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A BIBLIOMETRIC ANALYSIS OF HUMAN HORMONES IN CONSUMER NEUROSCIENCE AND HUMAN BEHAVIOR RESEARCH: TRENDS AND INSIGHTS WITH IMPLICATIONS FOR MARKETING

Ahmed H. Alsharif[1], Lina Pilelienė[2]

Abstract. The fields of consumer neuroscience, neuromarketing, human behaviour, and human hormones (such as dopamine, serotonin, oxytocin, and endorphins) have been widely studied. However, it is noteworthy that despite the considerable attention directed towards these domains, the phenomenon of happiness hormones in the field of marketing and consumer behaviour remains largely unexplored within academic investigations. To fill this gap, this study conducted a comprehensive bibliometric analysis of scientific articles published on this combination (neuro*marketing OR marketing OR consumer*neuroscience OR human AND behavi*) AND (dopamine OR serotonin OR oxytocin OR endorphins OR happy AND hormo*). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) system and VOSviewer software were used to select and analyse articles published in the Scopus database between January 2012 and December 2022. The analysis included 218 articles from various subject areas, including neuroscience, psychology, multidisciplinary studies, art and humanities, and social sciences. The results show an increasing number of publications over the years, with the United States being the leading country in terms of publication output, with 116 articles and 5920 citations. Influential authors, such as Jacob S., were identified, along with highly cited articles and keywords related to human behaviour and hormones, including "dopamine", "serotonin", "testosterone", "oxytocin", "depression", "stress", "motivation", "behaviour" and "anxiety". PLoS One was identified as the most productive journal (20 articles and 372 citations). This is the first study to provide a bibliometric analysis of the current state of research in consumer neuroscience, neuromarketing, human behaviour and human hormones, and to suggest directions for future research in the field.

Key words: bibliometrics, consumer neuroscience, human behaviour, human hormones, neuromarketing, PRISMA, Scopus database.

JEL Classification: M00, M31, M37

1. Introduction

Bibliometrics, a term coined by Pritchard in 1969, is the quantitative analysis of scientific publications (Ahmed et al., 2021). It reflects the study of literature in bibliographies, initially focused on the natural sciences and the development of disciplines, but now serving as a crucial tool for measuring research performance in many fields of science (Dong et al., 2023). Bibliometric analysis (also known as Scientometrics analysis) is a study to understand the internal structure of research in a given field (H-Alsharif et al., 2020; Pilelienė et al., 2022; Shukla et al., 2020).

Several attempts to perform bibliometric analyses of the scientific literature on hormones and human behaviour can be found in academic databases. For instance, de Vries et al. (2022) performed a systematic review according to the PRISMA guidelines on the association between well-being and physiological markers in four categories: neurotransmitters, hormones, inflammatory markers, and microbiome. Cera et al. (2021) conducted the study according to the PRISMA guidelines in the principal databases for studies that reported the collection of salivary or plasmatic samples with a dosage of oxytocin in relation to sexual activity during the induction of

[1] Azman Hashim International Business School;
Universiti Teknologi Malaysia, Malaysia
E-mail: ahmedalsharif07@gmail.com
ORCID: https://orcid.org/0000-0002-1364-3545
[2] Vytautas Magnus University, Lithuania *(corresponding author)*
E-mail: lina.pileliene@vdu.lt
ORCID: https://orcid.org/0000-0003-2704-8314

sexual arousal and orgasm. Furthermore, Aloufi et al. (2023) provided a narrative review followed by a systematic review of the available evidence on sex differences in auditory function and the effect of changes in female sex hormone levels on hearing. Hopf et al. (2020) applied PRISMA guidelines for systematic reviews to search for articles assessing neuroendocrine correlates of grief. Leslie et al. (2018) conducted a bibliometric analysis of studies investigating the effects of oxytocin on energy intake in animals and humans, and the factors that moderate this effect. Fava et al. (2015) applied PRISMA to detect withdrawal symptoms after discontinuation of serotonin-noradrenaline reuptake inhibitors. In the context of consumer behaviour, Koc & Boz (2014) proposed the term "psychoneurobiochemistry", which encompasses various factors from psychology, neurology, biology and chemistry that mutually influence consumers' physiological and psychological states through continuous interactions involving neurotransmitters and hormones such as serotonin, dopamine and melatonin, as well as biological factors such as photoperiod and circadian rhythm, and psychological factors including emotions and mood. Hence, it is reasonable to assume that human hormones, as shapers of human behaviour, can also be targeted by companies' marketing efforts to influence consumer behaviour.

