSR149415 decrease footshock-induced reinstatement of heroin seeking, and footshock-induced increases in plasma levels of ACTH and corticosterone, and amygdala AVP mRNA levels.
17	(Wang et al., 2012)	Footshock-induced reinstatement of heroin seeking is associated with increased glutamate and dopamine in VTA. Local injections of kynurenic acid (ionotropic glutamate receptor antagonist) decrease footshock-induced reinstatement and VTA dopamine release.
18	(Zhou et al., 2015)	Rats that displayed more lever pressing (termed high responders) during footshock-induced reinstatement of heroin seeking have higher AVP mRNA levels in BLA and lower Drd2 mRNA levels in caudate/putamen.

Acute 1-d food deprivation

Number	Paper	Major Finding
1	(Shalev et al., 2000)	Acute food deprivation reinstates heroin seeking.
2	(Shalev et al., 2001b)	Acute food deprivation reinstates heroin seeking. Ventricular leptin injections decrease this reinstatement.
3	(Shalev et al., 2003)	Acute food deprivation-induced reinstatement of heroin seeking is associated with Fos induction in dmPFC, but not cingulate cortex, BLA, CeA, BNST, or NAc.
4	(Shalev et al., 2006)	Acute ventricular injections alpha-helical CRF decrease acute food deprivation-induced reinstatement of heroin seeking. Adrenalectomy has no effect on this reinstatement.

5	(Maric et al., 2008)	Acute ventricular injections of neuropeptide Y (NPY) mimic the effect of acute food deprivation on reinstatement of heroin seeking.
6	(Tobin et al., 2009)	Systemic injections of SCH23390 decrease acute food deprivation-induced reinstatement of heroin seeking. Injections of raclopride or NGB 2904 (Drd3 antagonist) have no effect on this reinstatement.
7	(Maric et al., 2011)	Systemic injections of Lu-AA33810 (NPY Y5 receptor antagonist) but not BIBO 3304 (NPY Y1 receptor antagonist) decrease food deprivation-induced reinstatement of heroin seeking.
8	(Maric et al., 2012)	Ventricular injections of D-Lys-3]-GHRP-6 (ghrelin antagonist) has no effect on acute food deprivation-induced reinstatement of heroin seeking.
9	(Tobin et al., 2013)	NAc shell, dmPFC, or BLA (but not NAc core or vmPFC) SCH23390 injections decrease acute food deprivation-induced heroin seeking.
10	(Sedki et al., 2015a)	Systemic injections of norbinaltorphimine (KOR antagonist) but not naltrexone, decrease acute food deprivation-induced reinstatement of heroin seeking.

Chronic food restriction

1	(Shalev, 2012)	Chronic food restriction for 10 d potentiates spontaneous recovery of heroin seeking after extinction.
2-3	(D'Cunha et al., 2013; Sedki et al., 2013b)	Chronic food restriction during forced abstinence (14 d) increases heroin seeking (see text).
4	(Sedki et al., 2013a)	Systemic injections of selective CRFR1 antagonist (R121919), non-selective CRF antagonist (alpha-helical CRF), or glucocorticoid receptor antagonist (RU486) have no effect on food restriction-induced potentiation of heroin seeking. Adrenalectomy (ADX) is also ineffective.
5	(Sedki et al., 2015b)	Estradiol replacement in ovariectomized (OVX) female rats decreases food restriction-induced potentiation of heroin seeking. OVX alone and progesterone injections have no effect.
6	(D'Cunha et al., 2017)	Food restriction-induced potentiation of heroin seeking is associated with increased dopamine release in NAc shell and core. NAc core (but not shell) SCH39166 injections decrease food restriction-induced potentiation of heroin seeking.

Yohimbine-induced reinstatement

Number	Paper	Major Finding
1	(Banna et al., 2010)	Systemic injections of yohimbine reinstate heroin seeking and increase discrete cue-induced reinstatement of heroin seeking.
2	(Zhou et al., 2013)	Systemic injections of nor-BNI decrease yohimbine-induced reinstatement of heroin seeking and yohimbine-induced increases in ACTH and corticosterone. Yohimbine also increases ppDyn mRNA levels in NAc shell and CeA (not reversed by nor-BNI).
3	(Stopponi et al., 2014)	Chronic pretreatment with THC during adolescence increases yohimbine-induced reinstatement of heroin seeking.
4	(de Guglielmo et al., 2017)	Systemic injections of pioglitazone decrease yohimbine-induced reinstatement of heroin seeking.
5	(Minhas and Leri, 2014)	Non-contingent exposure to heroin (to induce opioid dependence) during heroin SA training has no effect on yohimbine-induced reinstatement of heroin seeking.

2.6. Withdrawal

Number	Paper	Major Finding
1	(Stewart and Wise, 1992)	Systemic injections of naltrexone several hours after daily heroin SA training do not reinstate heroin seeking after extinction.
2	(Shaham and Stewart, 1995)	Injections of naltrexone induce withdrawal, but not reinstatement of heroin seeking.
3	(Shaham et al., 1996)	In rats implanted with osmotic minipumps containing heroin during the extinction phase, naloxone-precipitated withdrawal decreases NAc dopamine release NAc but does not reinstate heroin seeking. Spontaneous withdrawal (24 h after minipump removal) does not alter NAc dopamine levels but reinstates heroin seeking.

2.7. Reacquisition

Number	Paper	Major Finding
1	(Davis et al., 1975)	Systemic injections of diethyldithiocarbamate or U-14,624 (dopamine β-hydroxylase inhibitors) decrease reacquisition of morphine SA after extinction.
2	(Olmstead et al., 1998)	PPTg-lesions have no effect on reacquisition of morphine SA after extinction.
3	(Li et al., 2003)	Reacquisition of morphine SA is observed under different progressive ratio reinforcement schedule.
4	(Grasing et al., 2005)	Chronic pretreatment with low dose selegiline does not alter reacquisition of morphine reinforcement.
5	(Grasing and He, 2005)	Chronic pretreatment with high dose selegiline decreases reacquisition of morphine SA.
6	(Minhas and Leri, 2014)	Acute injections of yohimbine have no effect on reacquisition of heroin SA.

