Bölüm 13

Psikonöroimmünoloji 2.0'de Fare Test Yöntemleri: Davranış Yanıtlarının Ölçülmesi

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Özet

Psikonöroimmünoloji (PNI) alanı sinir, bağışıklık ve endokrin sistem ilişkilerinin dayandığı olayları ve sonuçlarını örten örtüyü kaldırmayı amaçlar. Davranış bu tür etkileşimlerin bir sonucudur ve immüno-nöral ve nöro-immün iletişim dahil iç içe geçmiş karmaşık etmenlerin kendisini ortaya koymasıdır. Çoğu kez, nöroimmün aktivasyonun özgül bir epizoduna katılan işaretleşme molekülleri bilinmemekte ise de davranış yanıtı nörotransmiter ve sitokinler gibi biyoaktif maddelerde bozulma olduğuna dair kanıtlar sağlamaktadır. İmmünodavranışsal fenotiplendirme, nöroimmün sistemin ve bunun immün stimülasyon veya süpresyona verdiği tepkinin incelenmesinde ilk hat yaklaşımını temsil eder. Davranışsal yanıt tek bir özgül biyoaktif maddenin doğrudan ölçülmesinden anlamlı derecede daha duyarlıdır ve nöroimmüniteye karşı özgün bir immün zorlama veya terapötiğin ilgisi olup olmadığını hızla ve etkin şekilde ortaya koyar. Klasik olarak immünodavranışsal araştırma bakteriyel enfeksiyonla ilişkili hastalık semptomları üzerine odaklanmış ise de günümüzde nöroimmün aktivasyon kanserden diabete ve oradan Alzheimer'a kadar uzanan hastalık ve rahatsızlıkların komplikasyonu olarak tanınmaktadır. İmmünodavranış içinde letarji, iştah kaybı ve sosyal aktivite-çevresindeki ortama ilgi kaybı bulunmaktadır. Ek olarak, nöroimmün aktivasyon fiziksel aktiviteyi azaltabilir, depresyon ve anksiyete duygularını presipite edebilir ve bilişsel ve yürütme işlevini bozabilir. Burada, başarılı immünodavranış deneylerinin başarısını engelleyen veya bununla birlikte olan deney öncesi koşullar üzerinde özellikle durularak farelerde nöroimmün aktivasyonu incelemede sıklıkla kullanılan davranış testleri ayrıntılı olarak gözden geçirilmektedir.

Anahtar sözcükler Fare, Labirent, Yordama, Beyin tabanlı, Biyodavranış, Bellek, Motor aktivite, Anhedoni

1 Giriş

1970'lerde biline disiplinlerarası bir alan olarak girişinden itibaren davranış psikonöroimmünolojinin (PNI) ayrılmaz bir parçası olmuştur. Gerçekten de, PNI genel olarak davranış, nöral, immün ve endokrin sistem işlevleri arasındaki etkileşimlerin incelenmesi olarak tanımlanır [1, 2]. Davranış, özgül bir uyartı veya deneysel

7 Sonuç

Davranış testi PNI araştırmasının temel bir elemanı olup hastalık semptomlarının kaynağı ve anlamlarını araştırmada fareler güçlü bir araç sağlar. Herhangi bir deneysel protokolde olduğu gibi bilim adamları arasında hangi yöntemlerin en doğru olduğu konusunda tam bir görüş birliği sağlanamaz. Dolayısı ile yukarda sunulan bilgiler, hastalık ve depresif/anksiyetal, bilişsel ve fiziksel aktivite davranışlarının nasıl ölçüleceği konusuna genel bir bakış olarak kabul edilmelidir. Başarılı bir davranış testi eldesi için uygun protokollerin seçimi kadar önemli olan bir husus, deney-öncesi koşulların göz önüne alınması olup deneyin anlamı ve yinelenebilirliğini belirlemede olasılıkla en önemli belirleyici budur. Farelerin negatif stresörlerden uzak bir ortamda barınmaları ve herhangi bir barınak değişikliğine çok iyi uyum sağlamış olmaları esansiyel önem taşır. Barınma koşullarında ön görülmeyen ve beklenmedik değişikliklere oranla gereçler ve deney tasarımında yapılan değişiklikler mutad olarak fazla anlam taşımaz. Aslında ıslak kafesler, gürültü ve tanımadık kokular çoğu kez olumsuz biyodavranışların uyandırıcısı olarak kullanılır. Yani farelerle çalışılırken tutarlılık, ilgi ve bakım başarının en önemli anahtarlarıdır. Son olarak, zeki bir gözlem ek bir ödül getirir ve test sırasında beklenmeyen veya mutad olmayan davranışların varlığından emin olmak yepyeni keşiflere ve yeni davranış testleri ile immünodavranışsal paradigmalara yol açabilir.