Scholars de Vries et al. (2022) highlight the growing interest in happiness over the past 20 years, accompanied by an increase in the number of scientific publications. Due to their functions, four hormones are commonly referred to as the "happiness hormones". These are dopamine, serotonin, oxytocin, and endorphins. Dopamine (DA) is a neurotransmitter in the central and peripheral nervous system where it regulates physical and psychological activities such as the simulation of euphoria Cloninger et al. (1996), emotion, reward, cognition, memory, endocrine functions and motor control (Koc & Boz, 2014). Cognitive neuroscience has shown that positive social stimuli result in the release of dopamine, thereby reinforcing the initiating social behaviour (Chassiakos & Stager, 2020). Another hormone usually referred to as the happiness hormone, serotonin (5-HT – 5-hydroxytryptamine), is a neurotransmitter that influences an important part of the brain called the limbic system, which supports a variety of functions, including emotion, behaviour, motivation, long-term memory and olfaction (Koc & Boz, 2014). Oxytocin has attracted considerable attention from the scientific community due to its role in various cognitive and emotional processes and aspects of social behaviour, as it promotes social cohesion and social contact between individuals (Cera et al., 2021). Oxytocin is also known to reduce food intake (Leslie et al., 2018) and has stress-reducing effects, such as lowering heart rate, blood pressure and cortisol levels (Hopf et al., 2020). Another hormone known as happiness, endorphins, are released during physical activity (Ana-Maria, 2015).

Therefore, the aim of this paper is to perform a systematic review of the scientific literature on human behaviour related to the so-called "happiness hormones", namely dopamine, serotonin, oxytocin and endorphins, and their possible relationships with the field of marketing. For this purpose, a comprehensive bibliometric analysis of publication growth, prominent countries and institutions, productive journals and authors, keywords and citations will be carried out.

The structure of this study is as follows: Section 2 outlines the methodology used in this study. Section 3 presents the results and discussion of a bibliometric analysis of the relevant literature. Section 4 provides brief conclusions. Finally, Section 5 presents the limitations of the study and possible future directions.

2. Methodology

There are various types of review articles. These encompass bibliometric analysis, as demonstrated in studies by (Arar & Yurdakul, 2023; Chen et al., 2022; Flores et al., 2023); H-Alsharif et al. (2020) (Petrovich, 2022); Pilelienė et al. (2022); (Yao et al., 2022). Another approach is literature review (content) analysis (Ahmed et al., 2020; H-Alsharif et al., 2021a; 2021b). The study used the PRISMA protocol to find relevant papers and conducted a bibliometric analysis to determine global research trends in (neuro*marketing OR marketing OR consumer*neuroscience OR human behavi*) AND (dopamine OR serotonin OR oxytocin OR endorphines OR happy hormo*) research. The PRISMA protocol has been used in several areas to extract data from the Scopus or Web of Science (WoS) databases (see (Ahmed et al., 2023b; Ahmed et al., 2022b; Ahmed et al., 2022c; Ali et al., 2021; Alsharif et al., 2022; Lima et al., 2023) or Pubmed (Meyer et al., 2023) or other databases of scientific literature (De Nys et al., 2022); however, Web of Science and Scopus are the largest databases for bibliometric analysis (Ahmed et al., 2021; Shukla et al., 2020).

The study looked at the most productive countries and academic institutions, leading journals in the field, prolific authors, most cited papers and keyword occurrences to assess improvements in publications. The study aims to provide an overview of current trends in order to fill the existing gap. Accordingly, four research questions (RQs) were formulated to justify the structure and to obtain a complete view of the existing scientific research in the domain analysed:

RQ1: Are there any scientific publications in the field and what is the annual growth rate?

RQ2: What is the most productive a) countries; b) academic institutions; c) journals; d) authors?

RQ3: What are the most prominent keywords in the selected articles?

RQ4: What are the most-cited articles in the field?

In an effort to answer the research questions, the current study begins by extracting articles from the Scopus database in July 2023. The Scopus database was chosen for this study because it is widely used by scholars and researchers to identify the development in the relevant field (Słupińska et al., 2021). In addition, this study has followed the instruction of (Ahmed et al., 2023a); Alsharif et al. (2023) to present a thorough bibliometric analysis that identifies and lists the most productive countries, academic institutions, journals and authors; later, a brief description of each parameter analysed is provided. The screening and selection of articles and the assessment of the certainty of the evidence were carried out independently by two reviewers (De Nys et al., 2022). The VOSviewer software was used to create visualisation maps that facilitate bibliometric research in various fields (see (Alsharif et al., 2021; Pilelienė et al., 2022)). In particular, VOSviewer has been used in several studies related to gaining a comprehensive understanding of the development of the relevant field (Ahmed et al., 2022a). VOSviewer is an artificial intelligence software that uses Jaccard's similarity measures and Pearson's correlation to facilitate the analysis, investigation and visualisation of large amounts of scientific information, resulting in simplified and understandable scientific maps where the distances between elements indicate the strength of their relationships in graphical visualisations (Córdoba-Tovar et al., 2022).