3. Abstinence-based relapse models

3.1 Forced abstinence and incubation of drug craving

Forced abstinence

Number	Paper	Major Findings
1	(Zhou et al., 2005)	After 14 d of forced abstinence from heroin SA, discrete cue-induced reinstatement is higher than discriminative cue-induced reinstatement after extinction. The authors used within-session extinction-reinstatement procedure where extinction and reinstatement are determined on the same day after a forced abstinence period.
2	(Buccafusco and Bain, 2007)	Chronic systemic injections of arecoline (muscarinic acetylcholine receptor agonist) during morphine SA decrease morphine seeking after 6 weeks of forced abstinence.
3	(Liu et al., 2012b)	Daily Electroacupuncture during 14 d forced abstinence from heroin SA decreases cue-induced reinstatement (but not extinction responding) and Fos expression in NAc core but not shell. The authors used within-session extinction-reinstatement procedure.
4	(Madsen et al., 2012)	Morphine seeking after 3 weeks of forced abstinence from morphine SA is associated with Fos induction in NAc core, BLA, SN pars reticulata, and CeA.
5	(Gao et al., 2013)	After 3 weeks of forced abstinence from morphine SA, DLS and NAc shell lesions, SCH 23390 injections in DLS and NAc shell, and eticlopride (Drd2 receptor antagonist) injections in DLS (but not NAc shell) decrease morphine seeking.
6	(Lee et al., 2013)	Acupuncture decreases morphine priming-induced morphine seeking after 7 d of forced abstinence; this effect is blocked by systemic injections of GABAa (bicuculine) and GABAb (SCH5091) antagonists. Prior to the extinction test session rats were given priming morphine injections.
7	(Coffey et al., 2016)	During heroin SA, rats show reversed patterns of wakefulness, non-rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep which are restored during forced abstinence. Extinction responding and subsequent heroin priming-induced reinstatement after 14 d of forced abstinence have no effect on wakefulness/sleep. The authors used within-session extinction-reinstatement procedure.
8	(Imperio et al., 2018)	Environmental enrichment decreases heroin seeking after 14 days of forced abstinence and extinction responding after priming injections of heroin.

Incubation of craving

Number	Paper	Major Findings
1	(Shalev et al., 2001a)	Extinction responding and subsequent footshock-induced reinstatement of heroin seeking follows an inverted U-shaped curve with higher responding after 6 and 12 days of forced abstinence than after 1, 25, or 66 days. The authors used within-session extinction-reinstatement procedure.
2	(Zhou et al., 2004)	Cue-induced reinstatement after extinction (within-session procedure) was similar after 7, 14 and 28 days of forced abstinence from heroin SA. Heroin priming increases extinction responding elicited by cues after 7 days of forced abstinence but inhibits responding after 28 days of forced abstinence.
3	(Di Ciano and Everitt, 2004)	Incubation of heroin craving is observed in an acquisition of a new conditioned response procedure where after initial pairing of a discrete cue with drug infusions, the rats perform a new operant response that is only reinforced by the discrete cue.

4	(Kuntz et al., 2008b)	After heroin SA, extinction responding is higher after 14 d of forced abstinence than after 1 d (incubation of heroin craving).
5	(Kuntz et al., 2008a)	Expression of the immediately early genes EGR1 and EGR2 in mPFC is increased in rats with a history of heroin SA after 1 and 14 d forced abstinence. The behavioral (incubation of craving) data of the rats are described in (Kuntz et al., 2008b).
6	(Kuntz-Melcavage et al., 2009)	Incubation of heroin craving (tests performed on forced abstinence days 1 and 14) is associated with alterations in mPFC gene expression of brain derived neurotropic factor (BDNF), calbindin 1 (Calb1), dual specificity phosphatase 5 and 6 (Dusp5, Dusp6), regulator of G-protein signalling 2 (RGS2) EGR1, and NPY gene expression.
7	(Zhou et al., 2009)	Extinction responding, and subsequent discrete cue-induced reinstatement of heroin seeking are higher after 14 d of forced abstinence than after 1 d. This incubation effect is stronger after 10 or 14 d of heroin SA training than after 1 or 5 training days. Systemic naltrexone injections increase heroin seeking after 1 d of forced abstinence but not 14 d.
8	(Airavaara et al., 2011)	Incubation of heroin craving over 30 d of forced abstinence is associated with increases in VTA and NAc GDNF mRNA but not protein expression. VTA or NAc injections of anti-GDNF neutralizing antibodies have no effect on incubation of heroin craving.
9	(Fanous et al., 2012)	Incubation of heroin craving is associated with increases in OFC Fos expression. Muscimol+baclofen inactivation of the OFC selectively decreases 'incubated' heroin seeking after 14 forced abstinence days but not 'non-incubated response on day 1. Selective inactivation of incubation-associated Fos neurons in OFC (using the Daun02 procedure) decreases the 'incubated' heroin seeking on forced abstinence day 14.
10	(Theberge et al., 2012)	Incubation of heroin craving is not associated with changes in BDNF, the BDNF receptor TrkB, or methyl-CpG binding protein 2 (MeCP2) mRNA or protein levels in NAc, DS, or mPFC. In NAc, MOR mRNA decreases in early abstinence (1 d) and returns to basal levels over time (11 and 30 d). Systemic naloxone injections decrease heroin seeking after 15 abstinence d but not after 1 d.
11	(Doherty and Frantz, 2012)	Incubation of heroin craving (assessed using extinction responding and subsequent cue-induced reinstatement) is stronger in adult rats than in adolescent rats.
12	(Doherty et al., 2013)	The stronger incubation of craving in adult rats than in adolescent rats is associated with higher Fos expression in dmPFC and vmPFC.
13	(Theberge et al., 2013)	Chronic delivery of (+)-naltrexone (toll-like receptor 4 antagonist) during forced abstinence decreases incubation of heroin, but not methamphetamine, craving. Acute injections of (+)-naltrexone before late forced abstinence testing (day 13) have no effect on incubated heroin seeking.
14	(Venniro et al., 2017)	Male and female rats with a history of heroin SA show incubation of heroin craving after forced abstinence.
15	(Blackwood et al., 2018)	In rats that previously self-administered oxycodone under long-access conditions, incubation of oxycodone craving is associated with increased MOR mRNA expression but decreased MOR protein levels in dorsal striatum and decreased MOR and KOR mRNA expression but increased MOR and KOR protein levels in hippocampus.
16	(Coffey et al., 2018)	Rats that self-administered heroin in the dark phase show more incubation than rats that self-administered heroin in the light phase but show no differences in extinction responding after priming injections of heroin.

3.2. Voluntary abstinence induced by adverse consequences of drug intake

Punishment-induced voluntary abstinence

Number	Paper	Major Findings
1	(Panlilio et al., 2003)	Priming injections of remifentanil increase reacquisition of remifentanil after punishment-induced suppression of remifentanil SA.
2	(Panlilio et al., 2005)	Priming injections of heroin or the benzodiazepine lorazepam reinstate remifentanil seeking and cause faster reacquisition of remifentanil SA after punishment-induced suppression of remifentanil SA.

Electric barrier-induced voluntary abstinence (conflict model)

Number	Paper	Major Findings
1	(Peck et al., 2013)	The proportion of heroin-trained rats that demonstrate discrete cue-induced drugs seeking after electric barrier-induced abstinence is higher than that of cocaine-trained rats.
2	(Peck et al., 2015)	Environmental-enriched rats abstain from heroin SA in fewer sessions and at lower electric currents than control non-enriched rats.

3.3. Voluntary abstinence induced by a non-drug reward in a choice procedure

Number	Paper	Major Findings
1	(Venniro et al., 2017)	Male and female rats with a history of heroin SA do not show incubation of heroin craving after food choice-based voluntary abstinence.