Bilgilendirme

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Kaynaklar

1. Ader R (2000) On the development of psychoneuroimmunology. Eur J Pharmacol 405(1–3):167–176
2. Maier SF, Watkins LR, Fleshner M (1994) Psychoneuroimmunology—the interface between behavior, brain and immunity. Am Psychol 49(12):1004–1017
3. Kerschensteiner M, Meinl E, Hohlfeld R (2009) Neuro-immune crosstalk in CNS diseases. Neuroscience 158:1122–1132
4. Kelley KW et al (2003) Cytokine-induced sickness behavior. Brain Behav Immun 17: S112–S118
5. Irwin MR (2008) Human psychoneuroimmunology: 20 years of discovery. Brain Behav Immun 22:129–139
6. Dantzer R (2004) Cytokine-induced sickness behavior: a neuroimmune response to activation of innate immunity. Eur J Pharmacol 500:399–411
7. Johnson DR et al (2007) Acute hypoxia activates the neuroimmune system, which diabetes exacerbates. J Neurosci 27(5):1161–1166
8. Dantzer R (2001) Cytokine-induced sickness behavior: mechanisms and implications. Ann N Y Acad Sci 933:222–234
9. Gibertini M (1998) Cytokines and cognitive behavior. Neuroimmunomodulation 5:160–165
10. Wingfield JC et al (2006) Contexts and ethology of vertebrate aggression: implications for the evolution of hormone-behavior interactions. In: Nelson RJ (ed) Biology of aggression. Oxford University Press, New York
11. Dantzer R et al (2008) From inflammation to sickness and depression: when the immune system subjugates the brain. Nat Rev Neurosci 9:46–56
12. Lavin DN et al (2011) Fasting induces an anti-inflammatory effect on the neuroimmune system which a high-fat diet prevents. Obesity 19(8):1586–1594