The procedure used in the study (Figure 1) enabled the identification of 218 papers published in the last decade. The authors of the study focused specifically on papers, including articles. Furthermore, only articles written in English were included, as this is the most commonly used language in the field. The study aimed to identify as many relevant papers as possible in order to explore and analyse global

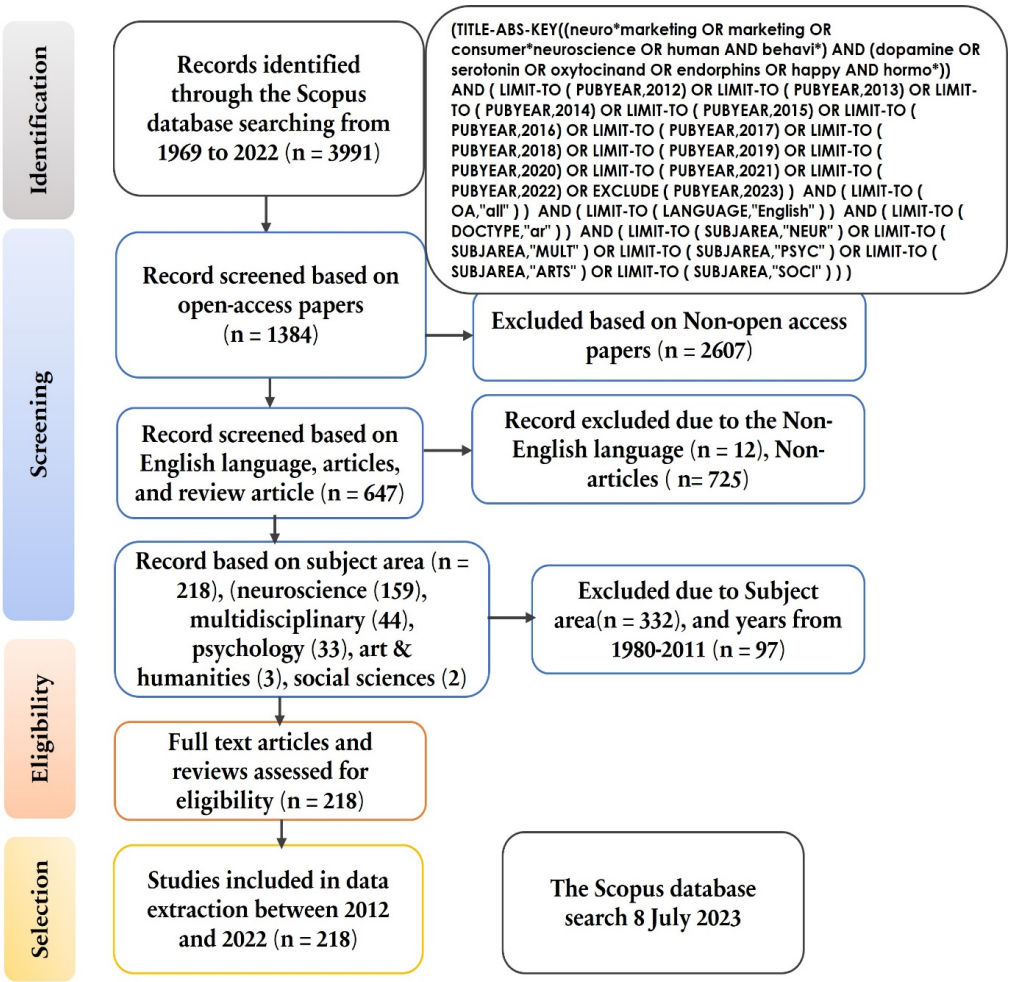

Figure 1. PRISMA process for extracting documents

academic trends (e.g., producing countries, institutions, authors and other relevant factors) related to (neuro*marketing OR marketing OR consumer*neuroscience OR human behavi*) AND (dopamine OR serotonin OR oxytocin OR endorphins OR happy hormo*). The process of selecting articles is shown in Figure 1.

This study does not require ethics committee approval, as it does not involve participants.

3. Results and Discussions

As a result of the procedure, 218 academic journal papers were identified. The analysis revealed a significant growth in publications, with over 50% of the total papers being published in the last six years, from 2017 to 2022. Figure 2 illustrates the annual publications published between 2012 and 2022. The increasing interest among researchers and practitioners in the (neuro*marketing OR marketing OR consumer*neuroscience OR human behavi*) AND (dopamine OR serotonin OR oxytocin OR endorphins OR happy AND hormo*) research has led to a rise in the number of publications and researchers' interests.

3.1 Bibliometric Analysis

3.1.1 Outstanding Countries and Institutions

The analysis carried out in this study shows that countries with a significant presence, i.e., at least nine articles, can be classified into four different clusters according to their productivity levels. The first category includes one country, the USA, which has demonstrated high productivity by producing more than 100 articles. The second cluster comprises two countries, including Germany and the UK, which have published 20-30 articles. The third cluster consists of the Netherlands, China, Italy, Australia and Sweden, which have published between 10 and 19 articles. Finally, the fourth c luster includes Canada and France, which have produced nine articles each.