References

Airavaara, M., Pickens, C. L., Stern, A. L., Wihbey, K. A., Harvey, B. K., Bossert, J. M., Liu, Q. R., Hoffer, B. J., Shaham, Y., 2011. Endogenous GDNF in ventral tegmental area and nucleus accumbens does not play a role in the incubation of heroin craving. Addiction Biol. 16, 261-272.

Alderson, H. L., Robbins, T. W., Everitt, B. J., 2000. Heroin self-administration under a second-order schedule of reinforcement: acquisition and maintenance of heroin-seeking behaviour in rats. Psychopharmacology (Berl) 153, 120-133.

Alvarez-Jaimes, L., Polis, I., Parsons, L. H., 2008. Attenuation of cue-induced heroin-seeking behavior by cannabinoid CB1 antagonist infusions into the nucleus accumbens core and prefrontal cortex, but not basolateral amygdala. Neuropsychopharmacology 33, 2483-2493.

Banna, K. M., Back, S. E., Do, P., See, R. E., 2010. Yohimbine stress potentiates conditioned cue-induced reinstatement of heroin-seeking in rats. Beh. Brain Res. 208, 144-148.

Blackwood, C. A., Hoerle, R., Leary, M., Schroeder, J., Job, M. O., McCoy, M. T., Ladenheim, B., Jayanthi, S., Cadet, J. L., 2018. Molecular Adaptations in the Rat Dorsal Striatum and Hippocampus Following Abstinence-Induced Incubation of Drug Seeking After Escalated Oxycodone Self-Administration. Mol Neurobiol.

Bossert, J. M., Adhikary, S., St Laurent, R., Marchant, N. J., Wang, H. L., Morales, M., Shaham, Y., 2016. Role of projections from ventral subiculum to nucleus accumbens shell in context-induced reinstatement of heroin seeking in rats. Psychopharmacology 233, 1991-2004.

Bossert, J. M., Busch, R. F., Gray, S. M., 2005. The novel mGluR2/3 agonist LY379268 attenuates cue-induced reinstatement of heroin seeking. Neuroreport 16, 1013-1016.

Bossert, J. M., Gray, S. M., Lu, L., Shaham, Y., 2006. Activation of group II metabotropic glutamate receptors in the nucleus accumbens shell attenuates context-induced relapse to heroin seeking. Neuropsychopharmacology 31, 2197-2209.

Bossert, J. M., Hoots, J. K., Fredriksson, I., Adhikary, Zhang, M., Venniro, M., Shaham, Y., 2018. Role of mu, but not delta or kappa, opioid receptors in context-induced reinstatement of oxycodone seeking. Eur. J. Neurosci. (in press).

Bossert, J. M., Liu, S. Y., Lu, L., Shaham, Y., 2004. A role of ventral tegmental area glutamate in contextual cue-induced relapse to heroin seeking. J. Neurosci. 24, 10726-10730.

Bossert, J. M., Poles, G. C., Wihbey, K. A., Koya, E., Shaham, Y., 2007. Differential effects of blockade of dopamine D1-family receptors in nucleus accumbens core or shell on reinstatement of heroin seeking induced by contextual and discrete cues. J. Neurosci. 27, 12655-12663.

Bossert, J. M., Stern, A. L., 2014. Role of ventral subiculum in context-induced reinstatement of heroin seeking in rats. Addict. Biol. 19, 338-342.

Bossert, J. M., Stern, A. L., Theberge, F. R., Cifani, C., Koya, E., Hope, B. T., Shaham, Y., 2011. Ventral medial prefrontal cortex neuronal ensembles mediate context-induced relapse to heroin. Nat. Neurosci. 14, 420-422.

Bossert, J. M., Stern, A. L., Theberge, F. R., Marchant, N. J., Wang, H. L., Morales, M., Shaham, Y., 2012. Role of projections from ventral medial prefrontal cortex to nucleus accumbens shell in context-induced reinstatement of heroin seeking. J. Neurosci. 32, 4982-4991.

Bossert, J. M., Wihbey, K., Pickens, C. L., Nair, S. G., Shaham, Y., 2009. Role of dopamine D1-family receptors in dorsolateral striatum in context-induced reinstatement of heroin seeking in rats. Psychopharmacology 206, 51-60.

Buccafusco, J. J., Bain, J. N., 2007. A 24-h access I.V. self-administration schedule of morphine reinforcement and the estimation of recidivism: Pharmacological modification by arecoline. Neuroscience 149, 487-498.

Chen, W., Wang, Y., Sun, A., Zhou, L., Xu, W., Zhu, H., Zhuang, D., Lai, M., Zhang, F., Zhou, W., Liu, H., 2016a. Activation of AMPA receptor in the infralimbic cortex facilitates extinction and attenuates the heroin-seeking behavior in rats. Neurosci. Lett. 612, 126-131.

Chen, W. S., Xu, W. J., Zhu, H. Q., Gao, L., Lai, M. J., Zhang, F. Q., Zhou, W. H., Liu, H. F., 2016b. Effects of histone deacetylase inhibitor sodium butyrate on heroin seeking behavior in the nucleus accumbens in rats. Brain Res 1652, 151-157.

Coffey, A. A., Fang, J., Grigson, P. S., 2018. Heroin self-administration as a function of time of day in rats. Psychopharmacology (Berl).

Coffey, A. A., Guan, Z., Grigson, P. S., Fang, J., 2016. Reversal of the sleep-wake cycle by heroin self-administration in rats. Brain Res. Bull. 123, 33-46.

D'Cunha, T. M., Daoud, E., Rizzo, D., Bishop, A. B., Russo, M., Mourra, G., Hamel, L., Sedki, F., Shalev, U., 2017. Augmentation of Heroin Seeking Following Chronic Food Restriction in the Rat: Differential Role for Dopamine Transmission in the Nucleus Accumbens Shell and Core. Neuropsychopharmacology 42, 1136-1145.

D'Cunha, T. M., Sedki, F., Macri, J., Casola, C., Shalev, U., 2013. The effects of chronic food restriction on cue-induced heroin seeking in abstinent male rats. Psychopharmacology 225, 241-250.

Davis, W. M., Smith, S. G., 1976. Role of conditioned reinforcers in the initiation, maintenance and extinction of drug-seeking behavior. Pavlovian. J. Biol. Sci. 11, 222-236.

Davis, W. M., Smith, S. G., Khalsa, J. H., 1975. Noradrenergic role in the self-administration of morphine or amphetamine. Pharmacol Biochem Behav 3, 477-484.

de Guglielmo, G., Kallupi, M., Scuppa, G., Demopulos, G., Gaitanaris, G., Ciccocioppo, R., 2017. Pioglitazone attenuates the opioid withdrawal and vulnerability to relapse to heroin seeking in rodents. Psychopharmacology 234, 223-234.

De Vries, T. J., Homberg, J. R., Binnekade, R., Raaso, H., Schoffelmeer, A. N., 2003. Cannabinoid modulation of the reinforcing and motivational properties of heroin and heroin-associated cues in rats. Psychopharmacology 168, 164-169.