13. Yi B, Sahn JJ, Ardestani PM et al (2017) Small molecule modulator of sigma 2 receptor is neuroprotective and reduces cognitive deficits and neuroinflammation in experimental models of Alzheimer's disease. J Neurochem 140:561–575. https://doi.org/10.1111/jnc.13917
14. Paul RH et al (2000) Fatigue and its impact on patients with Myasthenia Gravis. Muscle Nerve 23(9):1402–1406
15. Carmichael MD et al (2006) Role of brain IL-1β on fatigue after exercise-induced muscle damage. Am J Physiol Regul Integr Comp Physiol 291:R1344–R1348
16. Ro¨nnb€ack L, Hansson E (2004) On the potential role of glutamate transport in mental fatigue. J Neuroinflammation 1:22
17. Tanila H (2017) Testing cognitive functions in rodent disease models: present pitfalls and future perspectives. Behav Brain Res. https://doi.org/10.1016/j.bbr.2017.05.040
18. Warren EJ et al (1997) Coincidental changes in behavior and plasma cortisol in unrestrained pigs after intracerebroventricular injection of tumor necrosis factor-α. Endocrinology 138(6):2365–2371
19. Antonson AM, Radlowski EC, Lawson MA et al (2017) Maternal viral infection during pregnancy elicits anti-social behavior in neonatal piglet offspring independent of postnatal microglial cell activation. Brain Behav Immun 59:300–312. https://doi.org/10.1016/j.bbi.2016.09.019
20. Rytych JL, Elmore MRP, Burton MD et al (2012) Early life iron deficiency impairs spatial cognition in neonatal piglets. J Nutr 142:2050–2056. https://doi.org/10.3945/ jn.112.165522
21. Grippo AJ (2009) Mechanisms underlying altered mood and cardiovascular dysfunction: the value of neurobiological and behavioral research in animal models. Neurosci Biobehav Rev 33(2):171–180
22. Johnson A, Hamilton TJ (2017) Modafinil decreases anxiety-like behaviour in zebrafish. PeerJ 5:e2994. https://doi.org/10.7717/peerj.2994
23. Crawley JN (2003) Behavioral phenotyping of rodents. Comp Med 53(2):140–146
24. Shigemura N et al (2004) Leptin modulates behavioral responses to sweet substances by influencing peripheral taste structures. Endocrinology 145(2):839–847
25. Rodgers RJ, Cole JC (1993) Influence of social isolation, gender, strain and prior novelty on plus-maze behaviour in mice. Physiol Behav 54(4):729–736
26. Palanza P, Gioiosa L, Parmigiani S (2001) Social stress in mice: gender differences and effects of estrous cycle and social dominance. Physiol Behav 73:411–420
27. Lightfoot JT et al (2004) Genetic influence on daily wheel running activity level. Physiol Genomics 19:270–276
28. Basterfield L, Lumley LK, Mathers JC (2009) Wheel running in female C57BL/6J mice: impact of oestrus and dietary fat and effects on sleep and body mass. Int J Obes (Lond) 33:212–218
29. Clayton JA, Collins FS (2014) Policy: NIH to balance sex in cell and animal studies. Nature 509:282–283. https://doi.org/10.1038/509282a
30. Hawkley LC, Cacioppo JT (2004) Stress and the aging immune system. Brain Behav Immun 18(2):114–119
31. Dilger RN, Johnson RW (2008) Aging, microglial cell priming, and the discordant central inflammatory response to signals from the peripheral immune system. J Leukoc Biol 84(4):932–939
32. Martin SA et al (2011) Voluntary-wheel exercise training attenuates the visceral adipose, but not central, inflammatory response to LPS in aged C57BL/6J mice. Brain Behav Immun 25(S2):S217–S218. (Abstract)
33. Ma H et al (2010) Effects of diet-induced obesity and voluntary wheel running on bone properties in young male C57BL/6J mice. Calcif Tissue Int 86:411–419
34. Obernier JA, Baldwin RL (2006) Establishing an appropriate period of acclimatization following transportation of laboratory animals. ILAR J 47(4):364–369
35. Tuli JS, Smith JA, Morton DB (1995) Stress measurements in mice after transportation. Lab Anim 29:132–138
36. Jennings M et al (1998) Refining rodent husbandry: the mouse. Report of the Rodent Refinement Working Party. Lab Anim 32 (3):233–259
37. Cle´net F et al (2006) Light/dark cycle manipulation influences mice behavior in the elevated plus maze. Behav Brain Res 166 (1):140–149
38. Ciarleglio CM et al (2009) Population encoding by circadian clock neurons organizes circadian behavior. J Neurosci 29 (6):1670–1676
39. Goulding EH et al (2008) A robust automated system elucidates mouse home cage behavioral structure. Proc Natl Acad Sci U S A 105(52):20575–20582
40. National Research Council of the National Academies (2011) Guide for the care and use of laboratory animals. National Academy of Sciences, Washington, DC
41. Buchanan JB et al (2008) Cognitive and neuroinflammatory consequences of mild repeated stress are exacerbated in aged mice. Psychoneuroendocrinology 33(6): 755–765
42. Ajarem JS, Safar E, AhmadM(2011) Effect of ethanol and thermal stresses on the social behavior of male mice. Asian J Biol Sci 4:362–368
43. Goshen I et al (2003) The role of endogenous interleukin-1 in stress-induced adrenal activation and adrenalectomy-induced adrenocorticotropic hormone hypersecretion. Endocrinology 144:4453–4458
44. Naff KA et al (2007) Noise produced by vacuuming exceeds the hearing thresholds of C57BL/6 and CD1 mice. J Am Assoc Lab Anim Sci 46(1):52–57