The data presented in Table 1 provide a detailed overview of the results. In particular, the USA stands out as the most productive country, having produced a remarkable total of 116 articles with 5920 citations. Furthermore, the National Institutes of Health (NIH), which is affiliated to the USA, emerged as the leading academic institution, contributing 10 articles, which received the highest number of citations (491). Conversely, although Australia has published 10 articles, its most prominent academic institution, the University of Melbourne, has contributed six articles, with 60 citations.

Moreover, the Netherlands, despite publishing a total of 19 papers, has a notable institution, the Radboud University Medical Center, which published four papers and achieved the second highest number of citations (435). Finally, Canada, with nine published papers, is at the bottom of the list of prominent countries, and its notable academic institution, the Université McGill, has contributed three papers to the body of research.

3.1.2 Productive Journals

Table 2 shows the ten most productive journals that have published at least two articles. One journal has published 20 articles, three journals have published 10-15 articles and the remaining journals have published 4-8 articles. PLoS One is the most productive journal with 20 articles and 372 citations. Although the Journal of Neuroscience has contributed 10 articles, it has published the most

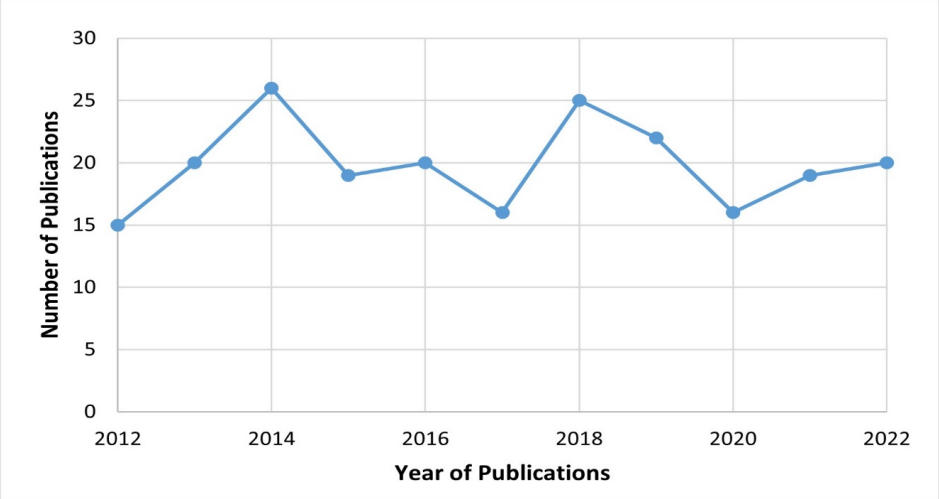

Figure 2. Annual publications from 2012 to 2022

Table 1
Ten outstanding countries

Clusters	Country	TPs	TCs	Productive establishment	TPs	TCs
Cluster 1	USA	116	5920	National Institutes of Health (NIH)	10	491
Cluster 2	Germany	26	679	Charité – Universitätsmedizin Berlin	5	8
	UK	20	824	King's College London	5	143
Cluster 3	the Netherlands	19	1212	Radboud University Medical Center	4	435
	China	13	380	Ministry of Education of the People's Republic of China	3	29
	Italy	12	218	Università degli Studi della Campania Luigi Vanvitelli	3	62
	Australia	10	426	University of Melbourne	6	60
	Sweden	10	251	Göteborgs Universitet	4	46
Cluster 4	France	9	278	Inserm	3	163
	Canada	9	263	Université McGill	3	85

TPs: total publications, TCs: total citations

highly cited article (221 citations), written by Yu et al. (2012). This was followed by the journal Hormones and Behavior with eight articles and 380 citations. This journal published the second most cited article (167 citations), written by Kim et al. (2016). Brain Sciences, which is at the bottom of the list with four articles, has the least cited article with 10 citations.

3.1.3 Productive Authors

Table 3 displays the most prolific authors in (neuro*marketing OR marketing OR consumer* neuroscience OR human behavi*) AND (dopamine OR serotonin OR oxytocin OR endorphins OR happy hormo*) research with the highest number of articles. Ten authors from five different countries and seven different academic institutions were identified. Five authors have published three articles each; five authors have published two articles each. Jacob, S. (affiliated with the University of Minnesota Twin Cities, USA), Enoch, M.A. (affiliated with the National Institute on Alcohol Abuse and Alcoholism, USA), Goldman, D. (affiliated with the National Institute on Alcohol Abuse and Alcoholism, USA), Jerlhag, E. (affiliated with the Sahlgrenska Academy, Sweden) and Navarro, G. (affiliated with the University of Barcelona, Spain) are the most prolific authors with three articles each. The rest of the authors have published two articles each. It is worth noting that although Bos, P.A. (affiliated with the Leiden University, the Netherlands) with two articles, is at the end of the ten most productive authors, his articles are the most highly cited with 303 citations. This is followed by Baier, H. (affiliated with the Max Planck Institute for Biological Intelligence, Germany), with two articles and the second highest citations (244).

