



OPEN ACCESS

**Approved by:**

Frontiers Editorial Office,  
Frontiers Media SA, Switzerland

**\*Correspondence:**

Frontiers Production Office  
[production.office@frontiersin.org](mailto:production.office@frontiersin.org)

**Specialty section:**

This article was submitted to  
Experimental Pharmacology and Drug

Discovery,

a section of the journal  
Frontiers in Pharmacology

**Received:** 28 March 2019

**Accepted:** 03 April 2019

**Published:** 05 April 2019

**Citation:**

Frontiers Production Office (2019)  
Erratum: Cannabinoid Receptor 2  
Signalling Bias Elicited by  
2,4,6-Trisubstituted 1,3,5-Triazines.  
*Front. Pharmacol.* 10:418.  
doi: 10.3389/fphar.2019.00418

# Erratum: Cannabinoid Receptor 2 Signalling Bias Elicited by 2,4,6-Trisubstituted 1,3,5-Triazines

**Frontiers Production Office\***

Frontiers Media SA, Lausanne, Switzerland

**Keywords:** cannabinoid receptor 2 (CB<sub>2</sub>), G protein-coupled receptor, signalling bias, signalling, synthetic cannabinoid, drug design, medicinal chemistry, immune therapeutics

## An Erratum on

### Cannabinoid Receptor 2 Signalling Bias Elicited by 2,4,6-Trisubstituted 1,3,5-Triazines

by Oyagawa, C. R. M., de la Harpe, S. M., Saroz, Y., Glass, M., Vernall, A. J., and Grimsey, N. L. (2018). *Front. Pharmacol.* 9:1202. doi: 10.3389/fphar.2018.01202

Due to a production error, 24 references with more than six authors were listed in the Reference list without "et al." The references affected are Bouaboula et al. (1993, 1996); Felder et al. (1995); Galiegue et al. (1995); Favata et al. (1998); Portier et al. (1999); Kilts et al. (2002); Karsak et al. (2005); Wright et al. (2005); Ofek et al. (2006); Jiang et al. (2007); Valant et al. (2008); Cencioni et al. (2010); Hurst et al. (2010); Schuehly et al. (2011); van der Stelt et al. (2011); Kleyer et al. (2012); Odan et al. (2012); Shonberg et al. (2013); Brailoiu et al. (2014); Herenbrink et al. (2016); Finlay et al. (2017); Soethoudt et al. (2017) and Yrjölä et al. (2015).

The publisher apologizes for this mistake. The original version of this article has been updated.

