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REPORT **報告**

UNDER THE AGREEMENT ON SCIENTIFIC COOPERATION WITH AIRES HUMAN GENOME RESEARCH FOUNDATION

基於與 AIRES 人類基因組研究基金會之科學合作協議

Subject: Study of high-frequency electromagnetic radiation impact and Aires resonators influence on behavior, genetic and epigenetic processes in cells of CNS and peripheral organs (models of rat Rattus norvegicus and honey bee Apis mellifera L.)

主題：高頻電磁輻射影響及 Aires 共振器對中樞神經系統與周邊器官細胞之行為、遺傳與表觀遺傳過程之研究（以褐家鼠 Rattus norvegicus 與西方蜜蜂 Apis mellifera L. 為模型）

FIFTH STAGE: Study of effect non-ionizing electromagnetic radiations and Aires Defender Pro resonators have on cognitive habits of rat strains with different excitability of nervous system.

第五階段：研究非電離電磁輻射與 Aires Defender Pro 共振器對神經系統興奮性不同之鼠系認知習性的影響

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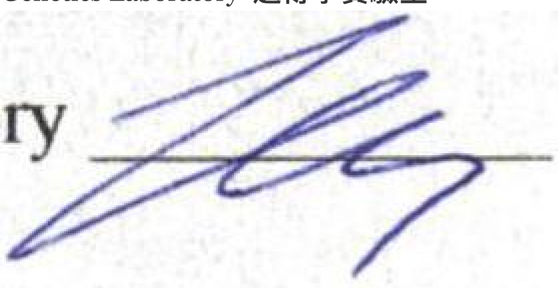

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Saint Petersburg, 2019 **聖彼得堡，2019**

REPORT **報告**

UNDER THE AGREEMENT ON SCIENTIFIC COOPERATION BETWEEN FSBIS PAVLOV INSTITUTE OF PHYSIOLOGY OF RAS AND AIRES HUMAN GENOME RESEARCH FOUNDATION "Study of high-frequency electromagnetic radiation impact and Aires resonators influence on behavior, genetic and epigenetic processes in cells of central and peripheral organs (models o Rattus norvegicus rat and Apis mellifera L. honey bee)".

根據俄羅斯科學院巴甫洛夫生理研究所（FSBIS PAVLOV INSTITUTE OF PHYSIOLOGY OF RAS）與 AIRES HUMAN GENOME RESEARCH FOUNDATION 關於科學合作的協議：「高頻電磁輻射及 Aires 共振器對中央與周邊器官細胞之行為、遺傳與表觀遺傳過程影響之研究（以糙家鼠 Rattus norvegicus 與蜜蜂 Apis mellifera L. 為模型）」。

STAGE FIVE (October 2018 - May 2019): Study of effect non-ionizing electromagnetic radiations and Aires Defender Pro resonators have on cognitive habits of rat lines with different excitation of nervous system.

第五階段（2018 年 10 月－2019 年 5 月）：研究非電離電磁輻射與 Aires Defender Pro 共振器對不同神經系統興奮性大鼠品系認知行為的影響。

Continuous improvement of communication systems and development of information technologies result in an increased intensity of the effect anthropogenic electromagnetic radiation sources (EMS) have on biological objects. Technology-caused electromagnetic fields are more intensive and have higher radiation frequencies. Both a decreased depth of penetration and increased energy influencing factor thereof characterize the impact they have on human beings. Insufficient data on this EMR effect on animals and humans makes studies of possible mechanisms of microbiological effect (MBE) forming, evaluation of aftereffect thereof on humans, and development of possible methods and means of electromagnetic protection, especially important (Lai, 2005).

通讯系統的不斷改進與資訊科技的發展，導致人工電磁輻射源（EMS）對生物體的影響強度增加。由技術產生的電磁場更為強烈且具有較高的輻射頻率。其作用於人體的特徵包括穿透深度降低與能量影響因子增加。關於此類電磁輻射對動物與人類影響的資料不足，使得研究微生物學效應（MBE）形成的可能機制、評估其對人體的後續影響，以及開發可能的電磁防護方法與手段，變得格外重要（Lai, 2005）。

The systems, protecting from this type of radiation, are different way developed, e.g., by decreasing intensity and changing different parameters of EMR sources. Aires Foundation has developed resonators that influence the living systems responses to non-ionizing EMR and have a protective effect (Zhabrev at al., 2005; Jasitis et al., 2018).

針對此類輻射的防護系統以不同方式開發，例如透過降低強度或改變電磁輻射源的各種參數。Aires Foundation 已開發出能影響生物系統對非電離電磁輻射反應並具有保護效果的共振器（Zhabrev et al., 2005；Jasitis et al., 2018）。

The mechanisms of the effect the nervous system functional state has on congenital elements of behaviour repertoire and cognitive body abilities, when exposed to EMR, and also on the efficient operation of devices meant for body protection from harmful effect thereof, have not been exploited to any great extent.

神經系統功能狀態在電磁輻射（EMR）下對先天行為譜要素與認知身體能力的影響機制，以及對旨在保護身體免受該等有害影響之裝置有效運作的影響，尚未被充分探討。

As shown earlier, the character of orientative-trying reaction of animals ("open field" test) to reduced external electric and magnetic fields, to router EMR depends on inherited produced excitation of the nervous system and centers around different components of behaviour. At that, the effect of Aires Defender Pro resonators was tested on the line of rats with low excitability threshold (LET) only and resulted in the animals changed behaviour, increased activity thereof when placed in a new environment. Specific behaviour components of the animals' response to the effect of resonators were also revealed, showing their selective positive impact on separate elements of behaviour.

如前所述，動物對降低的外部電場和磁場、以及路由器電磁輻射的定向—嘗試反應（"開放場"測試）的性質，取決於遺傳決定的神經系統興奮性，並集中於不同行為成分。於此，Aires Defender Pro 共振器的效果僅在低興奮閾值（LET）系系大鼠上進行測試，結果顯示當置於新環境時，動物行為改變、活動性增加。還揭示了動物對共振器作用的特定行為成分，顯示其對個別行為要素具有選擇性的正面影響。

Aires Defender Pro resonators effect under the same conditions using the line of rats with high excitability threshold (HET) was evaluated herein.

本文評估了在相同條件下，使用高興奮閾值（HET）系大鼠時，Aires Defender Pro 共振器的效應。

As shown earlier, animals exposure in a Faraday cage without any additional influences and combined with the router effect, resulted in problems to memorize the conditioned passive avoidance reflex in Vistar male rats. The resonators partially prevented a negative influence on the rats exposed in a Faraday cage in 24 hours after training. This protective effect reduced in 7 days.

如前所述，在法拉第籠內暴露動物而不施加任何額外影響，並結合路由器效應，導致 Vistar 雄性大鼠在條件性被動閃避反射的記憶上出現問題。共振器在訓練後 24 小時內部分預防了對置於法拉第籠中的大鼠的負面影響。這種保護效果在 7 天內減弱。

It is important to evaluate the influence of the researched effects on changes in the training and memory processes, using the same behaviour test in rats with contrasting excitability of the nervous system.

評估所研究效應對訓練與記憶過程改變的影響十分重要，應使用在神經系統興奮性上具有對比性的不同大鼠，採用相同的行為測試。

The goal and objectives of stage five:

第五階段的目標與任務：

study of Aires Defender Pro resonators effect when exposed to standard WiFi router EMR with a reduced external magnetic field and without any additional restrictions regarding behaviour of low threshold excitability male rats in the open field test (final fragment of stage 4) (section 1 hereafter)

在對標準 WiFi 路由器電磁輻射進行暴露且外部磁場降低的情況下，研究 Aires Defender Pro 共振器的效應，並在不對低閾值興奮性雄性大鼠的行為施加任何額外限制的前提下，於開放場測試中評估（第 4 階段的最終片段）（以下稱為第 1 節）

study of WiFi router and Aires Defender Pro resonators electromagnetic radiation effect on memorising the conditioned passive avoidance reflex (CPAR) in Vistar male rats and in rat lines with contrasting excitability of the nervous system (HET and LET) (section 2 hereafter).

研究 WiFi 路由器與 Aires Defender Pro 共振器之電磁輻射對維斯塔雄性大鼠及神經系統興奮性截然不同之大鼠系（高興奮性 HET 與低興奮性 LET）在條件性被動迴避反射（CPAR）記憶上的影響（以下稱第 2 節）。

MATERIALS AND METHODS **材料與方法**

5 month old male rats of the standard line Vistar and HET and LET lines selected in the Higher Nervous Activity Genetics Laboratory (Vaydo, 2000, Vaydo et al., 2018) and included in the biocollection of FSBIS Pavlov Institute of Physiology (No ГЗ 0134-2018-0003) were studied. 6-8 male rat groups were kept in standard cages on a standard diet.

研究對象為 5 個月大的雄性大鼠，包含標準品系 Wistar 以及在高等神經活動遺傳實驗室篩選出的 HET 與 LET 品系（Vaydo, 2000；Vaydo et al., 2018），並列入 FSBIS Pavlov 生理研究所的生物樣本庫（編號 ГЗ 0134-2018-0003）。每組 6–8 隻雄性大鼠置於標準籠中，餵以標準飼料。

Section 1. **第 1 節.**

In order to create a decayed external magnetic field (DMF hereafter), use was made of a shielded chamber made from a non-magnetic material (cardboard) coated with several layers of amphorous soft magnetic material AMAG-172, thereby the Earth's magnetic field's induction was 40 -fold reduced inside the chamber (from 48 mcTl to 1.2 mcTl) (Kuznetsov et al., 2006). A simulation chamber (without magnetic field decay, NDMF hereafter) was made from cardboard, had no shielding coating and was covered with black polyethylene. Both chambers were cylinder shaped 60 cm in diameter and 140 cm long, open from one end and plugged from the other so that a cage with rats easily fitted therein.

為了製造衰減的外部磁場（以下稱 DMF），使用了一個由非磁性材料（紙板）製成的屏蔽腔，外層塗覆了多層非晶軟磁性材料 AMAG-172，因此腔內的地磁感應強度被降低了 40 倍（從 48 mcTl 降至 1.2 mcTl）（Kuznetsov et al., 2006）。一個模擬腔（無磁場衰減，以下稱 NDMF）則由紙板製成，無任何屏蔽塗層，並覆蓋黑色聚乙烯。兩個腔體均為圓柱形，直徑 60 cm、長 140 cm，一端開放、另一端封閉，以便可輕易放入裝有大鼠的籠子。

Use was made of a WiFi router (LinkSys E1200-EE/RU wireless router) with the following technical parameters: carrier frequency of wireless communication: 2.4 Hz , number and type of antennas: 2 internal antennas, standard antenna(s) gain ratio, dBi : 4dBi.