Table 2
The ten most outstanding journals

#	Source/Journal	TPs	TCs	Title of the most cited document	Time cited
1	PLoS One	20	372	"The Impact of Intranasal Oxytocin on Attention to Social Emotional Stimuli in Patients with Anorexia Nervosa: A Double Blind within-Subject Cross-over Experiment"	44
2	Scientific Reports	14	159	"WINCS Harmoni: Closed-loop dynamic neurochemical control of therapeutic interventions"	38
3	Psychoneuroendocrinology	12	258	"Testosterone administration in women increases amygdala responses to fearful and happy faces"	61
4	The Journal Of Neuroscience	10	491	"Variant Brain-Derived Neurotrophic Factor Val66Met Polymorphism Alters Vulnerability to Stress and Response to Antidepressants"	221
5	Hormones and Behavior	8	380	"The maternal brain and its plasticity in humans"	167
6	Frontiers in Neuroscience	7	135	"Sex differences in self-regulation: an evolutionary perspective"	41
7	Frontiers in Behavioral Neuroscience	6	122	"A zebrafish model of glucocorticoid resistance shows serotonergic modulation of the stress response"	87
8	Behavioral Neuroscience	5	132	"Dopamine modulates novelty seeking behavior during decision making"	104
9	Neuropharmacology	4	57	"Receptor binding profiles and behavioral pharmacology of ring-substituted N, N-diallyltryptamine analogs"	22
10	Brain Sciences	4	17	"Clinical Severity and Calcium Metabolism in Patients with Bipolar Disorder"	10

Table 3
The ten most productive authors

Author's name	TPs	TCs	H-index	SC ID	Affiliation	Country
Jacob, S.	3	139	33	7202574761	University of Minnesota Twin Cities	USA
Enoch, M.A.	3	93	46	7006504046	National Institute on Alcohol Abuse and Alcoholism	USA
Goldman, D.	3	93	113	7202137872	National Institute on Alcohol Abuse and Alcoholism	USA
Jerlhag, E.	3	14	35	8602768300	Sahlgrenska Academy	Sweden
Navarro, G.	3	18	42	35238095000	University of Barcelona	Spain
Aguinaga, D.	2	18	14	55653650600	University of Barcelona	Spain
Albers, H.E.	2	67	50	7101748511	Georgia State University	USA
Anckarsäter, H.	2	42	47	54882141900	Sahlgrenska Academy	Sweden
Baier, H.	2	244	63	7007107041	Max Planck Institute for Biological Intelligence	Germany
Bos, P.A.	2	303	24	25959843500	Leiden University	the Netherlands

3.1.4 Keywords

In bibliometric analysis, keyword occurrences provide a quantitative approach to expressing the strength of links between paired keywords, with a higher number indicating a stronger link. This analysis provides a comprehensive explanation of the content of the article. The link strength between keywords reflects their frequency in the article, while the total number of links represents the total number of keyword occurrences in the article. In the current paper, a co-occurrence analysis of author keywords was carried out using VOSviewer software, which included 53 keywords with at least three occurrences. This method is important for making general statements about the content of the article and for assessing trend themes in a particular field. The results showed that "dopamine" and "serotonin" were the most common words. Figure 3 shows these results.

Table 4 provides an overview of the most frequently used keywords that occur at least four times in the data. The term "dopamine" has the highest frequency with 34 occurrences (occ) and 74 total links, followed by the term "serotonin". Both of these terms refer to happy hormones other than oxytocin. The term "oxytocin" was used 11 times with a total of 20 link-strengths, and "hormones" four times with a total of six link-strengths.