45. Turnbull AV, Rivier C (1995) Regulation of the HPA axis by cytokines. Brain Behav Immun 9(4):253–275
46. Beishuizen A, Thijs LG (2003) Review: endotoxin and the hypothalamo-pituitary-adrenal (HPA) axis. Innate Immun 9(1):3–24
47. Pfaff J (1974) Noise as an environmental problem in the animal house. Lab Anim 8:347–354
48. Arakawa H, Cruz S, Deak T (2011) From models to mechanisms: odorant communication as a key determinant of social behavior in rodents during illness-associated states. Neurosci Biobehav Rev 35(9):1916–1928
49. Alves GJ et al (2010) Odor cues from tumorbearing mice induces neuroimmune changes. Behav Brain Res 214:357–367
50. Conour LA, Murray KA, Brown MJ (2006) Preparation of animals for research—issues to consider for rodents and rabbits. ILAR J 47 (4):283–293
51. Balcombe JP, Barnard ND, Sandusky C (2004) Laboratory routines cause animal stress. Contemp Top Lab Anim Sci 43 (6):42–51
52. Hurst JL, West RS (2010) Taming anxiety in laboratory mice. Nat Methods 7 (10):825–826
53. Sun L, Min L, Zhou H et al (2017) Adolescent social isolation affects schizophrenia-like behavior and astrocyte biomarkers in the PFC of adult rats. Behav Brain Res 333:258–266. https://doi.org/10.1016/j.bbr.2017.07. 011
54. Koike H et al (2009) Behavioral abnormality and pharmacologic response in social isolation-reared mice. Behav Brain Res 202 (1):114–121
55. Ma X et al (2011) Social isolation-induced aggression potentiates anxiety and depressive-like behavior in male mice subjected to unpredictable chronic mild stress. PLoS One 6(6):e20955
56. Avitsur R, Stark JL, Sheridan JF (2001) Social stress induces glucocorticoid resistance in subordinate animals. Horm Behav 39 (4):247–257
57. Pardon M et al (2004) Repeated sensory contact with aggressive mice rapidly leads to an anticipatory increase in core body temperature and physical activity that precedes the onset of aversive responding. Eur J Neurosci 20(4):1033–1050
58. Van De Weerd HA et al (1994) Strain specific behavioural response to environmental enrichment in the mouse. J Exp Anim Sci 36:117–127
59. Olsson AS, Dahlborn K (2001) Improving housing conditions for laboratory mice: a review of 'environmental enrichment'. Lab Anim 36:243–270
60. Kent S et al (1992) Sickness behavior as a new target for drug development. Trends Pharmacol Sci 13:24–28
61. Dantzer R et al (1987) Modulation of social memory in male rats by neurohypophyseal peptides. Psychopharmacology (Berl) 91:363–368
62. Park SE et al (2011) Central administration of insulin-like growth factor-I decreases depressive-like behavior and brain cytokine expression in mice. J Neuroinflammation 8:12