De Vries, T. J., Schoffelmeer, A. N., Binnekade, R., Mulder, A. H., Vanderschuren, L. J., 1998. Drug-induced reinstatement of heroin- and cocaine-seeking behaviour following long-term extinction is associated with expression of behavioural sensitization. Eur. J. Neurosci 10, 3565-3571.

De Vries, T. J., Schoffelmeer, A. N., Binnekade, R., Raaso, H., Vanderschuren, L. J., 2002. Relapse to cocaine- and heroin-seeking behavior mediated by dopamine D2 receptors is time-dependent and associated with behavioral sensitization. Neuropsychopharmacology 26, 18-26.

De Vries, T. J., Schoffelmeer, A. N., Binnekade, R., Vanderschuren, L. J., 1999. Dopaminergic mechanisms mediating the incentive to seek cocaine and heroin following long-term withdrawal of IV drug self-administration. Psychopharmacology (Berl) 143, 254-260.

de Wit, H., Stewart, J., 1983. Drug reinstatement of heroin-reinforced responding in the rat. Psychopharmacology 79, 29-31.

Di Ciano, P., Everitt, B. J., 2004. Conditioned reinforcing properties of stimuli paired with self-administered cocaine, heroin or sucrose: implications for the persistence of addictive behaviour. Neuropharmacology 47 Suppl 1, 202-213.

Doherty, J., Ogbomnwan, Y., Williams, B., Frantz, K., 2009. Age-dependent morphine intake and cue-induced reinstatement, but not escalation in intake, by adolescent and adult male rats. Pharmacol. Biochem. Behav. 92, 164-172.

Doherty, J. M., Cooke, B. M., Frantz, K. J., 2013. A role for the prefrontal cortex in heroin-seeking after forced abstinence by adult male rats but not adolescents. Neuropsychopharmacology 38, 446-454.

Doherty, J. M., Frantz, K. J., 2012. Heroin self-administration and reinstatement of heroin-seeking in adolescent vs. adult male rats. Psychopharmacology 219, 763-773.

Fanous, S., Goldart, E. M., Theberge, F. R., Bossert, J. M., Shaham, Y., Hope, B. T., 2012. Role of orbitofrontal cortex neuronal ensembles in the expression of incubation of heroin craving. J. Neurosci. 32, 11600-11609.

Fattore, L., Spano, M., Melis, V., Fadda, P., Fratta, W., 2011. Differential effect of opioid and cannabinoid receptor blockade on heroin-seeking reinstatement and cannabinoid substitution in heroin-abstinent rats. Br J Pharmacol 163, 1550-1562.

Fattore, L., Spano, M. S., Cossu, G., Deiana, S., Fratta, W., 2003. Cannabinoid mechanism in reinstatement of heroin-seeking after a long period of abstinence in rats. European Journal of Neuroscience 17, 1723-1726.

Fattore, L., Spano, S., Cossu, G., Deiana, S., Fadda, P., Fratta, W., 2005. Cannabinoid CB(1) antagonist SR 141716A attenuates reinstatement of heroin self-administration in heroin-abstinent rats. Neuropharmacology 48, 1097-1104.

Fuchs, R. A., See, R. E., 2002. Basolateral amygdala inactivation abolishes conditioned stimulus- and heroin-induced reinstatement of extinguished heroin-seeking behavior in rats. Psychopharmacology 160, 425-433.

Galaj, E., Manuszak, M., Babic, S., Ananthan, S., Ranaldi, R., 2015. The selective dopamine D3 receptor antagonist, SR 21502, reduces cue-induced reinstatement of heroin seeking and heroin conditioned place preference in rats. Drug. Alcohol Depend. 156, 228-233.

Galaj, E., Manuszak, M., Ranaldi, R., 2016. Environmental enrichment as a potential intervention for heroin seeking. Drug. Alcohol Depend. 163, 195-201.

Gao, J., Li, Y., Zhu, N., Brimijoin, S., Sui, N., 2013. Roles of dopaminergic innervation of nucleus accumbens shell and dorsolateral caudate-putamen in cue-induced morphine seeking after prolonged abstinence and the underlying D1- and D2-like receptor mechanisms in rats. J. Psychopharmacol. 27, 181-191.

Ge, F., Wang, N., Cui, C., Li, Y., Liu, Y., Ma, Y., Liu, S., Zhang, H., Sun, X., 2017. Glutamatergic Projections from the Entorhinal Cortex to Dorsal Dentate Gyrus Mediate Context-Induced Reinstatement of Heroin Seeking. Neuropsychopharmacology 42, 1860-1870.

Ghitza, U. E., Nair, S. G., Golden, S. A., Gray, S. M., Uejima, J. L., Bossert, J. M., Shaham, Y., 2007. Peptide YY3-36 decreases reinstatement of high-fat food seeking during dieting in a rat relapse model. J. Neurosci. 27, 11522-11532.

Gracy, K. N., Dankiewicz, L. A., Weiss, F., Koob, G. F., 2000. Heroin-specific stimuli reinstate operant heroin-seeking behavior in rats after prolonged extinction. Pharmacol. Biochem. Behav. 65, 489-494.

Grasing, K., He, S., 2005. Effects of high-dose selegiline on morphine reinforcement and precipitated withdrawal in dependent rats. Behav. Pharmacol. 16, 1-13.

Grasing, K., He, S., Li, N., 2005. Selegiline modifies the extinction of responding following morphine self-administration, but does not alter cue-induced reinstatement, reacquisition of morphine reinforcement, or precipitated withdrawal. Pharmacol. Res. 51, 69-78.

Grella, S. L., Levy, A., Campbell, A., Djazayeri, S., Allen, C. P., Goddard, B., Leri, F., 2011. Oxycodone dose-dependently imparts conditioned reinforcing properties to discrete sensory stimuli in rats. Pharmacol. Res. 64, 364-370.

Guo, L., Zhou, H., Wang, R., Xu, J., Zhou, W., Zhang, F., Tang, S., Liu, H., Jiang, J., 2012. DBS of nucleus accumbens on heroin seeking behaviors in self-administering rats. Drug. Alcohol Depend. 129, 70-81.

He, S., Grasing, K., 2006. L-methamphetamine and selective MAO inhibitors decrease morphine-reinforced and non-reinforced behavior in rats; Insights towards selegiline's mechanism of action. Pharmacol. Biochem. Behav. 85, 675-688.

Highfield, D., Clements, A., Shalev, U., McDonald, R., Featherstone, R., Stewart, J., Shaham, Y., 2000. Involvement of the medial septum in stress-induced relapse to heroin seeking in rats. Eur. J. Neurosci. 12, 1705-1713.

Highfield, D., Yap, J., Grimm, J. W., Shalev, U., Shaham, Y., 2001. Repeated lofexidine treatment attenuates stress-induced, but not drug cues-induced reinstatement of a heroin-cocaine mixture (speedball) seeking in rats. Neuropsychopharmacology 25, 320-331.