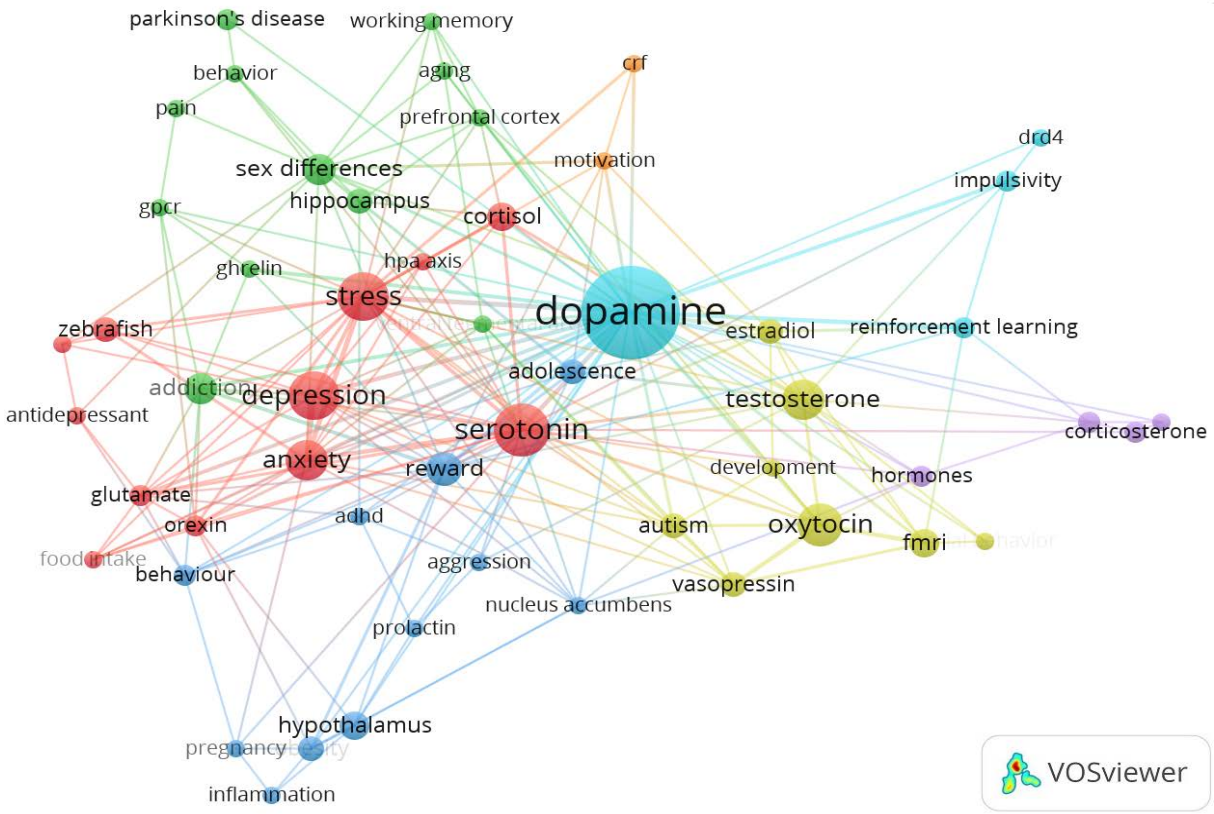

Figure 3. Map of authors' keywords with at least three occurrences

Table 4
Keywords of the authors with at least three occurrences

#	Keyword	Occ	TLS	#	Keyword	OCC	TLS
1	Dopamine	34	74	28	Corticosterone	4	3
2	Serotonin	15	37	29	Parkinsons disease	4	2
3	Stress	13	40	30	Nucleus accumbens	3	11
4	Depression	13	24	31	Ventral tegmental area	3	10
5	Oxytocin	11	20	32	Motivation	3	9
6	Anxiety	10	30	33	Prefrontal cortex	3	9
7	Testosterone	10	19	34	ADHD	3	7
8	Reward	8	22	35	Ghrelin	3	7
9	Sex differences	7	16	36	Food intake	3	6
10	Addiction	7	14	37	GPCR	3	6
11	fMRI	6	12	38	HPA axis	3	6
12	Cortisol	6	11	39	Aggression	3	5
13	Hypothalamus	6	8	40	Aging	3	5
14	Vasopressin	5	14	41	Behavior	3	5
15	Autism	5	13	42	CRF	3	5
16	Estradiol	5	13	43	Development	3	5
17	Adolescence	5	10	44	Fluoxetine	3	5
18	Obesity	5	9	45	Pregnancy	3	5
19	Zebrafish	5	7	46	Working memory	3	5
20	Hippocampus	5	5	47	Antidepressant	3	4
21	Glutamate	4	15	48	Prolactin	3	4
22	Orexin	4	12	49	Inflammation	3	3
23	Reinforcement learning	4	10	50	Pain	3	3
24	Behaviour	4	8	51	Progesterone	3	3
25	Impulsivity	4	7	52	Social behavior	3	3
26	Estrogen	4	6	53	DRD4	3	2
27	Hormones	4	6				

TLS: total-link-strength, Occ: Occurrences

3.1.5 Citations

Citation analysis is crucial for gaining insight into global trends in a particular field of research, as it provides valuable information about the most cited papers. This information can be used by future researchers or practitioners to identify high-impact articles. This study analysed 218 articles in (neuro*marketing OR marketing OR consumer* neuroscience OR human behavi*) and (dopamine OR serotonin OR oxytocin OR endorphins OR happy hormo*) research and identified the most frequently cited articles in Table 5, with over 167 total citations (TCs), which investigated consumer behavior and human hormones such as dopamine, serotonin, and so forth. Table 5 shows that one article had more than 650 TCs, and the article entitled "Social reward requires coordinated activity of nucleus accumbens oxytocin and serotonin", written by Dölen et al. (2013) and published in the Nature Journal, was the most cited article with 672 TCs. The second most cited article was "Transneuronal Propagation of Pathologic α-Synuclein from the Gut to the Brain Models Parkinson's Disease" which was written by Kim et al. (2019) and published in the Neuron Journal, with 545 citations. In addition, five articles had 200-400 citations, while two articles had less than 200 citations.