使用了一台 WiFi 路由器（LinkSys E1200-EE/RU 無線路由器），其技術參數如下：無線通訊載波頻率：2.4 Hz，天線數量與類型：2 支內建天線，標準天線增益比率， dBi : 4dBi **。**

Aires Defender Pro resonators were used in the experiments (Zhabrev et al., 2005; Jasaitis at al., 2018). Like previously, 6 resonators were used to evaluate the effect thereof when exposing rats to router EMR. The resonators were placed on top of the cage with animals (Experiment 1) or in the center point of each edge of the Faraday cage (Experiment 2).

實驗中使用了 Aires Defender Pro 共振器（Zhabrev et al., 2005；Jasaitis et al., 2018）。如先前一樣，使用六個共振器來評估在向大鼠暴露路由器電磁輻射時其效果。共振器放置在動物籠子頂部（實驗一）或法拉第籠每一面邊中央點（實驗二）。

In order to study the effect of resonators exposed to router EMR under the decayed external magnetic field (DMF) or without any additional restricting effects (NDMG), “a home” cage with animals was inserted in the shielding chamber with the router located on a tray in the central point on top of the cage upper cover jointly with resonators (group DMF+router+resonators). The experimental groups were exposed for 12 hours (10:00 p.m. 10:00 a.m.). Control groups were the groups of rats placed in the simulation chamber for the same period with the router and resonators (group NDMF+ router+ resonators).

為了研究在衰減外部磁場（DMF）下或在沒有任何額外限制效應（NDMG）情況下，暴露於無線路由器電磁輻射（EMR）的諧振器之效應，「一個家」樣式的籠子連同動物被置入屏蔽室內，路由器與諧振器共同放置在籠子上蓋中央位置的托盤上（DMF+router+resonators 組）。實驗組接受為期 12 小時的暴露（22:00 至次日 10:00）。對照組則是將大鼠放置在模擬室同一時段，且同樣放有路由器與諧振器（NDMF+router+resonators 組）。

The animals behaviour in the “open field” test were evaluated in an hour after the animals exposition in the chambers was over.

动物在开放場域試驗中的行為評估是在牠們離開試驗箱後一小時內進行的。

The intact control groups of animals (Control 1 hereafter) were those in the vivarium and not exposed to radiation.

未受干擾的對照組動物（以下稱為控制組 1）為飼育室內且未暴露於輻射的動物。

The used “open field” test was a circular apparatus 160 cm in diameter walled to a height of 35 cm . The circle bottom was divided into squares 20 cm in a side. 500 W lamp was fixed over the circle center at a height of 60 cm , which mirror reflector provided bottom level illumination of 2000 lux in the center and 1500 lux at the borders. The apparatus was placed in a darkened room. In testing, a rat’s behaviour was observed for 5 minutes after the animal’s placement in the central square. After testing, each animal was wiped with $35-40\%$ alcohol solution and then with dry gauze pads. The following behaviour parameters were recorded:

所使用的「開放場」測試裝置為一個直徑 160 公分、高邊牆 35 公分的圓形設備。圓底被劃分為邊長 20 公分的方格。中央上方 60 公分處固定了一盞 500 瓦的燈，配有反光鏡，能在中心提供 2000 勒克斯、邊緣提供 1500 勒克斯的底部照明。該設備置於昏暗的房間中。測試時，將大鼠放置於中央方格後，觀察其行為 5 分鐘。測試結束後，先以 $35-40\%$ **酒精溶液擦拭動物，然後以乾紗布擦拭。記錄以下行為參數：**

Latent periods from the first movement ©

從第一次動作起的潛伏期 ©

Horizontal locomotion (number of crossed squares)

水平行走距離（穿越方格數）

Vertical locomotion (getting on hind legs, a number of rearing responses)

垂直運動（直立支撐、立起回應次數）

Emotionality - number of defecatory boluses.

情緒性——排便顆粒數量。

Grooming (number of acts)

梳理（行為次數）

Freezing (number of acts)

僵直（次數）

Turns left (number of acts)

向左轉（次數）

Turns right (number of acts)

向右轉（次數）

Spinning (number of acts)

旋轉（次數）

The “open field” apparatus is used to assay rodents’ orientative-trying reaction and emotional behaviour when moved to a new environment; it enables complex evaluation of natural controlled behaviour and changes thereof when exposed to various effects (Amiksheeva et al., 2003): to measure the level of emotionality and locomotion activity (horizontal - number

「開放場」裝置用於檢測囓齒動物在被移置到新環境時的定向—嘗試反應及情緒行為；它可對自然受控行為及在暴露於各種影響下的變化進行複雜評估（**Amiksheeva et al., 2003**）：用以測量情緒性與運動活動水平（水平—次數

of crossed squares, and vertical - rearing respoinses, showing orientative-trying activity), as well as anxiodepressive component intensity (activity in the central most open and illuminated field sector, number of turns and spins), level of fear by freezing reaction, stereotype behaviour (grooming) (Kaluev 1998, Buresh et al., 1991). See our Report 2018 for this method detailed description (Stage 4).

交叉方格的數量，以及直立反應（豎立反應，顯示定向-嘗試性活動），以及焦慮抑鬱成分強度（最中央開闊且明亮區域的活動、轉身與旋轉次數）、通過凝固反應評估的恐懼程度、刻板行為（梳理）**(Kaluev 1998, Buresh et al., 1991)**。有關此方法的詳細描述，見我們 **2018** 年的報告（**Stage 4**）。

Section 2. **第 2 節.**

WiFi router electromagnetic radiation effect (rats were exposed for 4 days, 6 hours a day, for total of 24 hours) on memorizing the conditioned passive avoidance reflex (CPAR) was reevaluated in the Vistar rats under the same conditions in the Faraday cage with Aires Defender Pro resonators.

在法拉第籠中，使用 **Aires Defender Pro** 諧振器在相同條件下，重新評估了 **WiFi** 路由器電磁輻射（大鼠暴露 **4** 天，每天 **6** 小時，共 **24** 小時）對維斯塔大鼠記憶條件性被動迴避反射（**CPAR**）的影響。

In order to study WiFi router electromagnetic radiation effect on memorizing the conditioned passive avoidance reflex (CPAR), a standard cage with HET and LET rats and Aires Defender Pro resonators in the Faraday cage was exposed to the router radiation for 24 hours. As before (Stages 1-3), the resonators were placed in the central point of each edge of the Faraday chamber. The each line intact animals (Control 1) and those in the Faraday cage not exposed to any additional effects (Control 2) were used as the control ones.

為了研究 **WiFi** 路由器電磁輻射對條件性被動迴避反射（**CPAR**）記憶的影響，一個放有高興奮性（**HET**）和低興奮性（**LET**）大鼠以及 **Aires Defender Pro** 諧振器的標準籠子在法拉第籠內暴露於路由器輻射 **24** 小時。如先前（階段 **1–3**）所示，諧振器置於法拉第室每一邊的中央點。各系原生動物（**Control 1**）以及置於法拉第籠但未暴露於任何額外效應的動物（**Control 2**）被用作對照。

One hour after learning CPAR, the rats of the relevant groups, apart from intact control 1, were placed in the given experimental conditions. Memory consolidation. i.e. the process of transferring new learning from short- to long-term memory storage, was tested through checking CPAR retaining soon after the animals exposure in the Faraday cages with the router, router and resonators, was over.

在学习 CPAR 一小時後，相關組別的大鼠（不包括完整對照組 1）被置於指定的實驗條件中。記憶鞏固，也就是將新的學習從短期記憶轉移到長期記憶儲存的過程，透過在動物於配有路由器、路由器與共振器的法拉第籠暴露結束後立即檢測其 CPAR 保留情形來測試。

The passive avoidance reflex was conditioned by delivering a single adverse stimulus and using a chamber divided into a lit compartment and a dark compartment, with a gate between the two. As known, normally rats spent most time in the dark compartment due to instinctual drive thereof for a dark and confined space, i.e. a hole (hole exploratory behaviour). This method is based on rats acquiring the conditioned passive avoidance of the dark compartment in response to an unconditioned stimulus in the form of an electric shock. A rat was placed in the center of the lit compartment facing away from the dark compartment and was given 2 minutes to explore the compartments, during which the rat was capable of finding a hole to the dark compartment and enter it. Being in the dark compartment, the rat was delivered 1 mA electric shock within 1 min. This was the final stage of the conditioning. If a rat failed to enter the dark compartment within 2 minutes, it was excluded from further experiments. Recorded was a per cent of rats that did not enter the dark compartment.

被动躲避反射通过施加單次有害刺激並使用一個分為明亮隔間與陰暗隔間且兩者之間有閘門的箱室來進行條件化。眾所周知，老鼠通常因為本能驅使偏好陰暗且封閉的空間（即鑽洞探索行為），而在陰暗隔間停留較久。此方法基於老鼠對以電擊為無條件刺激的反應，習得對陰暗隔間的條件性被動躲避。實驗中將老鼠置於面向背離陰暗隔間的明亮隔間中央，給予 2 分鐘讓其探索各隔間，期間老鼠得以尋找通往陰暗隔間的洞穴並進入。當老鼠進入陰暗隔間後，於 1 分鐘內施以 1 mA 電擊。此為條件化的最後階段。若老鼠在 2 分鐘內未能進入陰暗隔間，則被排除於後續實驗之外。記錄的是未進入陰暗隔間之老鼠的百分比。

Statistical processing **統計處理**

Average values and medians were calculated for the results tabulation purpose. The figures show medians. The statistical significance of differences between the groups was determined by Mann-Whitney test, ANOVA, as well as by the significance of differences between samples (Plokhinsky, 1970). Use was made of Statgraphics Centurion XV11 and Statistica 6.0 software.