Imperio, C. G., McFalls, A. J., Hadad, N., Blanco-Berdugo, L., Masser, D. R., Colechio, E. M., Coffey, A. A., Bixler, G. V., Stanford, D. R., Vrana, K. E., Grigson, P. S., Freeman, W. M., 2018. Exposure to environmental enrichment attenuates addiction-like behavior and alters molecular effects of heroin self-administration in rats. Neuropharmacology 139, 26-40.

Koya, E., Spijker, S., Voorn, P., Binnekade, R., Schmidt, E. D., Schoffelmeer, A. N., De Vries, T. J., Smit, A. B., 2006. Enhanced cortical and accumbal molecular reactivity associated with conditioned heroin, but not sucrose-seeking behaviour. J. Neurochem. 98, 905-915.

Kuntz-Melcavage, K. L., Brucklacher, R. M., Grigson, P. S., Freeman, W. M., Vrana, K. E., 2009. Gene expression changes following extinction testing in a heroin behavioral incubation model. BMC. Neurosci. 10, 95.

Kuntz, K. L., Patel, K. M., Grigson, P. S., Freeman, W. M., Vrana, K. E., 2008a. Heroin self-administration: II. CNS gene expression following withdrawal and cue-induced drug-seeking behavior. Pharmacol. Biochem. Behav. 90, 349-356.

Kuntz, K. L., Twining, R. C., Baldwin, A. E., Vrana, K. E., Grigson, P. S., 2008b. Heroin self-administration: I. Incubation of goal-directed behavior in rats. Pharmacol. Biochem. Behav. 90, 344-348.

Lai, M., Chen, W., Zhu, H., Zhou, X., Liu, H., Zhang, F., Zhou, W., 2013. Low dose risperidone attenuates cue-induced but not heroin-induced reinstatement of heroin seeking in an animal model of relapse. Int. J. Neuropsychopharmacol. 16, 1569-1575.

Lai, M., Zhu, H., Sun, A., Zhuang, D., Fu, D., Chen, W., Zhang, H. T., Zhou, W., 2014. The phosphodiesterase-4 inhibitor rolipram attenuates heroin-seeking behavior induced by cues or heroin priming in rats. Int. J. Neuropsychopharmacol. 17, 1397-1407.

LaLumiere, R. T., Kalivas, P. W., 2008. Glutamate release in the nucleus accumbens core is necessary for heroin seeking. J. Neurosci. 28, 3170-3177.

Lee, B. H., Lim, S. C., Jeon, H. J., Kim, J. S., Lee, Y. K., Lee, H. J., In, S., Kim, H. Y., Yoon, S. S., Yang, C. H., 2013. Acupuncture suppresses reinstatement of morphine-seeking behavior induced by a complex cue in rats. Neurosci. Lett. 548, 126-131.

Lee, B. H., Ma, J. H., In, S., Kim, H. Y., Yoon, S. S., Jang, E. Y., Yang, C. H., 2012. Acupuncture at SI5 attenuates morphine seeking behavior after extinction. Neurosci Lett 529, 23-27.

Lenoir, M., Ahmed, S. H., 2007. Heroin-induced reinstatement is specific to compulsive heroin use and dissociable from heroin reward and sensitization. Neuropsychopharmacology 32, 616-624.

Leri, F., Burns, L. H., 2005. Ultra-low-dose naltrexone reduces the rewarding potency of oxycodone and relapse vulnerability in rats. Pharmacol. Biochem. Behav. 82, 252-262.

Leri, F., Stewart, J., 2001. Drug-induced reinstatement to heroin and cocaine seeking: a rodent model of relapse in poly-drug use. Exp. Clin. Psychopharmacol. 3, 297-306.

Leri, F., Stewart, J., 2002. The consequences of different "lapses" on relapse to heroin seeking in rats. Exp. Clin. Psychopharmacol. in press.

Leri, F., Tremblay, A., Sorge, R. E., Stewart, J., 2004. Methadone maintenance reduces heroin- and cocaine-induced relapse without affecting stress-induced relapse in a rodent model of poly-drug use. Neuropsychopharmacology 29, 1312-1320.

Li, N., He, S., Parrish, C., Delich, J., Grasing, K., 2003. Differences in morphine and cocaine reinforcement under fixed and progressive ratio schedules; effects of extinction, reacquisition and schedule design. Behav Pharmacol 14, 619-630.

Li, Q. Q., Luo, Y. X., Sun, C. Y., Xue, Y. X., Zhu, W. L., Shi, H. S., Zhai, H. F., Shi, J., Lu, L., 2011. A morphine/heroin vaccine with new hapten design attenuates behavioral effects in rats. J Neurochem 119, 1271-1281.

Li, Q. Q., Sun, C. Y., Luo, Y. X., Xue, Y. X., Meng, S. Q., Xu, L. Z., Chen, N., Deng, J. H., Zhai, H. F., Kosten, T. R., Shi, J., Lu, L., Sun, H. Q., 2014. A conjugate vaccine attenuates morphine- and heroin-induced behavior in rats. Int J Neuropsychopharmacol 18.

Liu, H., Lai, M., Zhou, X., Zhu, H., Liu, Y., Sun, A., Ma, B., Zhang, F., Zhou, W., 2012a. Galantamine attenuates the heroin seeking behaviors induced by cues after prolonged withdrawal in rats. Neuropharmacology 62, 2515-2521.

Liu, H., Liu, Y., Yu, J., Lai, M., Zhu, H., Sun, A., Chen, W., Zhou, W., 2011. Vagus nerve stimulation inhibits heroin-seeking behavior induced by heroin priming or heroin-associated cues in rats. Neurosci. Lett. 494, 70-74.

Liu, S., Zhu, F., Lai, M., Sun, L., Liu, Y., Zhou, W., 2012b. Electroacupuncture suppresses discrete cue-evoked heroin-seeking and fos protein expression in the nucleus accumbens core in rats. Evid Based Complement Alternat. Med. 2012.

Liu, Z., Liu, X. D., Zhang, J. J., Yu, L. C., 2012c. Increases in alphaCaMKII phosphorylated on Thr286 in the nucleus accumbens shell but not the core during priming-induced reinstatement of morphine-seeking in rats. Neurosci Lett 526, 39-44.

Liu, Z., Zhang, J. J., Liu, X. D., Yu, L. C., 2012d. Inhibition of CaMKII activity in the nucleus accumbens shell blocks the reinstatement of morphine-seeking behavior in rats. Neurosci Lett 518, 167-171.

Luo, F., Xi, Z. X., Wu, G., Liu, C., Gardner, E. L., Li, S. J., 2004. Attenuation of brain response to heroin correlates with the reinstatement of heroin-seeking in rats by fMRI. Neuroimage 22, 1328-1335.

Ma, B., Yue, K., Chen, L., Tian, X., Ru, Q., Gan, Y., Wang, D., Jin, G., Li, C., 2014. L-stepholidine, a natural dopamine receptor D1 agonist and D2 antagonist, inhibits heroin-induced reinstatement. Neurosci Lett 559, 67-71.