3.1.6 Bibliographic Coupling (Sources)

Bibliographic coupling is the number of times two entities (either authors or countries) cite the same entity (Shukla et al., 2020). In this study, the VOSviewer tool was used to assess the strength of the correlation between the two sources/journals. The tool used the bibliographic coupling (sources/journals) to determine the link strength between references associated with a couple of sources. Table 6 shows the link strengths, which indicate the degree of correlation. A higher number of links indicates a stronger connection between the sources.

The analysis revealed remarkable correlations between different pairs of sources. The strongest correlation was observed between "Hormones and Behavior" and "Psychoneuroendocrinology" with 19 links, highlighting a significant degree of connection between the respective sources. A close second was found between Frontiers in Neuroscience and Psychoneuroendocrinology, with 11 links.

Table 5
The ten top cited documents

#	Title of paper	Reference	Journal	TCs by the end of 2022
1	"Social reward requires coordinated activity of nucleus accumbens oxytocin and serotonin"	(Dölen et al., 2013)	Nature	672
2	"Transneuronal Propagation of Pathologic α-Synuclein from the Gut to the Brain Models Parkinson's Disease"	(Kim et al., 2019)	Neuron	545
3	"Ultrafast neuronal imaging of dopamine dynamics with designed genetically encoded sensors"	(Patriarchi et al., 2018)	Science	411
4	"Gating of social reward by oxytocin in the ventral tegmental area"	(Hung et al., 2017)	Science	267
5	"Serotonin engages an anxiety and fear-promoting circuit in the extended amygdala"	(Marcinkiewcz et al., 2016)	Nature	247
6	"Testosterone, cortisol, and serotonin as key regulators of social aggression: A review and theoretical perspective"	(Montoya et al., 2012)	Motivation and Emotion	242
7	"Variant Brain-Derived Neurotrophic Factor Val66Met Polymorphism Alters Vulnerability to Stress and Response to Antidepressants"	(Yu et al., 2012)	The Journal of Neuroscience	221
8	"Severe stress switches CRF action in the nucleus accumbens from appetitive to aversive"	(Lemos et al., 2012)	Nature	203
9	"MDMA enhances emotional empathy and prosocial behavior"	(Hysek et al., 2014)	Social Cognitive and Affective Neuroscience	178
10	"The maternal brain and its plasticity in humans"	(Kim et al., 2016)	Hormones and Behavior	167

The third strongest correlation was found between "The Journal of Neuroscience" and "Physiology and Behavior", with ten links. Conversely, "Psychoneuroendocrinology" and "Scientific Reports" have a second correlation with other journals, but no first correlation with other journals. These were the weakest links between the two sources in terms of correlation strength.

4. Conclusions

The study of human behaviour is of paramount importance as it provides valuable insights into the complexity of human interactions, decision-making processes and responses to various stimuli, facilitating advances in fields such as psychology, sociology, marketing and public policy. Human behaviour is shaped by a complex interplay of different factors, including genetics, environmental influences, culture, upbringing, social interactions, personal experiences, cognitive processes, emotions, beliefs, values and individual differences, all of which contribute to the way individuals perceive, interpret and respond to the world around them. Hormones can be seen as a group of these factors. Various bibliometric analyses of the scientific literature on hormones and human behaviour are available in the scientific literature. Recently, as researchers have become increasingly interested in the phenomenon of happiness, there has also been a growing focus on "happiness hormones".

Following a comprehensive bibliometric analysis of the scientific literature on human behaviour in relation to the so-called "happiness hormones", namely dopamine, serotonin, oxytocin and endorphins, and their possible relationships with the field of

Table 6
The top sources pair with a minimum number of documents (4) and citations (96) of a source

#	Item 1	Item 2	Links between items 1, 2
1	Hormones and Behavior	Psychoneuroendocrinology	19
2	Frontiers in Neuroscience	Psychoneuroendocrinology	11
3	The Journal of Neuroscience	Physiology and Behavior	10
4	Frontiers in Behavioral Neuroscience	Frontiers in Neuroscience	4
5	Behavioral Neuroscience	Hormones and Behavior	3
6	PLoS One	Psychoneuroendocrinology	2
7	Current Neuropharmacology	Scientific Reports	1
8	Physiology and Behavior	PLoS One	1
9	Psychoneuroendocrinology	-	-
10	Scientific Reports	-	-