為了編製結果表格，計算了平均值與中位數。圖表顯示的是中位數。組間差異的統計顯著性採用 Mann-Whitney 檢定、ANOVA，以及樣本間差異顯著性檢驗（Plokhinsky, 1970）。研究中使用了 Statgraphics Centurion XV11 與 Statistica 6.0 軟體。

RESULTS AND DISCUSSION **結果與討論**

Section 1. **第 1 節。**

During the last reported period (Stage 4) the open field test helped to study both the effect of the cylinder shaped chamber, shielding the external magnetic field, and the non-shielding simulation thereof, as well as the effect of a standard WiFi router EMR on the behaviour of HET and LET rats, however the effect of resonators was tested in the HET line only. This year the effect the resonators have on the rats exposed to WiFi router external magnetic field and without it was tested in highly excitable LET rats. For convenience of data comparison and discussion, total results obtained in LET rats are given below.

在上次報告的期間（第 4 階段），開放場測試用來研究圓柱形腔體（可屏蔽外磁場）及其非屏蔽模擬的效應，以及標準 WiFi 路由器電磁輻射對 HET 與 LET 大鼠行為的影響，但對共振器的效應僅在 HET 系列中進行過測試。今年則在高興奮性的 LET 大鼠中測試了共振器對暴露於 WiFi 路由器外磁場與未暴露情況下之大鼠的影響。為便於資料比較與討論，下文列出 LET 大鼠的總體結果。

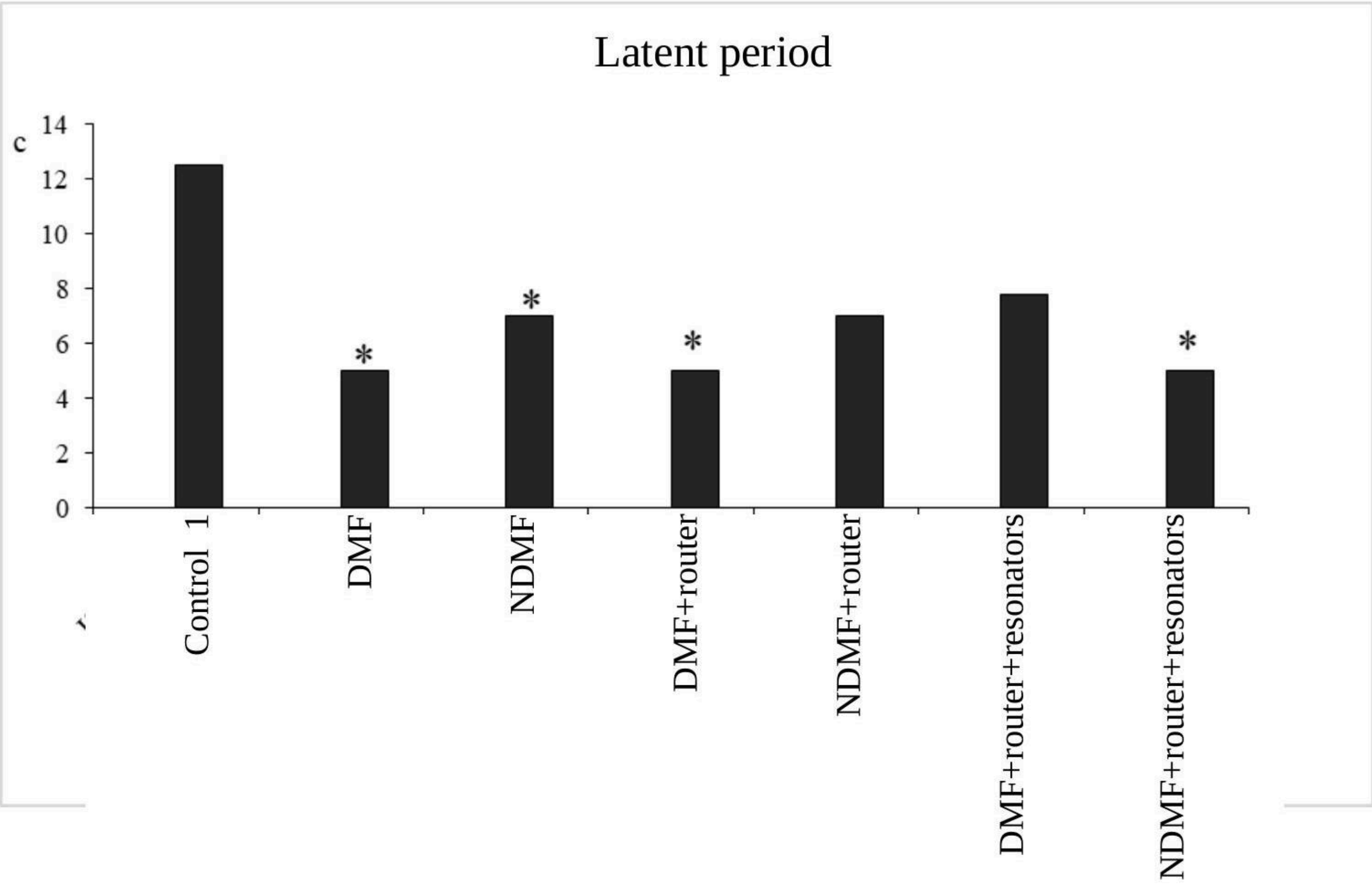

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Figure 1: Fig. 1. Latent period of the LET male rats first reaction in the open field test. Designations: * differences between LET line and Control 1 are significant ($\mathrm{P} < 0.05$), Control 1 - intact rats, DMF - decayed magnetic field (shielding chamber), NDMF - non-decayed magnetic field (simulation chamber).

圖 1：圖 1。LET 雄性大鼠在開放場試驗中第一次反應的潛伏期。標示：* 表示 LET 系列與 Control 1 之間的差異顯著（ $\mathrm{P} < 0.05$ ），Control 1 - 完整（未處理）大鼠，DMF - 衰減磁場（屏蔽室），NDMF - 未衰減磁場（模擬室）。

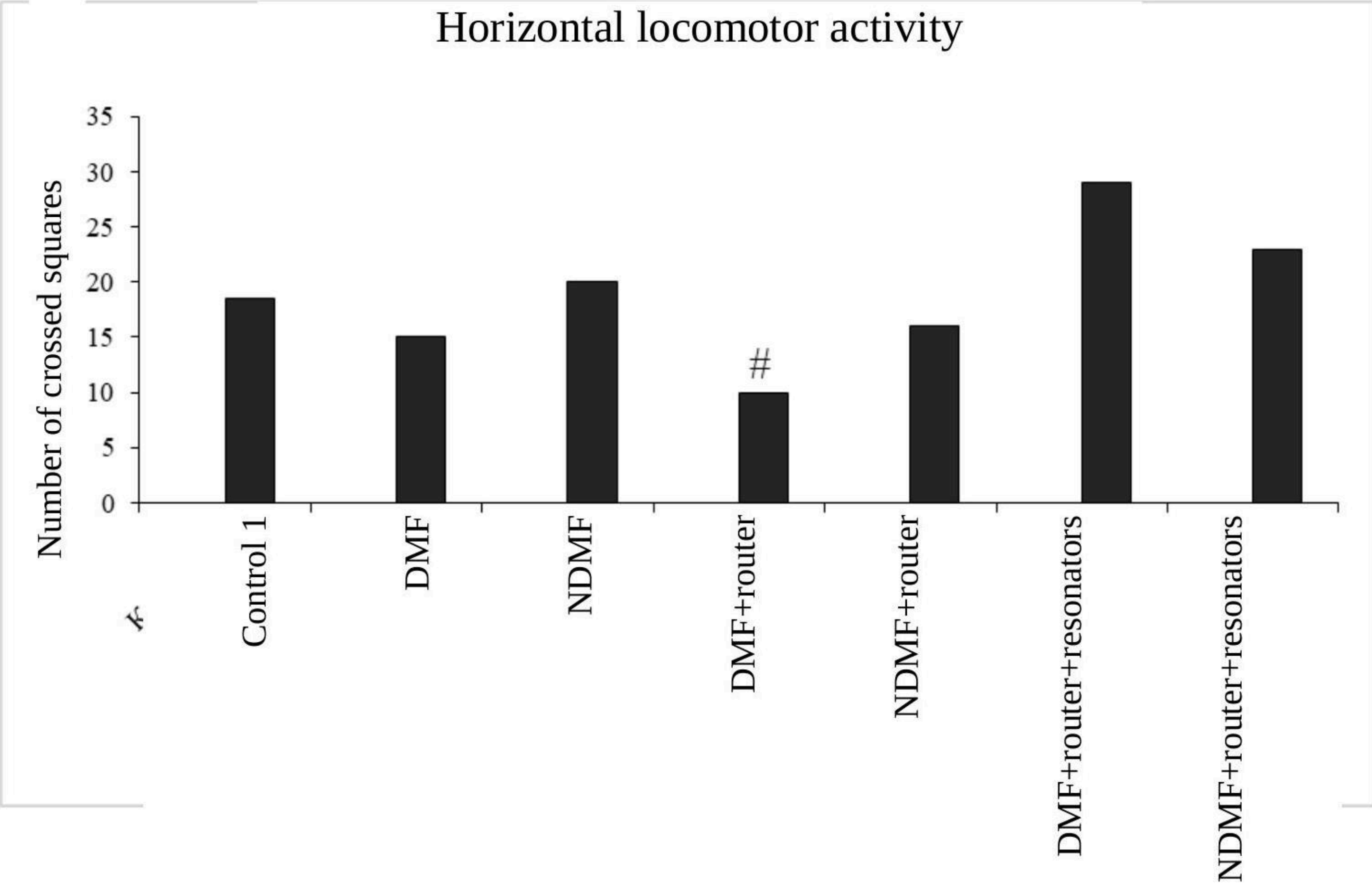

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Figure 2: Fig.2. LET male rats horizontal locomotor activity (number of crossed squares) in the open field test. Designations: # - differences from other LET line groups are significant ($P < 0.05$), other designations are similar to those in Fig. 1.