Madsen, H. B., Brown, R. M., Short, J. L., Lawrence, A. J., 2012. Investigation of the neuroanatomical substrates of reward seeking following protracted abstinence in mice. J. Physiol. 590, 2427-2442.

Maric, T., Sedki, F., Chafetz, D., Schoela, N., Shalev, U., 2011. A role for neuropeptide Y Y5 but not the Y1-receptor subtype in food deprivation-induced reinstatement of heroin seeking in the rat. Psychopharmacology 218, 693-701.

Maric, T., Sedki, F., Ronfard, B., Chafetz, D., Shalev, U., 2012. A limited role for ghrelin in heroin self-administration and food deprivation-induced reinstatement of heroin seeking in rats. Addict. Biol. 17, 613-622.

Maric, T., Tobin, S., Quinn, T., Shalev, U., 2008. Food deprivation-like effects of neuropeptide Y on heroin self-administration and reinstatement of heroin seeking in rats. Behav. Brain Res. 194, 39-43.

McFarland, K., Ettenberg, A., 1997. Reinstatement of drug-seeking behavior produced by heroin-predictive environmental stimuli. Psychopharmacology 131, 86-92.

Minhas, M., Leri, F., 2014. The effect of heroin dependence on resumption of heroin self-administration in rats. Drug. Alcohol Depend. 138, 24-31.

Montanari, C., Stendardo, E., De Luca, M. T., Meringolo, M., Contu, L., Badiani, A., 2015. Differential vulnerability to relapse into heroin versus cocaine-seeking as a function of setting. Psychopharmacology (Berl) 232, 2415-2424.

Neelakantan, H., Holliday, E. D., Fox, R. G., Stutz, S. J., Comer, S. D., Haney, M., Anastasio, N. C., Moeller, F. G., Cunningham, K. A., 2017. Lorcaserin Suppresses Oxycodone Self-Administration and Relapse Vulnerability in Rats. ACS Chem. Neurosci. 8, 1065-1073.

Olmstead, M. C., Munn, E. M., Franklin, K. B., Wise, R. A., 1998. Effects of pedunculopontine tegmental nucleus lesions on responding for intravenous heroin under different schedules of reinforcement. J Neurosci 18, 5035-5044.

Panlilio, L. V., Thorndike, E. B., Schindler, C. W., 2003. Reinstatement of punishment-suppressed opioid self-administration in rats: an alternative model of relapse to drug abuse. Psychopharmacology 168, 229-235.

Panlilio, L. V., Thorndike, E. B., Schindler, C. W., 2005. Lorazepam reinstates punishment-suppressed remifentanil self-administration in rats. Psychopharmacology 179, 374-382.

Peck, J. A., Galaj, E., Eshak, S., Newman, K. L., Ranaldi, R., 2015. Environmental enrichment induces early heroin abstinence in an animal conflict model. Pharmacol Biochem Behav 138, 20-25.

Peck, J. A., Wercberger, R., Kariyeva, E., Ranaldi, R., 2013. Cue-induced resumption of heroin and cocaine seeking in rats using a conflict model of abstinence and relapse. Psychopharmacology (Berl) 228, 651-658.

Peng, X. Q., Xi, Z. X., Li, X., Spiller, K., Li, J., Chun, L., Wu, K. M., Froimowitz, M., Gardner, E. L., 2010. Is slow-onset long-acting monoamine transport blockade to cocaine as methadone is to heroin? Implication for anti-addiction medications. Neuropsychopharmacology : official publication of the American College of Neuropsychopharmacology 35, 2564-2578.

Porter-Stransky, K. A., Bentzley, B. S., Aston-Jones, G., 2017. Individual differences in orexin-I receptor modulation of motivation for the opioid remifentanil. Addict. Biol. 22, 303-317.

Raleigh, M. D., Pentel, P. R., LeSage, M. G., 2014. Pharmacokinetic correlates of the effects of a heroin vaccine on heroin self-administration in rats. PLoS One 9, e115696.

Rogers, J. L., Ghee, S., See, R. E., 2008. The neural circuitry underlying reinstatement of heroin-seeking behavior in an animal model of relapse. Neuroscience 151, 579-588.

Rubio, F. J., Quintana-Feliciano, R., Warren, B., Li, X., Witonsky, K., Soto del Valle, F., Selvam, P. V., Caprioli, D., Venniro, M., Bossert , J. M., Shaham, Y., Hope, B. T., 2018. Prelimbic cortex is a common brain area activated during cue-induced reinstatement of cocaine and heroin seeking in a polydrug self-administration rat model. Eur J Neurosci (accepted pending minor revisions).

Schippers, M. C., Binnekade, R., Schoffelmeer, A. N., Pattij, T., De Vries, T. J., 2012. Unidirectional relationship between heroin self-administration and impulsive decision-making in rats. Psychopharmacology 219, 443-452.

Schmidt, E. D., Voorn, P., Binnekade, R., Schoffelmeer, A. N., De Vries, T. J., 2005. Differential involvement of the prelimbic cortex and striatum in conditioned heroin and sucrose seeking following long-term extinction. Eur. J. Neurosci. 22, 2347-2356.

Sedki, F., Abbas, Z., Angelis, S., Martin, J., D'Cunha, T., Shalev, U., 2013a. Is it stress? The role of stress related systems in chronic food restriction-induced augmentation of heroin seeking in the rat. Front. Neurosci. 7, 1-10.

Sedki, F., D'Cunha, T., Shalev, U., 2013b. A procedure to study the effect of prolonged food restriction on heroin seeking in abstinent rats. J. Vis. Exp., e50751.

Sedki, F., Eigenmann, K., Gelinas, J., Schouela, N., Courchesne, S., Shalev, U., 2015a. A role for kappa-, but not mu-opioid, receptor activation in acute food deprivation-induced reinstatement of heroin seeking in rats. Addict. Biol. 20, 423-432.

Sedki, F., Gardner Gregory, J., Luminare, A., D'Cunha, T. M., Shalev, U., 2015b. Food restriction-induced augmentation of heroin seeking in female rats: manipulations of ovarian hormones. Psychopharmacology 232, 3773-3782.

See, R. E., 2009. Dopamine D1 receptor antagonism in the prelimbic cortex blocks the reinstatement of heroin-seeking in an animal model of relapse. Intern. J. Neuropsychopharmacol. 12, 431-446.

Shaham, Y., Erb, S., Leung, S., Buczek, Y., Stewart, J., 1998. CP-154,526, a selective, non peptide antagonist of the corticotropin-releasing factor type 1 receptor attenuates stress-induced relapse to drug seeking in cocaine-and heroin-trained rats. Psychopharmacology 137, 184-190.

Shaham, Y., Funk, D., Erb, S., Brown, T. J., Walker, C. D., Stewart, J., 1997a. Corticotropin-releasing factor, but not corticosterone, is involved in stress-induced relapse to heroin-seeking in rats. J. Neurosci. 17, 2605-2614.