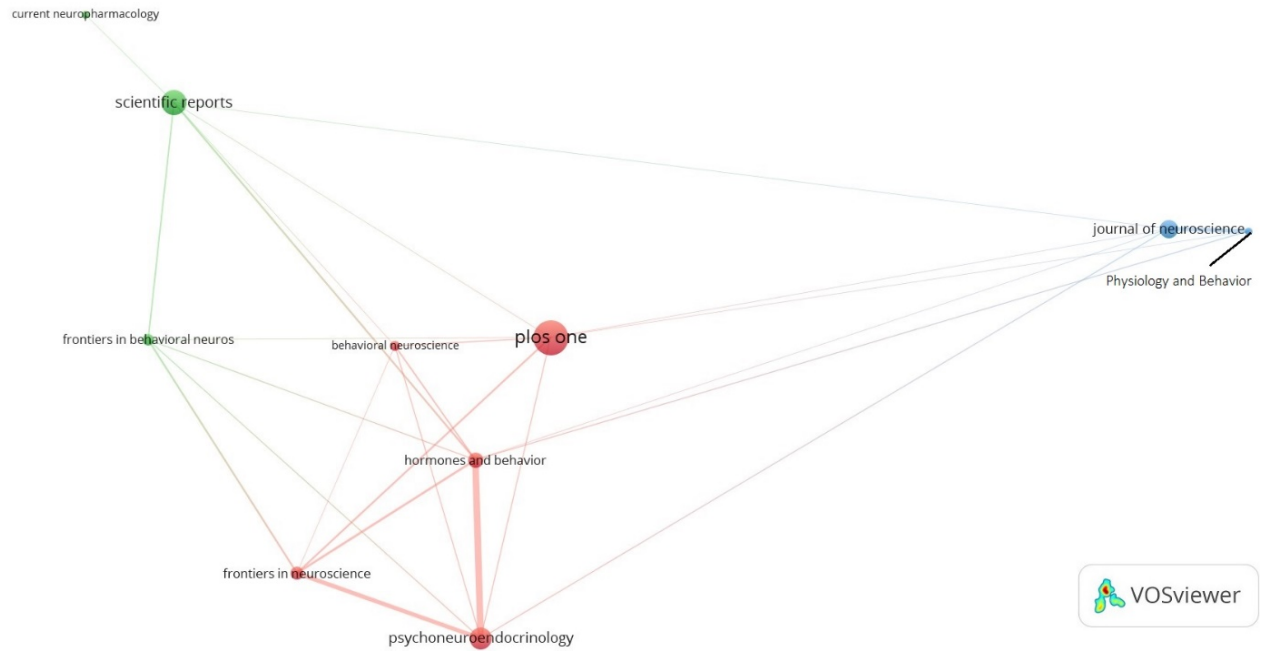

Figure 4. Map of top sources pair with minimum number of documents (4) and citations (96) of a source

marketing, several conclusions can be drawn. During the period analysed (Y2012-Y2022), the number of academic publications in the field of interest of this study fluctuated, leading to an increase in the general number of publications and a growing interest among researchers.

As the search query was intended to find articles related not only to marketing but also to human behaviour, the extracted publications can be divided into two main groups: a) studies analysing the role of hormone(s) in human behaviour without any relevance or insight for marketers (those related to pathologies, disorders or diseases) and b) studies analysing the role of hormone(s) in human behaviour providing relevant information that could underpin some marketing efforts. The first group of studies is obviously the larger one and attracts the lion's share of attention from scholars; the second group is still evolving, taking its background from the first. Based on this general division, several implications can be drawn for scholars and practitioners in the field of marketing and consumer sciences.

The first trend for further research can be identified as research into stimuli that trigger hormone release in the human body and their influence on human behaviour in shopping and/or consumption situations. On the basis of the analysis provided, several examples of such stimuli (which induce one or more of the hormones included in the analysis) can be named: social reward; stress, anxiety and fear related or inducing sensory stimuli (e.g., fearful and happy faces); social aggression; emotional empathy or prosocial behaviour inducing stimuli; social-emotional stimuli; etc.

Another trend in research can be seen in the analysis of reactions to the above stimuli expressed by people of different sexes, ages, races and ethnicities, as later human characteristics are identified as having an influence on hormonal activity.

Another trend of research can be the study of different consumer reactions in shopping and/or consumption situations to the above-mentioned stimuli or under the influence of the release of different hormones, i.e., novelty or variety seeking; aggressive or pro-social behaviour; self-regulation and control, etc.

Finally, neuromarketing research can be carried out by directly analysing the influence of different hormones or their combinations on consumer decision-making and choice behaviour. Further development of neuroscientific research in these areas of marketing and consumer behaviour would strengthen the field of knowledge by establishing a stable background and key milestones for those interested in the field.

5. Limitations and Future Directions

The aim of the paper was to minimise the methodological limitations of the study, but some limitations were still found and suggestions were made for future research. The study focused only on articles published in English-language journals indexed in the Scopus database between 2012 and 2022. However, this approach ignored other

documents such as conference papers, book chapters, short surveys, editorials, books and notes, which can lead to selection bias in systematic reviews and meta-analyses (De Nys et al., 2022). To address this limitation, the authors recommend that researchers and marketers from emerging countries should publish their work in this area for future studies. Another limitation is the choice of hormones; the research was limited to four hormones (known as "happiness hormones"): dopamine, serotonin, oxytocin and endorphins. Therefore, other hormones and neurotransmitters may be included in further analyses. Overall, the article provides a comprehensive overview of the global academic trends of (neuro*marketing OR marketing OR consumer*neuroscience OR human behavi*) AND (dopamine OR serotonin OR oxytocin OR endorphins OR happy hormo*) research between 2012 and 2022, based on the analysed publications.

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