圖 2：圖 2。LET 雄性大鼠在開放場試驗中的水平運動活動（穿越格子數）。標示：# - 與其他 LET 系列組別相比差異顯著（ $P < 0.05$ ），其他標示與圖 1 相同。

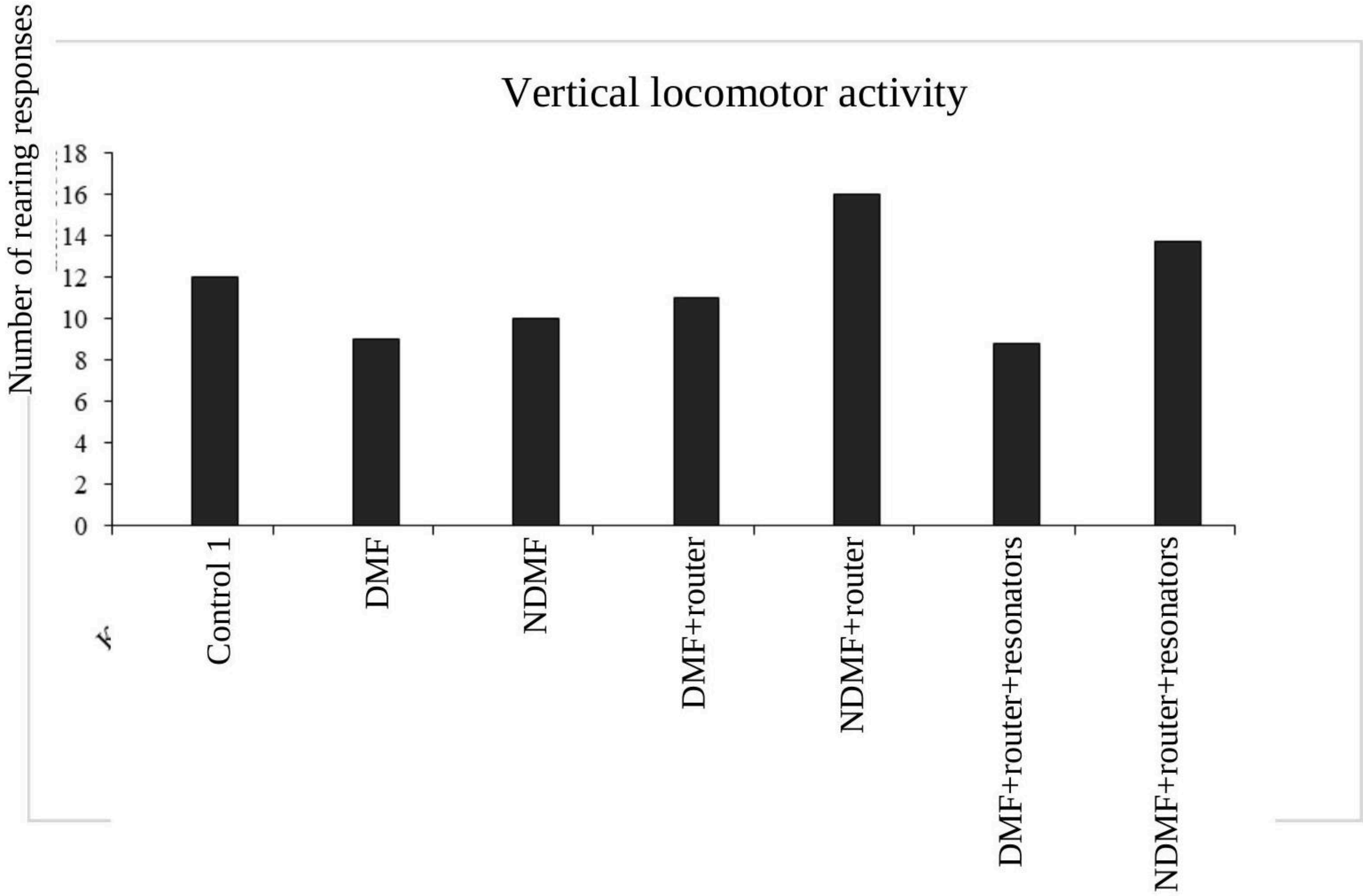

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Figure 3: Fig.3. LET male rats vertical locomotor activity (number of rearing responses) in the open field test. Designations are similar to those in Fig. 1.

圖 3：圖 3。LET 雄性大鼠在開放場試驗中的垂直運動活動（豎立反應次數）。標示與圖 1 相同。

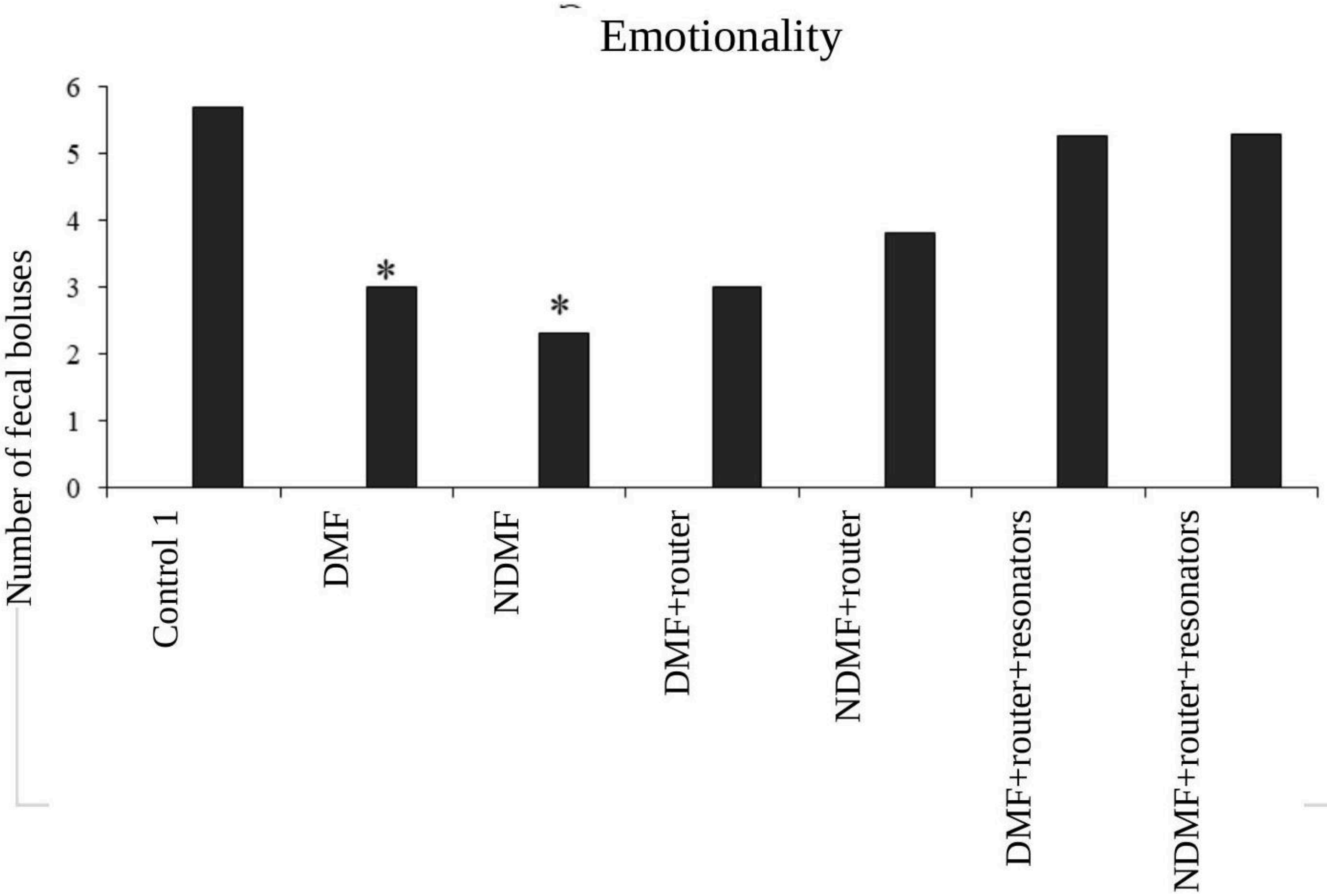

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Figure 4: Fig.4. LET male rats emotionality (number of fecal boluses) in the open field test.

圖 4：圖 4。LET 雄性大鼠在開放場試驗中的情緒性（糞球數）。

Designations: * - differences from Control 1 and DMF+router+resonators and NDMF+router+resonators of the LET line are significant ($P < 0.05$), other designations are similar to those in Fig. 1.

符號說明：* - LET 系列中與 Control 1 以及 DMF+router+resonators 與 NDMF+router+resonators 之差異具有顯著性（ $P < 0.05$ ），其他符號說明與圖 1 相同。

