

Supporting information for

**Nano-La₂O₃ undermines honeybee cognition by invading
the brain and accelerating neuronal apoptosis**

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Table S1 The sample size in different experiments of this study

Experiment	Group						Sample
	T0	T1	T10	T100	T500	T1000	
Sucrose perception	25/25/26	30/30/32	24/24/23	18/18/18	18/18/18	18/18/17	Honeybee
Learning	24/24/24	30/30/29	22/22/22	18/18/17	15/15/14	18/18/16	Honeybee
Memory	21/22/22	28/25/23	19/19/16	14/15/12	12/10/12	13/11/13	Honeybee

Table S2 The primer sequences for RT-qPCR

Gene	Abbreviation	Primer sequences (5'-3')	Accession number
<i>caspase-1</i>	<i>caspase-1</i>	AACTGATGGTCAACCAGCTTC CGCGAGTGGTATTTCTCCAT	XM_395697.7
<i>caspase-3</i>	<i>caspase-3</i>	TCGTTACGCCAAAAGATTCC GTCCCGTTTCGTTGTGATTC	XM_394855.6
<i>cAMP-dependent protein kinase</i>	<i>pka</i>	ACAAGTGGTTCGCCAGTACC GTGTCTCCTGGCCCTTTACA	XM_393285.7
<i>cAMP-responsive element binding protein</i>	<i>creb</i>	AATTGCAACCCAAGGTGAAG CTTGGCCTTGTGCATACTGA	XM_006570049.3
<i>n-methyl-D-aspartate receptor 1</i>	<i>nmdar1</i>	AAATGCGCAAGCAAGAGTTT GCTTGCTCTGTCACAATCCA	NM_001011573.1
<i>vitellogenin</i>	<i>vg</i>	GAGAAACGTGATCAGCGACA TGGATCGTGCAATGTTTGTT	NM_001011578.1
<i>catalase</i>	<i>cat</i>	GAGCTGGTGCATTCGGTTAT CGCCACCCACAGTAGAAAAT	NM_001178069.1
<i>apidaecin 1</i>	<i>apid1</i>	TGAAGAATTTTGCCTTAGCAAT AGGTCGAGTAGGCGGATCTA	NM_001011613.1
<i>ribosomal protein L32</i>	<i>rpl32</i>	TGAAGAATTTTGCCTTAGCAAT AGGTCGAGTAGGCGGATCTA	NM_001011587.1

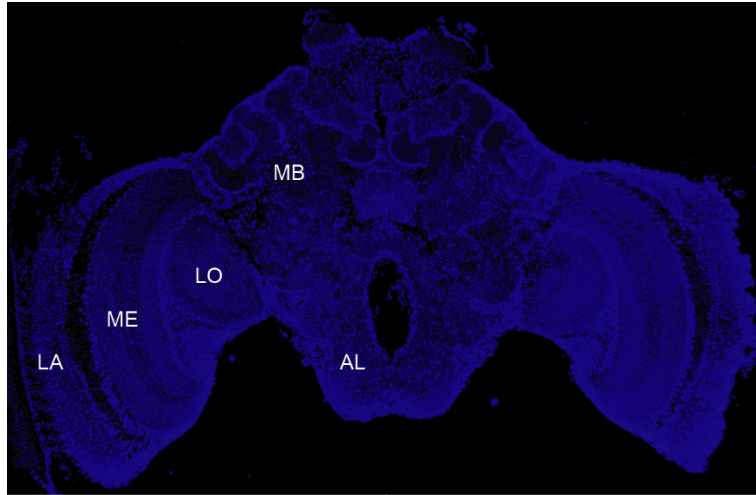


Fig. S1 The anatomical diagram of the honeybee brain. MB, mushroom body; AL, antennal lobe; LO, lobula; ME, medulla; LA, lamina.

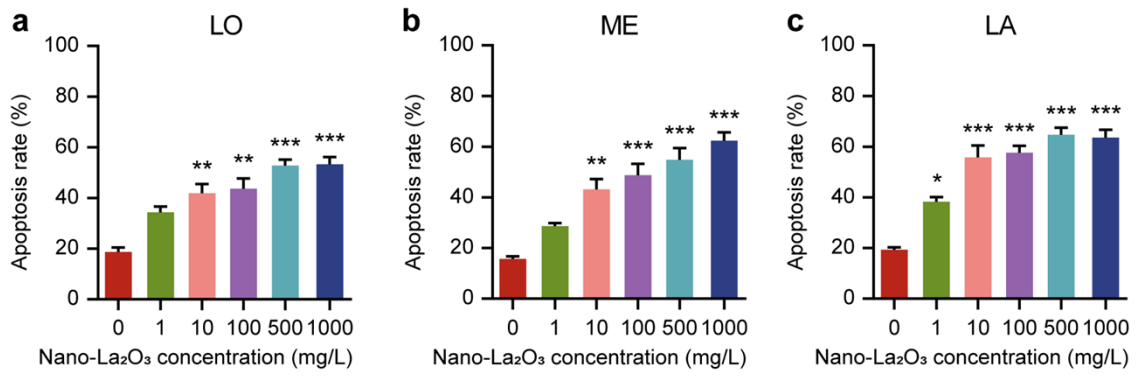


Fig. S2 Nano-La₂O₃ treatment increased apoptosis in honeybee optic lobe neurons. The apoptosis rate of optic lobes (OLs), including (A) lobula (LO), (B) medulla (ME), and (C) lamina (LA), in honeybees treated with different concentrations of nano-La₂O₃. Data were from five honeybee brains and presented as mean ± standard error of the mean (sem). Statistical analysis was performed by one-way ANOVA with Dunnett's multiple comparisons (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).