63. Krzyszton CP et al (2008) Exacerbated fatigue and motor deficits in interleukin-10-deficient mice after peripheral immune stimulation. Am J Physiol Regul Integr Comp Physiol 295(4):R1109–R1114
64. Pecaut MJ et al (2002) Behavioral consequences of radiation exposure to simulated space radiation in the C57BL/6 mouse: open field, rotarod, and acoustic startle. Cogn Affect Behav Neurosci 2(4):329–340
65. Thor DH, Holloway WR (1982) Social memory of the male laboratory rat. J Comp Physiol Psychol 96(6):1000–1006
66. Bluthe´ RM, Dantzer R, Kelley KW (1991) Interleukin-1 mediates behavioural but not metabolic effects of tumor necrosis factor α in mice. Eur J Pharmacol 209:281–283
67. Bluthe´ RM, Schoenen J, Dantzer R (1990) Androgen-dependent vasopressinergic neurons are involved in social recognition in rats. Brain Res 519:150–157
68. Dantzer R, Bluthe´ RM, Kelley KW (1991) Androgen-dependent vasopressinergic neurotransmission attenuates interleukin-1-induced sickness behavior. Brain Res 557:115–120
69. Abraham J et al (2008) Aging sensitizes mice to behavioral deficits induced by central HIV-1 gp120. Neurobiol Aging 29:614–621
70. Sherry CL et al (2009) Behavioral recovery from acute hypoxia is reliant on leptin. Brain Behav Immun 23(2):169–175
71. Cao JL et al (2010) Mesolimbic dopamine neurons in the brain reward circuit mediate susceptibility to social defeat and antidepressant action. J Neurosci 30(49):16453–16458
72. Basso AM et al (2009) Behavioral profile of P2X7 receptor knockout mice in animal models of depression and anxiety: relevance for neuropsychiatric disorders. Behav Brain Res 198:83–90
73. York JM, Blevins NA, McNeil LK, Freund GG (2013) Mouse short- and long-term locomotor activity analyzed by video tracking software. J Vis Exp:e50252–e50252. https://doi.org/10.3791/50252
74. Buchanan JB, Sparkman NL, Johnson RW (2010) A neurotoxic regimen of methamphetamine exacerbates the febrile and neuroinflammatory response to a subsequent peripheral immune stimulus. J Neuroinflammation 7:82
75. FanelliMT, Kaplan ML(1978) Effects of high fat and high carbohydrate diets on the body composition and oxygen consumption of ob/ob mice. J Nutr 108(9):1491–1500
76. Jones BJ, Roberts DJ (1968) The quantitative measurement of motor incoordination in naı¨ve mice using and accelerating rotarod. J Pharm Pharmacol 20(4):302–304
77. Tarantino LM, Gould TJ, Druhan JP, Bucan M (2000) Behavior and mutagenesis screens: the importance of baseline analysis of inbred strains. Mamm Genome 11:555–564