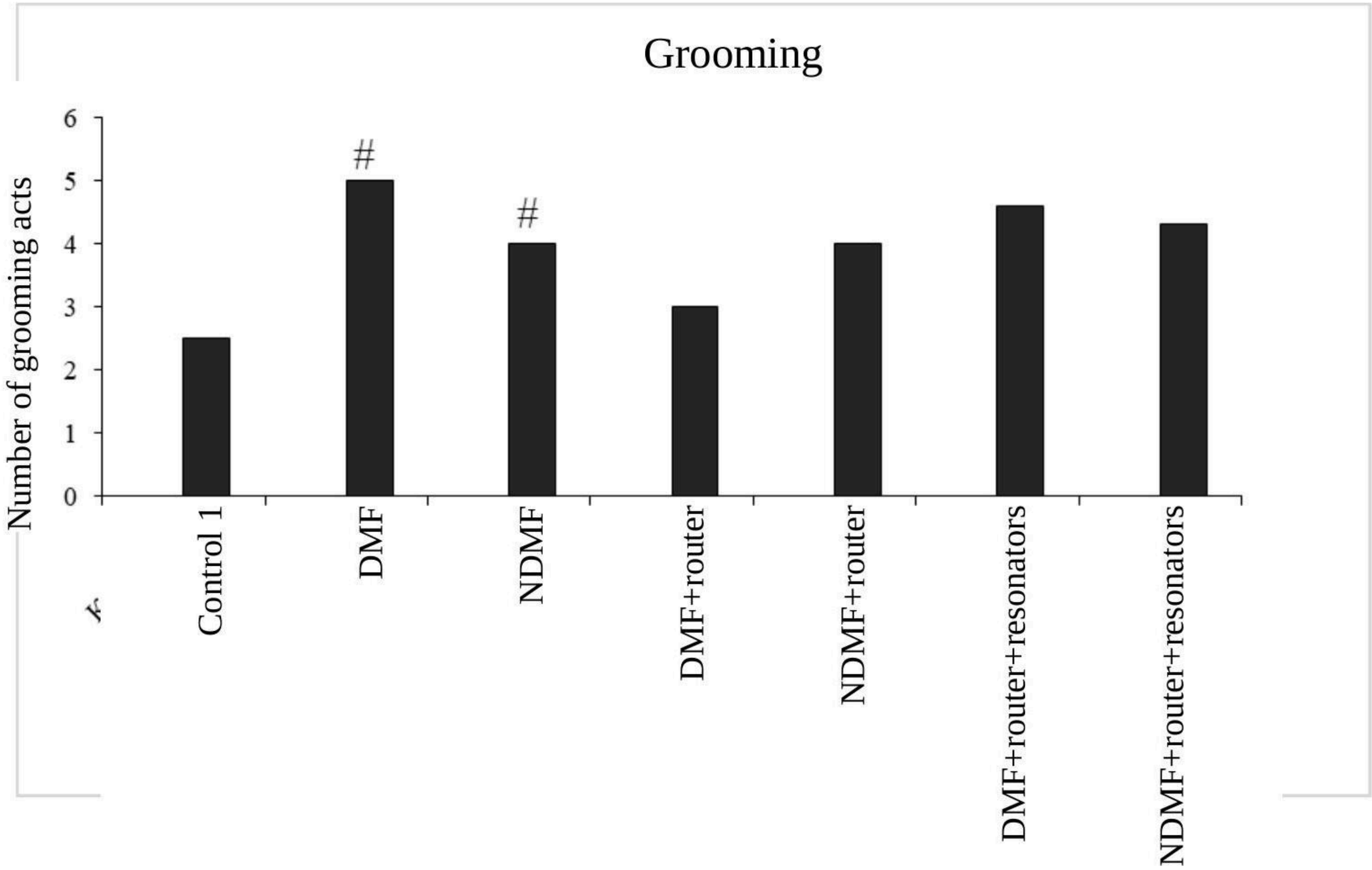

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Figure 5: Fig.5. LET male rats grooming acts in the open field test.

圖 5：Fig.5. LET 雄性大鼠在開放場測試中的梳理（grooming）行為。

Designations: # - differences of LET line from Control 1 are significant ($\mathrm{P} < 0.05$), other designations are similar to those in Fig. 1.

符號說明：# - LET 系列與 Control 1 之差異具有顯著性（ $\mathrm{P} < 0.05$ ），其他符號說明與圖 1 相同。

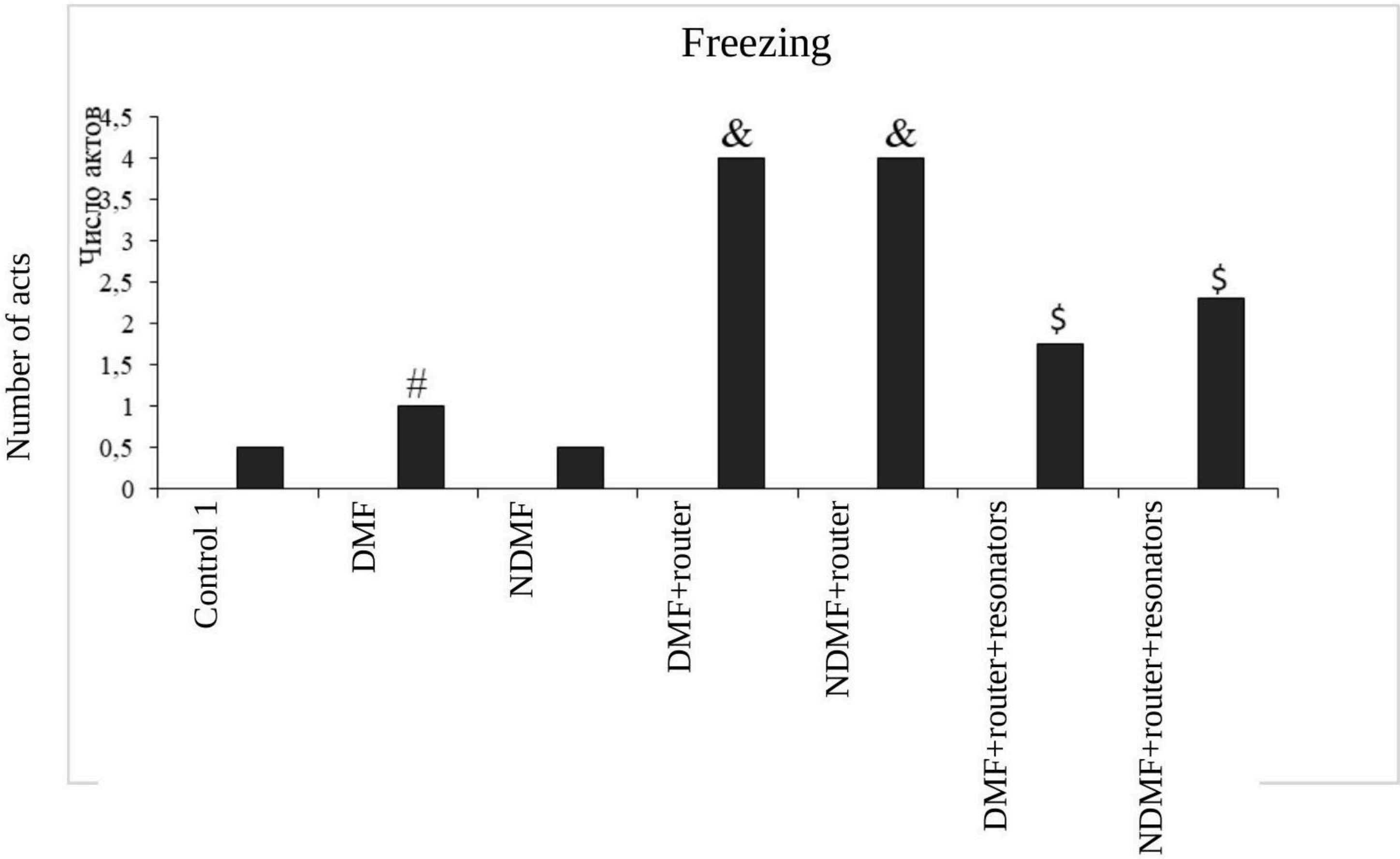

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Figure 6: Fig.6. LET and HET male rats freezing acts in the open field test.

圖 6：Fig.6. LET 與 HET 雄性大鼠在開放場測試中的僵直（freezing）行為。

Designations: # - differences from LET rats of NDMF group are significant ($P<0.05$), & differences from LET rats of DMF and NDMF groups are significant ($P<0.05$); \$ - difference from LET rats of the relevant DMF+router and NDMG+router are significant ($P<0.05$). Other designations are similar to those in Fig. 1.

標示說明：# - 與 NDMF 組的 LET 大鼠之差異顯著（ $P<0.05$ ），& - 與 DMF 及 NDMF 組的 LET 大鼠之差異顯著（ $P<0.05$ ）； \$ - 與相關的 DMF+router 及 NDMG+router 組的 LET 大鼠之差異顯著（ $P<0.05$ ）。其他標示與圖 1 相同。

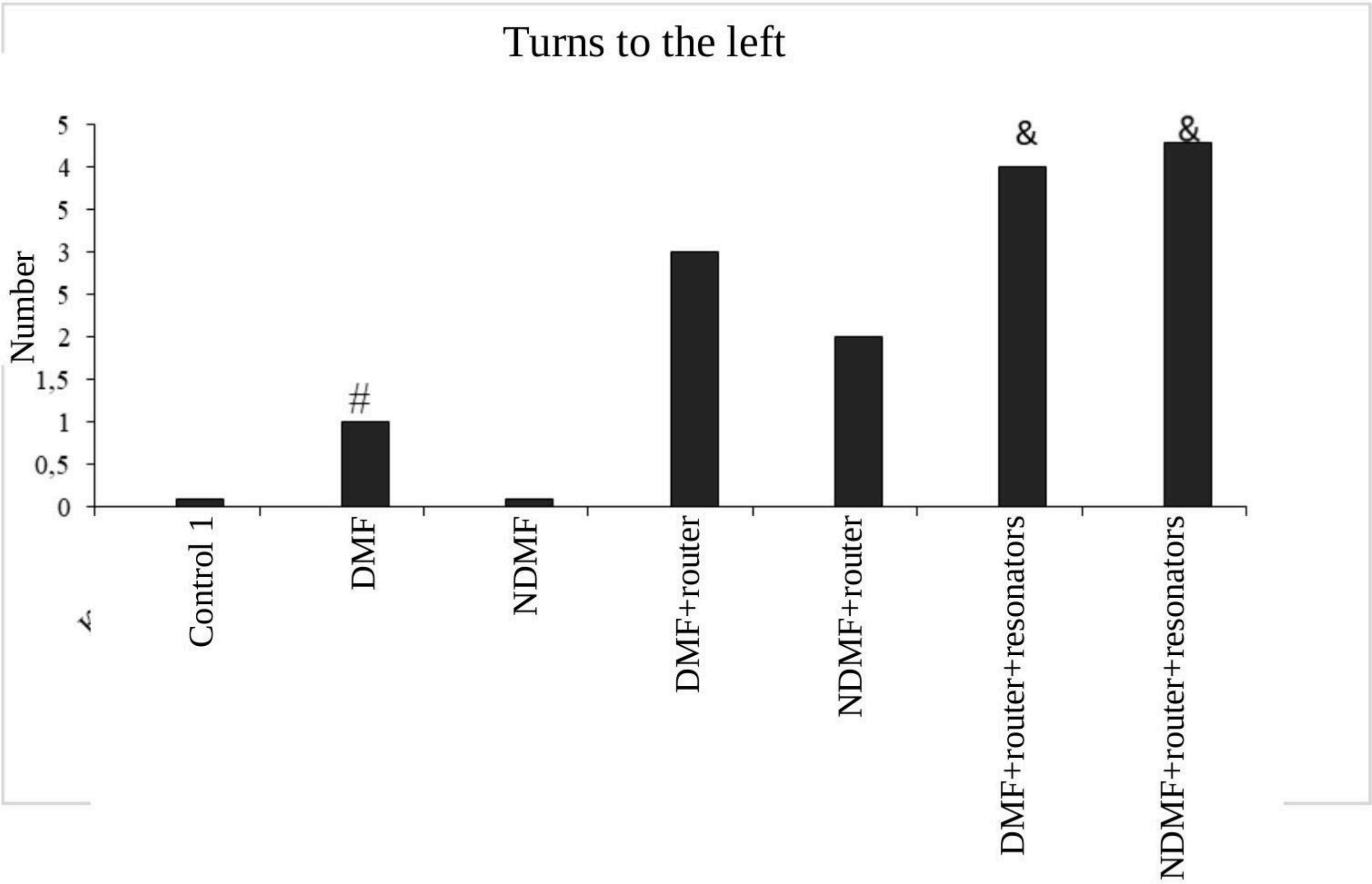

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Figure 7: Fig.7. LET male rats turns to the left in the open field test.