Shaham, Y., Highfield, D., Delfs, J., Leung, S., Stewart, J., 2000. Clonidine blocks stress-induced reinstatement of heroin seeking in rats: an effect independent of locus coeruleus noradrenergic neurons. Eur. J. Neurosci. 12, 292-302.

Shaham, Y., Puddicombe, J., Stewart, J., 1997b. Sexually arousing events do not induce relapse to heroin-seeking in sexually experienced male rats. Physiol. Behav. 61, 337-341.

Shaham, Y., Rajabi, H., Stewart, J., 1996. Relapse to heroin-seeking in rats under opioid maintenance: the effects of stress, heroin priming, and withdrawal. J. Neurosci. 16, 1957-1963.

Shaham, Y., Rodaros, D., Stewart, J., 1994. Reinstatement of heroin-reinforced behavior following long-term extinction: Implications for the treatment of relapse to drug taking. Behavioural Pharmacology 5, 360-364.

Shaham, Y., Stewart, J., 1995. Stress reinstates heroin self-administration behavior in drug-free animals: An effect mimicking heroin, not withdrawal. Psychopharmacology 119, 334-341.

Shaham, Y., Stewart, J., 1996. Effects of opioid and dopamine receptor antagonists on relapse induced by stress and reexposure to heroin in rats. Psychopharmacology 125, 385-391.

Shalev, U., 2012. Chronic food restriction augments the reinstatement of extinguished heroin-seeking behavior in rats. Addict. Biol. 17, 691-693.

Shalev, U., Finnie, P. S., Quinn, T., Tobin, S., Wahi, P., 2006. A role for corticotropin-releasing factor, but not corticosterone, in acute food-deprivation-induced reinstatement of heroin seeking in rats. Psychopharmacology 187, 376-384.

Shalev, U., Highfield, D., Yap, J., Shaham, Y., 2000. Stress and relapse to drug seeking in rats: studies on the generality of the effect. Psychopharmacology 150, 337-346.

Shalev, U., Morales, M., Hope, B., Yap, J., Shaham, Y., 2001a. Time-dependent changes in extinction behavior and stress-induced reinstatement of drug seeking following withdrawal from heroin in rats. Psychopharmacology 156, 98-107.

Shalev, U., Robarts, P., Shaham, Y., Morales, M., 2003. Selective induction of c-Fos immunoreactivity in the prelimbic cortex during reinstatement of heroin seeking induced by acute food deprivation in rats. Behav. Brain Res. 145, 79-88.

Shalev, U., Yap, J., Shaham, Y., 2001b. Leptin attenuates acute food deprivation-induced relapse to heroin seeking. J. Neurosci. 21, RC129.

Shen, H., Moussawi, K., Zhou, W., Toda, S., Kalivas, P. W., 2011. Heroin relapse requires long-term potentiation-like plasticity mediated by NMDA2b-containing receptors. Proc Natl Acad Sci U S A 108, 19407-19412.

Shen, H. W., Scofield, M. D., Boger, H., Hensley, M., Kalivas, P. W., 2014. Synaptic glutamate spillover due to impaired glutamate uptake mediates heroin relapse. J. Neurosci. 34, 5649-5657.

Smith, A. C., Kupchik, Y. M., Scofield, M. D., Gipson, C. D., Wiggins, A., Thomas, C. A., Kalivas, P. W., 2014. Synaptic plasticity mediating cocaine relapse requires matrix metalloproteinases. Nat. Neurosci. 17, 1655-1657.

Smith, R. J., Aston-Jones, G., 2012. Orexin / hypocretin 1 receptor antagonist reduces heroin self-administration and cue-induced heroin seeking. Eur. J. Neurosci. 35, 798-804.

Sorge, R. E., Rajabi, H., Stewart, J., 2005. Rats maintained chronically on buprenorphine show reduced heroin and cocaine seeking in tests of extinction and drug-induced reinstatement. Neuropsychopharmacology 30, 1681-1692.

Spanagel, R., Sillaber, I., Zieglgansberger, W., Corrigall, W. A., Stewart, J., Shaham, Y., 1998. Acamprosate suppresses the expression of morphine-induced sensitization in rats but does not affect heroin self-administration or relapse induced by heroin or stress. Psychopharmacology 139, 391-401.

Spano, M. S., Fattore, L., Fratta, W., Fadda, P., 2007. The GABAB receptor agonist baclofen prevents heroin-induced reinstatement of heroin-seeking behavior in rats. Neuropharmacology 52, 1555-1562.

Stewart, J., 1984. Reinstatement of heroin and cocaine self-administration behavior in the rat by intracerebral application of morphine in the ventral tegmental area. Pharmacol. Biochem. Behav. 20, 917-923.

Stewart, J., Vezina, P., 1988. A comparison of the effects of intra-accumbens injections of amphetamine and morphine on reinstatement of heroin intravenous self-administration behavior. Brain Res. 457, 287-294.

Stewart, J., Wise, R. A., 1992. Reinstatement of heroin self-administration habits: morphine prompts and naltrexone discourages renewed responding after extinction. Psychopharmacology 108, 79-84.

Stopponi, S., Soverchia, L., Ubaldi, M., Cippitelli, A., Serpelloni, G., Ciccocioppo, R., 2014. Chronic THC during adolescence increases the vulnerability to stress-induced relapse to heroin seeking in adult rats. Eur. Neuropsychopharmacol. 24, 1037-1045.

Theberge, F. R., Li, X., Kambhampati, S., Pickens, C. L., St Laurent, R., Bossert, J. M., Baumann, M. H., Hutchinson, M. R., Rice, K. C., Watkins, L. R., Shaham, Y., 2013. Effect of chronic delivery of the Toll-like receptor 4 antagonist (+)-naltrexone on incubation of heroin craving. Biol. Psychiatry 73, 729-737.

Theberge, F. R., Pickens, C. L., Goldart, E., Fanous, S., Hope, B. T., Liu, Q. R., Shaham, Y., 2012. Association of time-dependent changes in mu opioid receptor mRNA, but not BDNF, TrkB, or MeCP2 mRNA and protein expression in the rat nucleus accumbens with incubation of heroin craving. Psychopharmacology (Berl) 224, 559-571.

Tobin, S., Newman, A. H., Quinn, T., Shalev, U., 2009. A role for dopamine D1-like receptors in acute food deprivation-induced reinstatement of heroin seeking in rats. Int. J. Neuropsychopharmacol. 12, 217-226.

Tobin, S., Sedki, F., Abbas, Z., Shalev, U., 2013. Antagonism of the dopamine D1-like receptor in mesocorticolimbic nuclei attenuates acute food deprivation-induced reinstatement of heroin seeking in rats. Eur. J. Neurosci. 37, 972-981.

Van den Oever, M. C., Goriounova, N. A., Li, K. W., Van der Schors, R. C., Binnekade, R., Schoffelmeer, A. N., Mansvelder, H. D., Smit, A. B., Spijker, S., De Vries, T. J., 2008. Prefrontal cortex AMPA receptor plasticity is crucial for cue-induced relapse to heroin-seeking. Nat. Neurosci. 11, 1053-1058.