## REFERENCES

- Bouaboula, M., Poinot-Chazel, C., Marchand, J., Canat, X., Bourrie, B., Rinaldi-Carmona, M., et al. (1996). Signaling pathway associated with stimulation of CB2 peripheral cannabinoid receptor. Involvement of both mitogen-activated protein kinase and induction of Krox-24 expression. *Eur. J. Biochem.* 237, 704–711. doi: 10.1111/j.1432-1033.1996.0704p.x
- Bouaboula, M., Rinaldi, M., Carayon, P., Carillon, C., Delpech, B., Shire, D., et al. (1993). Cannabinoid-receptor expression in human leukocytes. *Eur. J. Biochem.* 214, 173–180. doi: 10.1111/j.1432-1033.1993.tb17910.x
- Brailoiu, G. C., Deliu, E., Marcu, J., Hoffman, N. E., Console-Bram, L., Zhao, P., et al. (2014). Differential activation of intracellular versus plasmalemmal CB2 cannabinoid receptors. *Biochemistry* 53, 4990–4999. doi: 10.1021/bi500632a
- Cencioni, M. T., Chiurchiu, V., Catanzaro, G., Borsellino, G., Bernardi, G., Battistini, L., et al. (2010). Anandamide suppresses proliferation and cytokine release from primary human T-lymphocytes mainly via CB2 receptors. *PLoS ONE* 5:e8688. doi: 10.1371/journal.pone.0008688
- Favata, M. F., Horiuchi, K. Y., Manos, E. J., Daulerio, A. J., Stradley, D. A., Feeser, W. S., et al. (1998). Identification of a novel inhibitor of mitogen-activated protein kinase kinase. *J. Biol. Chem.* 273, 18623–18632. doi: 10.1074/jbc.273.29.18623
- Felder, C. C., Joyce, K. E., Briley, E. M., Mansouri, J., Mackie, K., Blond, O., et al. (1995). Comparison of the pharmacology and signal transduction of the human cannabinoid CB1 and CB2 receptors. *Mol. Pharmacol.* 48, 443–450.
- Finlay, D. B., Cawston, E. E., Grimsey, N. L., Hunter, M. R., Korde, A., Vemuri, V. K., et al. (2017). Gas signalling of the CB1 receptor and the influence of receptor number. *Br. J. Pharmacol.* 174, 2545–2562. doi: 10.1111/bph.13866
- Galiegue, S., Mary, S., Marchand, J., Dussossoy, D., Carriere, D., Carayon, P., et al. (1995). Expression of central and peripheral cannabinoid receptors in human immune tissues and leukocyte subpopulations. *Eur. J. Biochem.* 232, 54–61.
- Herenbrink, C. K., Sykes, D. A., Donthamsetti, P., Canals, M., Coudrat, T., Shonberg, J., et al. (2016). The role of kinetic context in apparent biased agonism at GPCRs. *Nat. Commun.* 7:10842. doi: 10.1038/ncomms10842
- Hurst, D. P., Grossfield, A., Lynch, D. L., Feller, S., Romo, T. D., Gawrisch, K., et al. (2010). A lipid pathway for ligand binding is necessary for a cannabinoid G protein-coupled receptor. *J. Biol. Chem.* 285, 17954–17964. doi: 10.1074/jbc.M109.041590
- Jiang, L. I., Collins, J., Davis, R., Lin, K.-M., DeCamp, D., Roach, T., et al. (2007). Use of a cAMP BRET sensor to characterize a novel regulation of cAMP by the sphingosine 1-Phosphate/G(13) pathway. *J. Biol. Chem.* 282, 10576–10584. doi: 10.1074/jbc.M609695200
- Karsak, M., Cohen-Solal, M., Freudenberg, J., Ostertag, A., Morieux, C., Kornak, U., et al. (2005). Cannabinoid receptor type 2 gene is associated with human osteoporosis. *Hum. Mol. Genet.* 14, 3389–3396. doi: 10.1093/hmg/ddi370
- Kilts, J. D., Connery, H. S., Arrington, E. G., Lewis, M. M., Lawler, C. P., Oxford, G. S., et al. (2002). Functional selectivity of dopamine receptor agonists. II. Actions of dihydrexidine in D2L receptor-transfected MN9D cells and pituitary lactotrophs. *J. Pharmacol. Exp. Ther.* 301, 1179–1189. doi: 10.1124/jpet.301.3.1179
- Kleyer, J., Nicolussi, S., Taylor, P., Simonelli, D., Furger, E., Anderle, P., et al. (2012). Cannabinoid receptor trafficking in peripheral cells is dynamically regulated by binary biochemical switch. *Biochem. Pharmacol.* 83, 1393–1412. doi: 10.1016/j.bcp.2012.02.014
- Odan, M., Ishizuka, N., Hiramatsu, Y., Inagaki, M., Hashizume, H., Fujii, Y., et al. (2012). Discovery of S-777469: an orally available CB2 agonist as an antipruritic agent. *Bioorg. Med. Chem. Lett.* 22, 2803–2806. doi: 10.1016/j.bmcl.2012.02.072
- Ofek, O., Karsak, M., Leclerc, N., Fogel, M., Frenkel, B., Wright, K., et al. (2006). Peripheral cannabinoid receptor, CB2, regulates bone mass. *Proc. Natl. Acad. Sci. U.S.A.* 103, 696–701. doi: 10.1073/pnas.0504187103
- Portier, M., Rinaldi-Carmona, M., Pecceu, F., Combes, T., Poinot-Chazel, C., Calandra, B., et al. (1999). SR 144528, an antagonist for the peripheral cannabinoid receptor that behaves as an inverse agonist. *J. Pharmacol. Exp. Ther.* 288, 582–589.
- Schuehly, W., Paredes, J. M., Kleyer, J., Huefner, A., Anavi-Goffer, S., Raduner, S., et al. (2011). Mechanisms of osteoclastogenesis inhibition by a novel class of biphenyl-type cannabinoid CB(2) receptor inverse agonists. *Chem. Biol.* 18, 1053–1064. doi: 10.1016/j.chembiol.2011.05.012
- Shonberg, J., Herenbrink, C. K., López, L., Christopoulos, A., Scammells, P. J., Capuano, B., et al. (2013). A structure–activity analysis of biased agonism at the dopamine D2 receptor. *J. Med. Chem.* 56, 9199–9221. doi: 10.1021/jm401318w
- Soethoudt, M., Grether, U., Fingerle, J., Grim, T. W., Fezza, F., de Petrocellis, L., et al. (2017). Cannabinoid CB2 receptor ligand profiling reveals biased signalling and off-target activity. *Nat. Commun.* 8:13958. doi: 10.1038/ncomms13958
- Valant, C., Gregory, K. J., Hall, N. E., Scammells, P. J., Lew, M. J., Sexton, P. M., et al. (2008). A novel mechanism of G protein-coupled receptor functional selectivity. Muscarinic partial agonist McN-A-343 as a bitopic orthosteric/allosteric ligand. *J. Biol. Chem.* 283, 29312–29321. doi: 10.1074/jbc.M803801200
- van der Stelt, M., Cals, J., Broeders-Josten, S., Cottney, J., van der Doelen, A. A., Hermkens, M., et al. (2011). Discovery and optimization of 1-(4-(Pyridin-2-yl)benzyl)imidazolidine-2,4-dione derivatives as a novel class of selective cannabinoid CB2 receptor agonists. *J. Med. Chem.* 54, 7350–7362. doi: 10.1021/jm200916p
- Wright, K., Rooney, N., Feeney, M., Tate, J., Robertson, D., Welham, M., et al. (2005). Differential expression of cannabinoid receptors in the human colon: cannabinoids promote epithelial wound healing. *Gastroenterology* 129, 437–453. doi: 10.1016/j.gastro.2005.05.026
- Yrjölä, S., Sarparanta, M., Airaksinen, A. J., Hytti, M., Kauppinen, A., Pasonen-Seppänen, S., et al. (2015). Synthesis, *in vitro* and *in vivo* evaluation of 1,3,5-triazines as cannabinoid CB2 receptor agonists. *Eur. J. Pharm. Sci.* 67, 85–96. doi: 10.1016/j.ejps.2014.11.003

Copyright © 2019 Frontiers Production Office. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.