圖 7：Fig.7. LET 雄性大鼠在開放場試驗中向左轉的次數。

Designations: # - differences from NDMF group are significant ($P < 0.05$), & - differences from Control 1 and NDMF groups are significant ($P < 0.05$). Other designations are similar to those in Fig. 1.

標示說明：# - 與 NDMF 組之差異顯著（ $P < 0.05$ ），& - 與 Control 1 及 NDMF 組之差異顯著（ $P < 0.05$ ）。其他標示與圖 1 相同。

Figure 8: Turns to the right

圖 8：向右轉的次數

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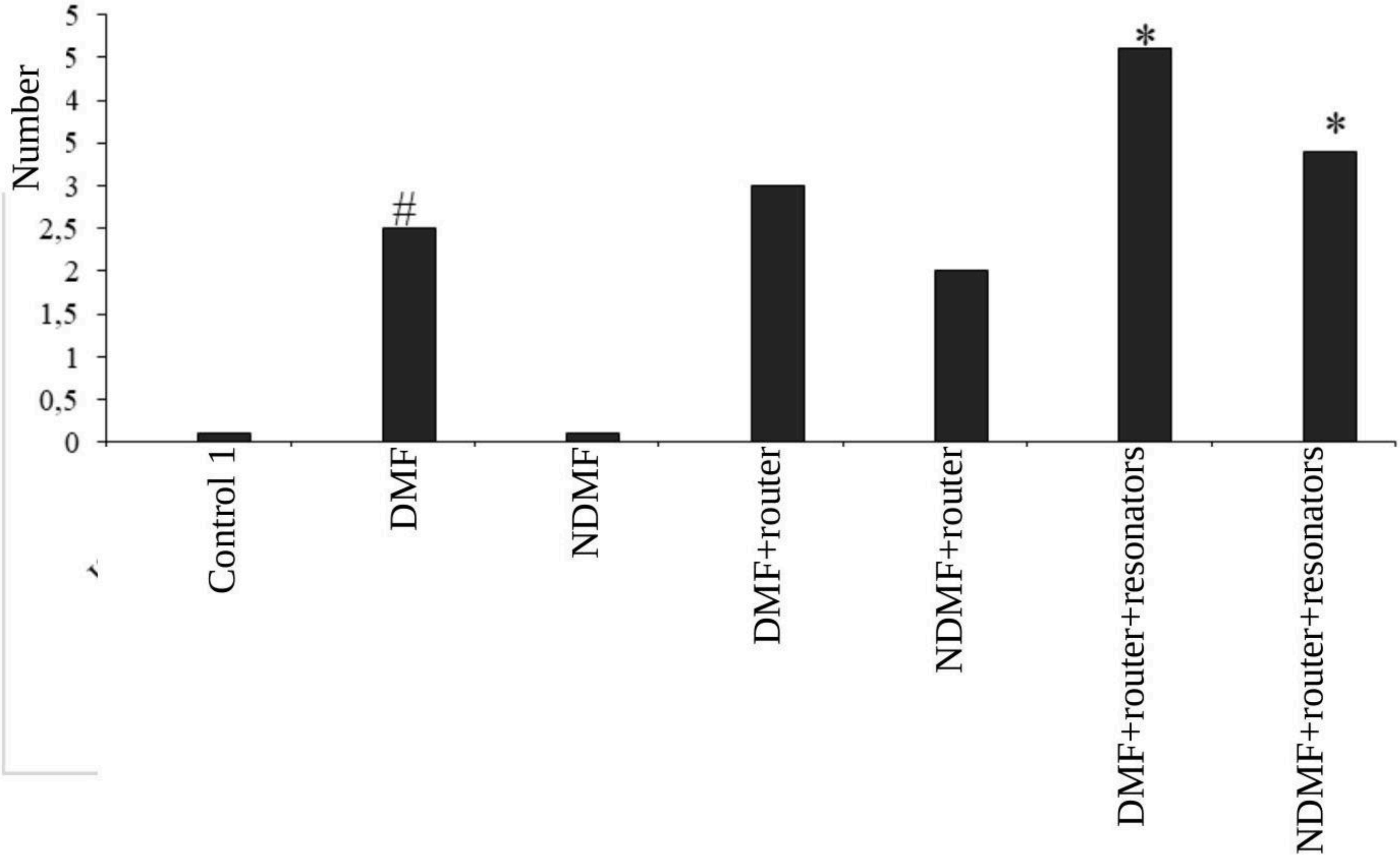

Fig.8. LET male rats turns to the right in the open field test.

圖 8. LET 雄性大鼠在開放場測試中向右轉。

Designations: * - differences from Control 1 and NDMF groups are significant ($\mathrm{P} < 0.05$), # differences from NDMF group are significant ($\mathrm{P} < 0.05$); Other designations are similar to those in Fig. 1.

標示：* - 與 Control 1 及 NDMF 組差異有顯著性 ($\mathrm{P} < 0.05$ **)，# 與 NDMF 組差異有顯著性 (** $\mathrm{P} < 0.05$ **)；其他標示與圖 1 相同。**

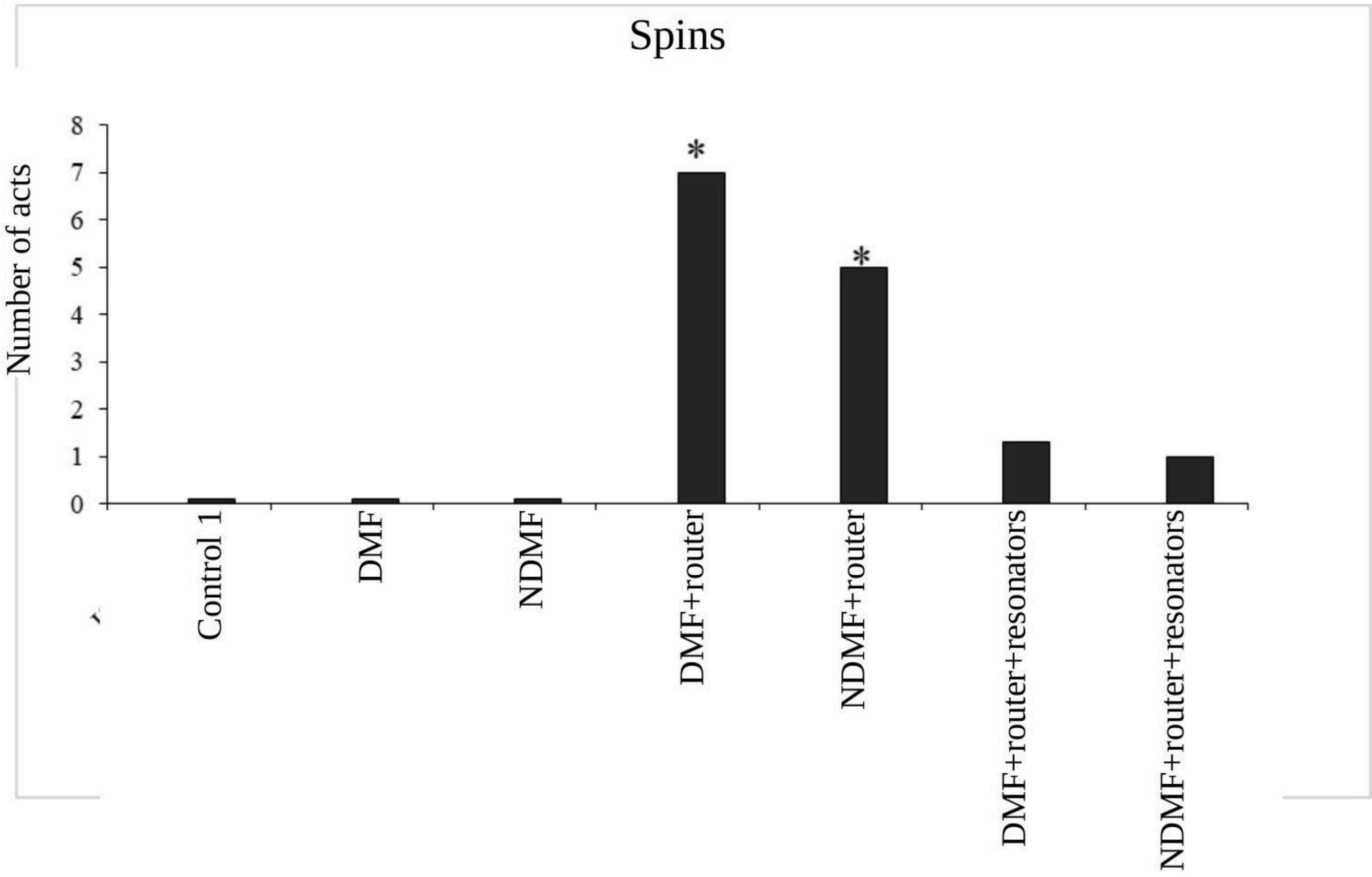

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Figure 9: Fig.9. LET male rats number of spins in the open field test.

圖 9：圖 9. LET 雄性大鼠在開放場測試中的旋轉次數。

Designations: * - differences from other groups are significant ($\mathrm{P} < 0.05$). Other designations are similar to those in Fig. 1.

標示：* - 與其他組差異有顯著性 ($\mathrm{P} < 0.05$)。其他標示與圖 1 相同。

Compared to the router adverse impact, the effect of resonators causes restoration of the following highly excitable LET line rats behaviour indicators: 1) horizontal locomotor activity (HLA): under the decayed magnetic field, the router causes HLA decrease, while the exposure to resonators restores HLA to the control levels (Fig.2); 2) freezing: independently on DMF existence or absence thereof, the router intensifies freezing responses, while the resonators decrease the number freezing acts and time thereof in both experimental groups (DMF and NDMF) (Fig.6); 3) spins: a number of spins is increased by the router exposure, while the resonators decrease it to the control level (Fig.9). However, it should be noted that the combined resonators-router effect independently on DMF existence or absence thereof, resulted in an increased number of rats spins (Figs. 7,8). It is hard to say why. No router and resonators caused changes in the first reaction latent period, vertical locomotor activity, emotionality, and grooming behaviour indicators were revealed (Figs. 1, 3, 4, 5).