78. Dang MT et al (2006) Disrupted motor learning and long-term synaptic plasticity in mice lacking NMDAR1 in the striatum. Proc Natl Acad Sci U S A 103(41):15254–15259
79. Carter RJ, Morton AJ, Dunnett SB (2001) Motor coordination and balance in rodents. Curr Protoc Neurosci Chapter 8:Unit 8.12
80. Loftis JM, Huckans M, Morasco BJ (2010) Neuroimmune mechanisms of cytokineinduced depression: current theories and novel treatment strategies. Neurobiol Dis 37:519–533
81. Deacon RMJ (2006) Burrowing in rodents: a sensitive method for detecting behavioral dysfunction. Nat Protoc 1(1):118–121
82. Walf AA, Frye CA (2007) The use of the elevated plus maze as an assay of anxietyrelated behavior in rodents. Nat Protoc 2 (2):322–328
83. Cryan JF, Holmes A (2005) The ascent of mouse: advances in modeling human depression and anxiety. Nat Rev Drug Discov 4:775–790
84. Gould TD, Dao DT, Kovacsics CE (2009) The open field test. In: Gould T (ed) Mood and anxiety related phenotypes in mice: characterization using behavioral tests. Humana Press, New York
85. Petit-Demouliere B, Chenu F, Bourin M (2004) Forced swimming test in mice: a review of antidepressant activity. Psychopharmacology (Berl) 177:245–255
86. Avgustinovich DF, Lipina TV, Bondar NP et al (2000) Features of the genetically defined anxiety in mice. Behav Genet 30:101–109
87. Moon ML, Joesting JJ, Blevins NA et al (2015) IL-4 knock out mice display anxietylike behavior. Behav Genet 45:451–460. https://doi.org/10.1007/s10519-015-9714-x
88. Muralidharan A, Kuo A, Jacob M et al (2016) Comparison of burrowing and stimuli-evoked pain behaviors as end-points in rat models of inflammatory pain and peripheral neuropathic pain. Front Behav Neurosci 10:88. https://doi.org/10.3389/fnbeh.2016.00088
89. Tonelli LH et al (2009) Allergic rhinitis induces anxiety-like behavior and altered social interaction in rodents. Brain Behav Immun 23:784–793
90. Komada M, Takao K, Miyakawa T (2008) Elevated plus maze for mice. J Vis Exp 22: e1088
91. Fromm L et al (2004) Magnesium attenuates post-traumatic depression/anxiety following diffuse traumatic brain injury in rats. J Am Coll Nutr 23(5):529S–533S
92. Shepherd JK et al (1994) Behavioural and pharmacological characterisation of the elevated "zero-maze" as an animal model of anxiety. Psychopharmacology (Berl) 116:56–64
93. Heisler LK et al (1998) Elevated anxiety and antidepressant-like responses in serotonin 5-HT1A receptor knockout mutant mice. Proc Natl Acad Sci U S A 95:15049–15054
94. Ennaceur A (2014) Tests of unconditioned anxiety — pitfalls and disappointments. Physiol Behav 135:55–71. https://doi.org/10.1016/j.physbeh.2014.05.032
95. Hascoe¨ M, Bourin M (2009) The mouse light–dark box test. In: Gould T (ed) Mood and anxiety related phenotypes in mice, Neuromethods, vol 42. Humana Press, Totowa, NJ. https://doi.org/10.1007/978-1- 60761-303-9_11
96. Takao K, Miyakawa T (2006) Light/dark transition test for mice. J Vis Exp: e104–e104. https://doi.org/10.3791/104
97. Cryan JF, Mombereau C, Vassout A (2005) The tail suspension test as a model for assessing antidepressant activity: review of pharmacological and genetic studies in mice. Neurosci Biobehav Rev 29(4–5):571–625
98. Porsolt RD et al (2001) Rodent models of depression: forced swimming and tail suspension behavioral despair tests in rats and mice. Curr Protoc Neur sci:8.10A.1–8.10A.10
99. Lad HVet al (2007) Quantitative traits for the tail suspension test: automation, optimization, and BXD RI mapping. Mamm Genome 18:482–491
100. Steru L et al (1985) The tail suspension test: a new method for screening antidepressants in mice. Psychopharmacology (Berl) 85:367–370
101. Cryan JF, Markou A, Lucki I (2002) Assessing antidepressant activity in rodents: recent developments and future needs. Trends Pharmacol Sci 23(5):238–245
102. Cryan JF, Page ME, Lucki I (2005) Differential behavioral effects of the antidepressantsreboxetine, fluoxetine, and moclobemide in a modified forced swim test following chronic treatment. Psychopharmacology (Berl) 182:335–344
103. Moreau Met al (2008) Innoculation of Bacillus Calmette-Guerin to mice induces an acute episode of sickness behavior followed by chronic depressive-like behavior. Brain Behav Immun 22(7):1087–1095
104. Udo H et al (2008) Enhanced adult neurogenesis and angiogenesis and altered affective behaviors in mice overexpressing vascular endothelial growth factor 120. J Neurosci 28(53):14522–14536
105. He´dou G et al (2001) An automated analysis of rat behavior in the forced swim test. Pharmacol Biochem Behav 70(1):65–76
106. DSM-IV (1994) Diagnostic and statistical manual of mental disorders, 4th edn. American Psychological Association, Washington, DC
107. Strekalova T, Steinbusch H (2009) Factors of reproducibility of anhedonia induction in a chronic stress depression model in mice. In: Gould T (ed) Mood and anxiety related phenotypes in mice: characterization using behavioral tests. Humana Press, New York
108. Niemi MB et al (2008) Neuro-immune associative learning. In: Lajtha A, Galoyan A, Besedovski HO (eds) Handbook of neurochemistry and molecular neurobiology. Springer, New York