Van den Oever, M. C., Lubbers, B. R., Goriounova, N. A., Li, K. W., Van der Schors, R. C., Loos, M., Riga, D., Wiskerke, J., Binnekade, R., Stegeman, M., Schoffelmeer, A. N., Mansvelder, H. D., Smit, A. B., De Vries, T. J., Spijker, S., 2010. Extracellular matrix plasticity and GABAergic inhibition of prefrontal cortex pyramidal cells facilitates relapse to heroin seeking. Neuropsychopharmacology 35, 2120-2133.

Venniro, M., Zhang, M., Shaham, Y., Caprioli, D., 2017. Incubation of Methamphetamine but not Heroin Craving After Voluntary Abstinence in Male and Female Rats. Neuropsychopharmacology 42, 1126-1135.

Wager, T. T., Chandrasekaran, R. Y., Bradley, J., Rubitski, D., Berke, H., Mente, S., Butler, T., Doran, A., Chang, C., Fisher, K., Knafels, J., Liu, S., Ohren, J., Marconi, M., DeMarco, G., Sneed, B., Walton, K., Horton, D., Rosado, A., Mead, A., 2014. Casein kinase 1delta/epsilon inhibitor PF-5006739 attenuates opioid drug-seeking behavior. ACS Chem Neurosci 5, 1253-1265.

Wager, T. T., Chappie, T., Horton, D., Chandrasekaran, R. Y., Samas, B., Dunn-Sims, E. R., Hsu, C., Nawreen, N., Vanase-Frawley, M. A., O'Connor, R. E., Schmidt, C. J., Dlugolenski, K., Stratman, N. C., Majchrzak, M. J., Kormos, B. L., Nguyen, D. P., Sawant-Basak, A., Mead, A. N., 2017. Dopamine D3/D2 Receptor Antagonist PF-4363467 Attenuates Opioid Drug-Seeking Behavior without Concomitant D2 Side Effects. ACS Chem. Neurosci. 8, 165-177.

Wang, B., You, Z. B., Wise, R. A., 2012. Heroin self-administration experience establishes control of ventral tegmental glutamate release by stress and environmental stimuli. Neuropsychopharmacology 37, 2863-2869.

Wang, N., Ge, F., Cui, C., Li, Y., Sun, X., Sun, L., Wang, X., Liu, S., Zhang, H., Liu, Y., Jia, M., Yang, M., 2018. Role of Glutamatergic Projections from the Ventral CA1 to Infralimbic Cortex in Context-Induced Reinstatement of Heroin Seeking. Neuropsychopharmacology 43, 1373-1384.

Wise, R. A., Murray, A., Bozarth, M. A., 1990. Bromocriptine self-administration and bromocriptine- reinstatement of cocaine-trained and heroin-trained lever pressing in rats. Psychopharmacology 100, 355-360.

Xue, Y. X., Luo, Y. X., Wu, P., Shi, H. S., Xue, L. F., Chen, C., Zhu, W. L., Ding, Z. B., Bao, Y. P., Shi, J., Epstein, D. H., Shaham, Y., Lu, L., 2012. A memory retrieval-extinction procedure to prevent drug craving and relapse. Science 336, 241-245.

Yao, L., McFarland, K., Fan, P., Jiang, Z., Ueda, T., Diamond, I., 2006. Adenosine A2a blockade prevents synergy between mu-opiate and cannabinoid CB1 receptors and eliminates heroin-seeking behavior in addicted rats. Proc Natl Acad Sci U S A 103, 7877-7882.

You, Z. B., Gao, J. T., Bi, G. H., He, Y., Boateng, C., Cao, J., Gardner, E. L., Newman, A. H., Xi, Z. X., 2017. The novel dopamine D3 receptor antagonists/partial agonists CAB2-015 and BAK4-54 inhibit oxycodone-taking and oxycodone-seeking behavior in rats. Neuropharmacology 126, 190-199.

Yue, K., Ma, B., Chen, L., Tian, X., Ru, Q., Gan, Y., Wang, D., Jin, G., Li, C., 2014. L-Stepholidine, a naturally occurring dopamine D1 receptor agonist and D2 receptor antagonist, attenuates heroin self-administration and cue-induced reinstatement in rats. Neuroreport 25, 7-11.

Yue, K., Ma, B., Ru, Q., Chen, L., Gan, Y., Wang, D., Jin, G., Li, C., 2012. The dopamine receptor antagonist levo-tetrahydropalmatine attenuates heroin self-administration and heroin-induced reinstatement in rats. Pharmacol Biochem Behav 102, 1-5.

Zhang, F., Zhou, W., Liu, H., Zhu, H., Tang, S., Lai, M., Yang, G., 2005. Increased c-Fos expression in the medial part of the lateral habenula during cue-evoked heroin-seeking in rats. Neurosci. Lett. 386, 133-137.

Zhou, W., Kalivas, P. W., 2008. N-acetylcysteine reduces extinction responding and induces enduring reductions in cue- and heroin-induced drug-seeking. Biol. Psychiatry 63, 338-340.

Zhou, W., Liu, H., Zhang, F., Tang, S., Zhu, H., Lai, M., Kalivas, P. W., 2007. Role of acetylcholine transmission in nucleus accumbens and ventral tegmental area in heroin-seeking induced by conditioned cues. Neuroscience 144, 1209-1218.

Zhou, W., Zhang, F., Liu, H., Tang, S., Lai, M., Zhu, H., Kalivas, P. W., 2009. Effects of training and withdrawal periods on heroin seeking induced by conditioned cue in an animal of model of relapse. Psychopharmacology 203, 677-684.

Zhou, W., Zhang, F., Tang, S., Liu, H., Gu, J., Yang, G., 2005. The dissociation of heroin-seeking patterns induced by contextual, discriminative, or discrete conditioned cues in a model of relapse to heroin in rats. Psychopharmacology (Berl) 181, 197-206.

Zhou, W., Zhang, F., Tang, S., Liu, H., Lai, M., Yang, G., 2004. Low dose of heroin inhibits drug-seeking elicited by cues after prolonged withdrawal from heroin self-administration in rats. Neuroreport 15, 727-730.

Zhou, Y., Leri, F., Cummins, E., Hoeschele, M., Kreek, M. J., 2008. Involvement of arginine vasopressin and V1b receptor in heroin withdrawal and heroin seeking precipitated by stress and by heroin. Neuropsychopharmacology 33, 226-236.

Zhou, Y., Leri, F., Cummins, E., Kreek, M. J., 2015. Individual differences in gene expression of vasopressin, D2 receptor, POMC and orexin: vulnerability to relapse to heroin-seeking in rats. Physiol. Behav. 139, 127-135.

Zhou, Y., Leri, F., Grella, S. L., Aldrich, J. V., Kreek, M. J., 2013. Involvement of dynorphin and kappa opioid receptor in yohimbine-induced reinstatement of heroin seeking in rats. Synapse 67, 358-361.