與無线路由器的不良影響相比，諧振器的作用使下列高興奮性 LET 品系大鼠的行為指標恢復：1）水平運動活動（HLA）：在衰減磁場下，路由器使 HLA 下降，而暴露於諧振器則將 HLA 恢復到對照水平（圖 2）；2）凝滯（freezing）：不論是否存在衰減磁場，路由器都會強化凝滯反應，而諧振器則在兩個實驗組（DMF 與 NDMF）中減少凝滯次數及持續時間（圖 6）；3）旋轉（spins）：路由器暴露會增加旋轉次數，而諧振器將其降至對照水平（圖 9）。然而需注意的是，無論是否存在衰減磁場，諧振器與路由器的共同作用導致大鼠旋轉次數增加（圖 7、8）。至於原因則難以確定。未發現路由器或諧振器對首次反應潛伏期、垂直運動活動、情緒性及梳理行為指標造成變化（圖 1、3、4、5）。

The obtained results as a whole show a router caused possible growth of fear and anxiety in the highly excitable LET line rats and decrease thereof when the resonators are used as an additional factor of influence. It should be noted that the low excitable HET line rats exposed to EMR of the router and resonators demonstrated the suppressed fear reaction, but increased general locomotor and exploratory activity, which was considered as possible adaptive reactions of the animals under the new conditions (for more details see Report 2018, Stage 4).

整體所得結果顯示，路由器可能導致高度興奮型 LET 系列大鼠的恐懼與焦慮增加，而在使用共振器作為額外影響因子時則出現降低。值得注意的是，暴露於路由器與共振器電磁輻射的低興奮型 HET 系列大鼠，其恐懼反應受到抑制，但整體活動量與探索行為增加，這被視為動物在新環境下可能的適應性反應（更多細節見 2018 年報告，第 4 階段）。

Section 2. **第 2 節。**

The experiments in evaluating the router (4 days ×6 hours) and resonators effect on CPAR forming and retaining aimed at confirming the earlier obtained results were repeated using the Vistar rats.

為了驗證先前獲得的結果，使用 Wistar 大鼠重複進行評估路由器（4 天 ×6 小時）和共振器對條件被動避免反應（CPAR）形成與保持影響的實驗。

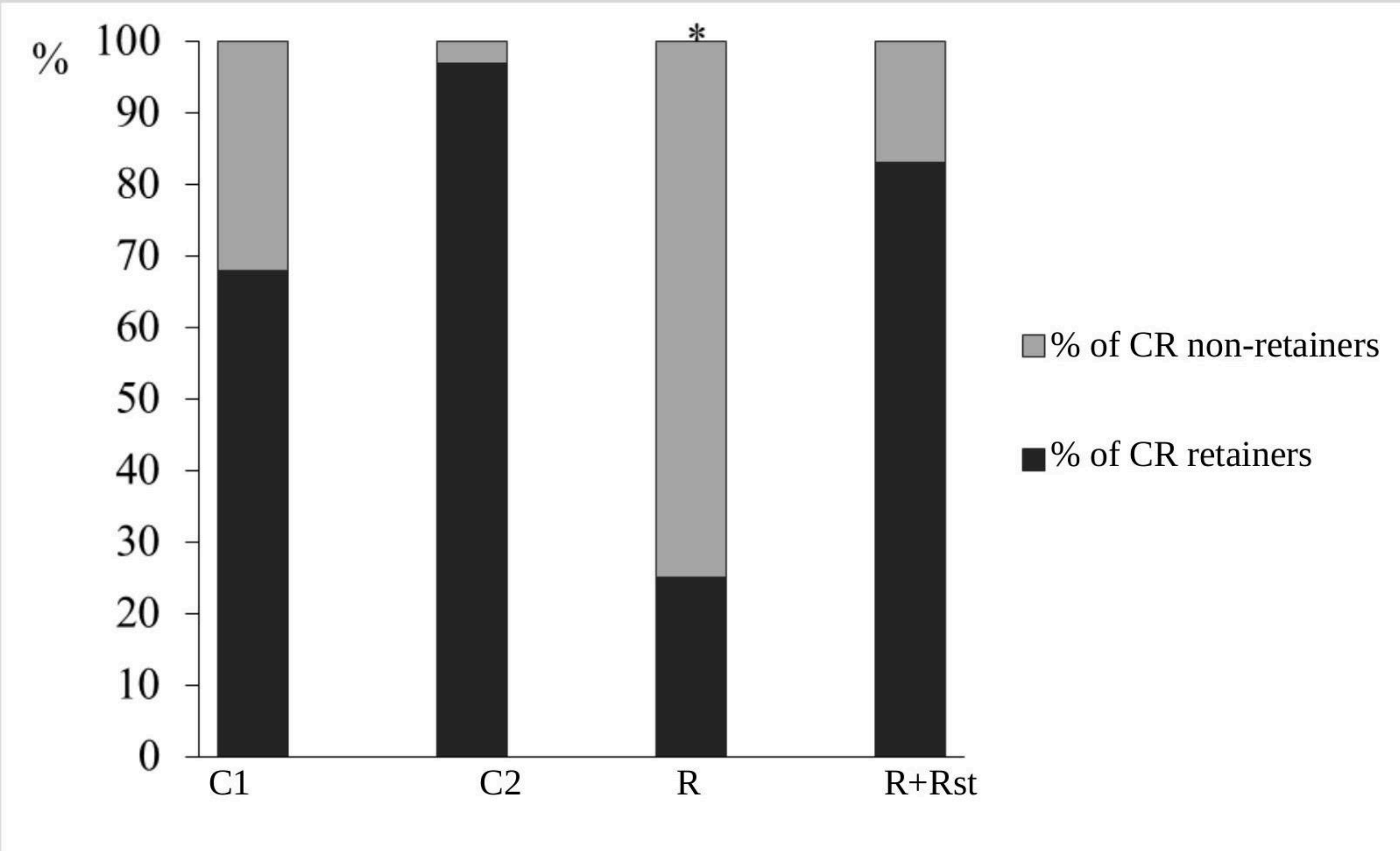

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Figure 10: Fig. 10. CPAR retaining after exposure to EMR UHF of the router and resonators in the Vistar rats. Designations: *- differences from all other groups are significant ($P < 0.05$). C 1 - intact control, C2 - Faraday cage, R- router, R+Rst - routers + resonators.

圖 10：圖 10. Wistar 大鼠在暴露於路由器與共振器超高頻電磁輻射後之 CPAR 保持情形。符號說明：*－與所有其他組別差異顯著（ $P < 0.05$ ）。C1－原始對照，C2－法拉第籠，R－路由器，R+Rst－路由器 + 共振器。

The effects demonstrated in Stage 3 Report were confirmed (Fig. 10). Router's EMR UHF caused 2-fold suppression of CPAR retaining in the Vistar rats compared to the intact control and 3 -fold suppression compared to the active control, i.e. the Faraday cage, while introducing the resonators into the experiments restored the conditioned reflex retaining to the control values.

第三階段報告中顯示的效應已被確認（圖 10）。與完整對照組相比，無線路由器的超高頻電磁輻射使 Vistar 大鼠的條件恐懼反射保持（CPAR retaining）降低了 2 倍，與主動對照組（即法拉第籠）相比則降低了 3 倍；而在實驗中引入共振器則將條件反射保持恢復到對照值。

No differences in retaining the reflex by HET line rats of Control 1, Control 2, router, router+resonators groups were determined (Fig.11). The exposure of the highly excitable LET line rats in the Faraday cage and without any additional effects, as well as exposed to the router significantly affected memory consolidation, resulting in a considerably worsened

CPAR retaining ability (Fig. 11). Appearance of more than 2 -fold interline differences in CPAR retaining efficiency when exposed to the router should be noted (Fig.11). It means that the highly excitable LET line rats are found to be more sensitive to EMR UHF. Use of the resonators had a positive effect on these rats CPAR retaining (Fig.11).

在 Control 1、Control 2、路由器、路由器+共振器四組的 HET 系大鼠中，未發現條件反射保持有差異（圖 11）。對高度興奮性的 LET 系大鼠而言，不論是在法拉第籠內、未施加額外處理，或暴露於路由器，都顯著影響了記憶鞏固，導致 CPAR 保持能力明顯下降（圖 11）。值得注意的是，暴露於路由器時出現了超過 2 倍的系間差異（圖 11），這意味著高度興奮的 LET 系大鼠對超高頻電磁輻射更為敏感。使用共振器對這些大鼠的 CPAR 保持具有正面效果（圖 11）。