109. Brennan PA, Keverne EB (1997) Neural mechanisms of mammalian olfactory learning. Prog Neurobiol 51(4):457–481
110. Bryan KJ et al (2009) Chapter 1: transgenic mouse models of Alzheimer's disease: behavioral testing and considerations. In: Buccafusco JJ (ed) Methods of behavior analysis in neuroscience, 2nd edn. CRC Press, Boca Raton, FL
111. Bevins RA, Besheer J (2006) Object recognition in rats and mice: a one-trial non-matching-to-sample learning task to study 'recognition memory'. Nat Protoc 1 (3):1306–1311
112. Stefanko DP et al (2009) Modulation of longterm memory for object recognition via HDAC inhibition. Proc Natl Acad Sci U S A 106(23):9447–9452
113. Chiu GS, Chatterjee D, Darmody PT et al (2012) Hypoxia/reoxygenation impairs memory formation via adenosine-dependent activation of caspase 1. J Neurosci 32:13945–13955. https://doi.org/10.1523/JNEUROSCI.0704-12.2012
114. Win-Shwe TT, Fujimaki H (2012) Acute administration of toluene affects memory retention in novel object recognition test and memory function-related gene expression in mice. J Appl Toxicol 32(4):300–304
115. Gainey SJ, Kwakwa KA, Bray JK et al (2016) Short-term high-fat diet (HFD) induced anxiety-like behaviors and cognitive impairment are improved with treatment by glyburide. Front Behav Neurosci 10:156. https://doi.org/10.3389/fnbeh.2016. 00156
116. Towers AE, Oelschlager ML, Patel J et al (2017) Acute fasting inhibits central caspase-1 activity reducing anxiety-like behavior and increasing novel object and object location recognition. Metabolism 71:70–82. https:// doi.org/10.1016/j.metabol.2017.03.005
117. Wehner JM, Radcliffe RA (2004) Cued and contextual fear conditioning in mice. Curr Protoc Neurosci Chapter 8:Unit 8.5C
118. Deacon RMJ, Rawlins JNP (2006) T-maze alternation in the rodent. Nat Protoc 1 (1):7–12
119. Lalonde R (2002) The neurological basis of spontaneous alternation. Neurosci Biobehav Rev 26:91–104
120. Bekker A et al (2006) Isoflurane preserves spatial working memory in adult mice after moderate hypoxia. Anesth Analg 102:1134–1138
121. Harrison FE et al (2006) Spatial and nonspatial escape strategies in the Barnes maze. Learn Mem 13(6):809–819
122. O'Leary TP, Brown RE (2009) Visuo-spatial learning and memory deficits on the Barnes maze in the 16-month-old APPswe/PS1dE9 mouse model of Alzheimer's disease. Behav Brain Res 201:120–127
123. Vorhees CV, Williams MT (2006) Morris water maze: procedures for assessing spatial and related forms of learning and memory. Nat Protoc 1(2):848–858
124. Rosczyk HA, Sparkman NL, Johnson RW (2008) Neuroinflammation and cognitive function in aged mice following minor surgery. Exp Gerontol 43:840–846
125. Carli M, Robbins TW, Evenden JL, Everitt BJ (1983) Effects of lesions to ascending noradrenergic neurones on performance of a 5-choice serial reaction task in rats; implications for theories of dorsal noradrenergic bundle function based on selective attention and arousal. Behav Brain Res 9:361–380
126. Horner AE, Heath CJ, Hvoslef-Eide M et al (2013) The touchscreen operant platform for testing learning and memory in rats and mice. Nat Protoc 8:1961–1984. https://doi.org/10.1038/nprot.2013.122
127. Bushnell PJ, Strupp BJ (2009) Assessing attention in rodents. CRC Press/Taylor & Francis, Boca Raton, FL
128. Young JW, Light GA, Marston HM et al (2009) The 5-choice continuous performance test: evidence for a translational test of vigilance for mice. PLoS One 4:e4227. https://doi.org/10.1371/journal.pone. 0004227
129. Grissom NM, Herdt CT, Desilets J et al (2015) Dissociable deficits of executive function caused by gestational adversity are linked to specific transcriptional changes in the prefrontal cortex. Neuropsychopharmacology 40:1353–1363. https://doi.org/10.1038/npp.2014.313
130. Dishman RK et al (2006) Neurobiology of exercise. Obesity 14:345–346
131. Leasure JL, Jones M (2008) Forced a voluntary exercise differentially affect brain and behavior. Neuroscience 156:456–465
132. Garland TH Jr et al (2011) The biological control of voluntary exercise, spontaneous physical activity and daily energy expenditure in relation to obesity: human and rodent perspectives. J Exp Biol 214(pt 2):206–229
133. Noakes TD (2011) Time to move behind a brainless exercise physiology: the evidence for complex regulation of human exercise performance. Appl Physiol Nutr Metab 36:23–35
134. Takeshita H, Yamamoto K, Nozato S et al (2017) Modified forelimb grip strength test detects aging-associated physiological decline in skeletal muscle function in male mice. Sci Rep 7:42323. https://doi.org/10.1038/srep42323
135. Messina S, Bitto A, Aguennouz M et al (2006) Nuclear factor kappa-B blockade reduces skeletal muscle degeneration and enhances muscle function in Mdx mice. Exp Neurol 198:234–241. https://doi.org/10. 1016/j.expneurol.2005.11.021