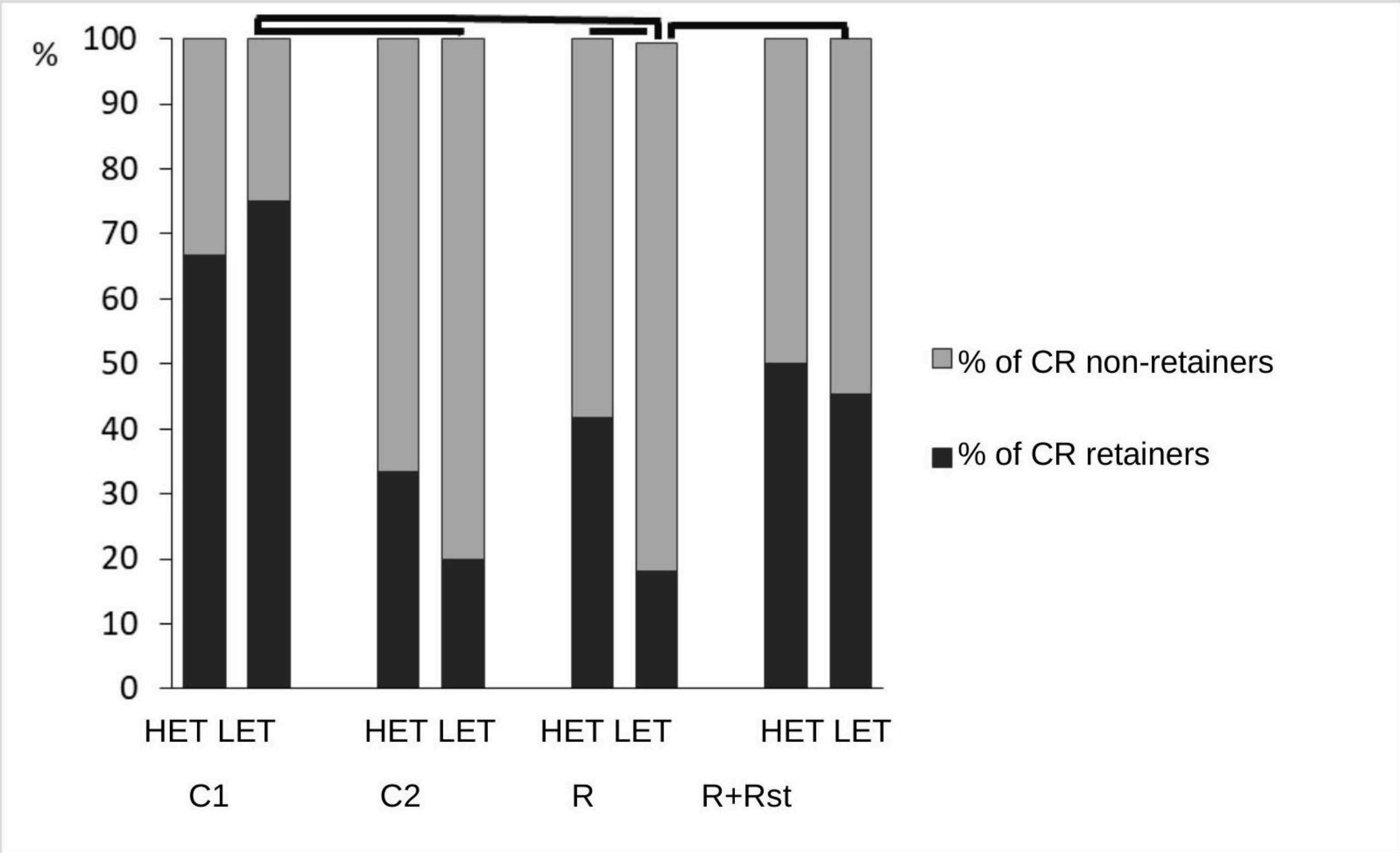

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Figure 11: Fig. 11. CPAR retaining after exposure of two lines of rats (LET, HET) within 24 hours in the

圖 11：圖 11. 两系大鼠（LET、HET）在暴露後 24 小時的 CPAR 保持

The obtained results made it possible to arrive at the conclusion that the disturbed memory consolidation in learning CPAR due to the decayed electric field in the Faraday cage and combined with the router EMR additional effect is apparent in rats with the inherited high excitability of the nervous system (LET line) and downplays once exposed to the resonators effect. The used experimental effects did not cause any statistically important changes in the ability to retain CPAR in rats with the low excitable nervous system (HET line) both between the animals and compared with the intact control group.

所得結果使我們得出結論：在法拉第籠內衰減的電場，結合路由器電磁輻射的附加影響，會造成学习 CPAR 的記憶固化受損，這一現象在具有遺傳性高神經系統興奮性（LET 系列）的大鼠中顯著，而在暴露於共振器效應後則有所減輕。所用的實驗處理並未在低興奮性神經系統（HET 系列）的大鼠中，無論在動物間或與未受處理的對照組比較，導致任何具有統計學意義的保持 CPAR 能力變化。

The effect of a variable but not static electric field ($35 \mathrm{kV/m}$) on the ability to learn and spatial memory is shown in mice (Di at al., 2019). The effect high frequency electromagnetic fields have on the adult male rats memory is demonstrated by the social discrimination tests (Schneider at al., 2014). It is shown that ultra-high frequency EMRs cause metabolic reprogramming of the cerebral mitochondria in the Vistar rats thereby increasing a speed of forming superoxide radicals and nitrogen oxide that may initiate development of neuregenerative diseases and cancer (Burlaka et al., 2016).

變動但非靜態電場 ($35 \mathrm{kV/m}$) 對學習能力與空間記憶的影響已在小鼠中顯示（Di et al., 2019）。高頻電磁場對成年雄性大鼠記憶的影響，則通過社會辨識測試得以證明（Schneider et al., 2014）。研究顯示，超高頻電磁輻射使 Wistar 大鼠大腦線粒體發生代謝重編程，從而加速超氧自由基與一氧化氮的形成，這可能啟動神經退化性疾病與癌症的發展（Burlaka et al., 2016）。

As was earlier revealed (Stage 2), the highly excitable LET rats' chromosomes are more vulnerable to the damaging effect of high frequency EMRs compared to the HET line. High

如同先前揭示（階段 2），高度興奮的 LET 大鼠其染色體較 HET 系譜更易受到高頻電磁輻射的損害。高度

excitability of the nervous system determines a greater apparency of mitotic disturbances reduction in presence of Aires Defender Pro resonators when exposed to standard WiFi router UHF radiator. In studying destabilisation of EMR UHF exposed bone marrow cells genome, it was demonstrated that the efficiency of the resonators' protective effect may depend on the animal nervous system functional state (Dyuzhikova et al., 2019).

神經系統的高興奮性決定了在受標準 WiFi 路由器超高頻發射器照射時，置入 Aires Defender Pro 諧振器會使有絲分裂擾動的減少更為明顯。在研究超高頻電磁輻射暴露下骨髓細胞基因組不穩定化時，證實了諧振器保護效應的效率可能依賴於動物神經系統的功能狀態（Dyuzhikova et al., 2019）。

The mechanisms of the effects EMR and magnetic fields have on the body are presently under active studies with concomitant multiple discussions, regarding possible ways of effect thereof on the body, displayed magnetobiological impacts and consequences thereof (Karthick et al., 2017; Pall, 2016; Terzi et al., 2016, etc). A group of American and Japanese researchers, using EEG method, has recently found a human ability to feel magnetic field changes (cerebral activity changes in the alpha-range with a magnetic field differently oriented relative to a tested person in the Faraday cage) (Wang et al., 2019), nevertheless, the mechanisms of magnetoreception in humans are not clear yet.

电磁輻射與磁場對機體影響的機制目前正受到積極研究，並伴隨大量討論，涉及其可能影響機體的途徑、所顯示的磁生物學效應及其後果（Karthick et al., 2017；Pall, 2016；Terzi et al., 2016 等）。一組美日研究者最近使用腦電圖（EEG）方法發現人類能夠感知磁場變化（在法拉第籠內對受試者採用不同方向的磁場時，腦部在α波段的活動會改變）（Wang et al., 2019）；然而，人類磁覺的機制仍不清楚。

The molecular concept (Bukachenko, 2014) based on the importance of a radical ion pair as a magnetic fields receiver and source of magnetic effects is most substantiated among the hypotheses under discussion. Non-paired electrons therein are the carriers of spin magnetism and interact with constant and variable magnetic fields. Involvement of these pairs in the enzymic synthesis of ATF (adenosine triphosphate), being the main energy carrier of live systems, and replicative synthesis of DNA with polymerases has been shown.

分子概念（Bukachenko，2014）主張自由基離子對作為磁場接收器和產生磁效應的來源，其重要性在討論中的各種假說中最為有力。這些離子對中的未配對電子是自旋磁性的載體，並與恆定及變動磁場相互作用。已有研究顯示，這些電子對參與了 ATP（腺苷三磷酸）——生物系統主要的能量載體——的酶促合成，以及在聚合酶作用下的 DNA 複製合成。

Overall, the findings of this paper confirm an adverse effect the external electric and magnetic fields and UHF range EMR have on the rats' behaviour and memory and demonstrate Aires Defender Pro resonators' positive effect on restoration of a number of disturbed elements of rats' innate behaviour and cognitive abilities when exposed to non-ionising electromagnetic radiations. They also show the necessity to consider typological features of the nervous system in developing the means of protection against an adverse effect of EMR and correction of magnetobiological effects produced by various radiation sources. This approach is important for understanding the causes of an individual's variable sensitivity to EMR and determining the ways of correcting pathogenic processes in humans on this basis, which is a necessary link of the evidence based medicine.

總體而言，本論文的結果確認外來電場與磁場以及超高頻（UHF）範圍電磁輻射對大鼠行為與記憶具有不良影響，並顯示 Aires Defender Pro 共振器在大鼠暴露於非游離電磁輻射時，對恢復若干受擾亂的本能行為要素與認知能力具有正面效果。研究亦顯示，在開發防護電磁輻射不良影響以及矯正由各種輻射源產生的磁生物效應的防護措施時，有必要考量神經系統的類型學特徵。此一方法對於理解個體對電磁輻射敏感性差異的成因，以及在此基礎上確定矯正人體致病過程的方法極為重要，而這也是循證醫學所需的一個關鍵環節。

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LIST OF PUBLICATIONS FOR THE REPORTED PERIOD:

報告期刊物清單：

N.V. Shirayeva, A.I. Vaydo, N.A. Dyuzhikova, B.F. Schegolev, S.V.Surma, I.N. Serov. Impact of high-frequency electromagnetic radiation and resonators on behavior of rats with different excitability of the nervous system.//In scientific papers of VIII International Congress “Weak and super weak fields and radiations in biology and medicine”, September 10-14, 2018. Saint Petersburg, V.8, p. 160-161 (poster-report and abstracts)

N.V. Shirayeva、A.I. Vaydo、N.A. Dyuzhikova、B.F. Schegolev、S.V. Surma、I.N. Serov。高頻電磁輻射及共振器對不同神經系統興奮性大鼠行為的影響。// 刊於第八屆國際大會「生物與醫學中的弱場與超弱場及輻射」學術論文，2018 年 9 月 10–14 日，聖彼得堡，卷 8，第 160–161 頁（海報報告及摘要）

N.V. Shirayeva, A.I. Vaydo, I.N. Serov. Impact of UHF electromagnetic radiation and resonators on the memory consolidation in learning the conditioned passive avoidance reflex by the rats lines with contrasting excitability of the nervous system// All Russian “Integrative Physiology” Conference with foreign participants devoted to the 170^{th} birth anniversary of I.P.Pavlov, September 24-26, 2019 (poster-report and abstracts)

N.V. Shirayeva、A.I. Vaydo、I.N. Serov。超高頻電磁輻射與共振器對具有對比性神經系統興奮性的大鼠系譜在學習條件性被動避免反射過程中記憶鞏固的影響。// 全俄「整合生理學」大會（含外國參會者），致敬 I.P. Pavlov 170^{th} **週年誕辰，2019 年 9 月 24–26 日（海報報告及摘要）**

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