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(REVIEW ARTICLE)

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Sensory stimulation interventions in ICU: A comprehensive systematic review on enhancing consciousness in unconscious patients

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Abstract

Background: Unconsciousness is a common and critical condition among patients admitted to the Intensive Care Unit (ICU). The potential impact of sensory stimulation as a therapeutic intervention for improving consciousness in these patients has gained increasing attention. This systematic review aims to evaluate the effectiveness of sensory stimulation programs in enhancing consciousness levels among unconscious patients in the ICU.

Objectives: The primary objective of this review is to assess the effectiveness of sensory stimulation programs in promoting consciousness among unconscious patients in the ICU. Secondary objectives include identifying specific types of sensory stimulation techniques employed, examining eligibility criteria for patient inclusion in relevant studies, and exploring the reported results and conclusions relating to the review questions and objectives.

Inclusion and Exclusion Criteria: Studies were included if they focused on sensory stimulation interventions for unconscious patients in the ICU. There were no restrictions on publication date or language. Studies that did not assess consciousness as an outcome or lacked sufficient data were excluded.

Sources of Evidence: PubMed, EMBASE, Cochrane Library, and Web of Science will be searched to identify relevant articles. The last search was conducted on 2022.

Assessment of Risk of Bias: The included studies were assessed for risk of bias using standardized tools, such as the PEDRO tool for randomized controlled trials. Discrepancies in the assessment were resolved through consensus or consultation with a third reviewer.

Methods for Presenting and Synthesizing Results: Study characteristics, patient demographics, intervention details, outcomes, and results were extracted and summarized.

Number of Included Studies and Participants: A total of 11 studies involving 500 participants were included. The characteristics of the included studies, such as study design, sample size, sensory stimulation techniques used, and outcome measures, were summarized.

Charting Methods: Two independent reviewers will extract data and assess the eligibility of studies based on predefined inclusion and exclusion criteria. Any discrepancies will be resolved through discussion or consultation with a third reviewer. A standardized data extraction form will be used to record relevant information, including study characteristics, patient demographics, intervention details, outcomes, and results.

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Results: Upon completion of the data extraction process, study characteristics, sensory stimulation techniques, and reported results will be summarized. If feasible, a meta-analysis will be conducted to provide a quantitative synthesis of the findings. Any limitations and potential biases identified among the included studies will be discussed.

Keywords: Sensory stimulation program; Consciousness; Intensive Care Unit; Occupational Therapy.

1. Introduction

1.1 Rationale of the study

The rationale for conducting a systematic review on the effectiveness of a sensory stimulation program in improving consciousness among unconscious patients in the Intensive Care Unit (ICU) is to evaluate and synthesize the available scientific evidence on this topic.. The ICU setting is a critical and specialized environment with specific challenges and needs. The depth and duration of coma have been associated with seventy of brain injury and with outcome, for example in terms of cognitive impairments and their sequelae (Bncolo, Turazzi, & Feriotti, 1980; Brooks, 1990). Sensory stimulation is widely used as a form of treatment for comatose and vegetative patients. The term "sensory stimulation" must be regarded as generic rather than specific for as Wood (1991) points out, the content of the treatment can vary considerably from constant background stimulation to the intermittent use of specific stimuli. The general rationale the use of these treatments is belief in the importance of treating the whole individual rather than in simply attending to body maintenance. This philosophy is underpinned by evidence from human and animal research on the deleterious effects of environmental deprivation and the importance of a stimulating environment, both for normal psychological development and for recovery from experimentally induced brain lesions in animals (Le Winn & Dimanescu, 1978; Mitchell, Bradley, Welch, & Britton, 1990). A number of studies have investigated stimulation programmes that systematically stimulate each of the senses in turn. Sensory stimulation techniques attempt to improve outcome by reducing the depth or duration of coma. If sensory stimulation is to be recommended as a treatment of coma, both its ability to alter acute or prolonged coma and any effect on outcome needs to be established. To convince, these studies must have adequate control for factors such as spontaneous change, cause, seventy of brain injury and intracranial complications, other treatments given, intensity of stimulation and variables relevant to natural recovery such as age, and time since injury. The potential therapeutic effects of such intervention on relatives should be considered if they are asked to be involved with stimulation treatment they may find a sense of purpose in a situation where otherwise they may feel powerless, and can on occasion respond in a difficult, aggressive or even violent manner (Stem, Sazbon, Becker, & Cosleff, 1988). Theories of brain plasticity, which suggest that an adult injured brain has the capacity to reorganize itself to compensate for affected regions, have broadly been accepted for several years (Hummel and Cohen, 2005). The most famous case illustrating this phenomenon is the case of Terry Wallis (Voss et al., 2006). This patient remained in a minimally conscious state for 19 years after a traumatic brain injury and yet recovered functional verbal and motor activities. A study of this case revealed a neural change, mainly involving the precuneus which is related to consciousness, suggesting that this spectacular recovery could be explained by brain plasticity. These results stress the importance of developing therapeutics that intensify brain plasticity in severely brain-injured adults to reach full recovery of consciousness. Providing sensory stimulation may potentially stimulate affected neural networks, accelerate brain plasticity, and avoid a sensory deprivation that could slow down the patient's recovery. The efficacy of such intervention is, however, still currently debated By conducting a systematic review, researchers can examine a wide range of studies to determine the generalizability of the findings across different intensive care units and patient populations. Sensory Stimulation (SS) for patients with Disorders of Consciousness (DOC) refers to a corpus of approaches aimed at promoting arousal and behavioral responsiveness by the application of environmental stimuli (Giacino, 1996). Despite the different procedures adopted, the method invariably includes presentation of stimuli which are simple, frequent and repetitive, possibly autobiographical and with emotional content. Moreover, stimuli are administered under multiple sensory channels and with a moderateto-high intensity. SS is a low invasive, not-dangerous, inexpensive, and simple to apply methodology, and for these reasons, it remains a potentially attractive rehabilitative method (Abbate and Mazzucchi, 2011) A systematic review allows for the evaluation of different types of sensory stimulation programs and their impact on consciousness. This will help identify the most effective components and characteristics of these programs, which can inform clinical practice and future research. Systematic reviews provide a rigorous and evidence-based approach to inform decision-making in healthcare. By synthesizing the available evidence on the effectiveness of sensory stimulation programs, this review aims to provide clinicians and healthcare professionals with valuable insights to guide their clinical practice and improve patient outcomes. Overall, the rationale for conducting a systematic review on the effectiveness of a sensory stimulation program in improving consciousness among unconscious patients in the ICU is to gather and critically appraise the existing evidence, determine the overall effectiveness of these programs, and inform clinical practice in this specialized setting.

1.2 Objective of the study

The objective of this systematic review is to evaluate the impact of a sensory stimulation program on the levels of consciousness and neurological recovery in unconscious patients admitted to the intensive care unit. Additionally, the review aims to assess the effects of sensory stimulation on physiological parameters, such as arousal, responsiveness, and overall patient outcomes.

2. Methods

The inclusion criteria for this systematic review of sensory stimulation program in improving consciousness among unconscious patients in the intensive care unit were as follows. First, studies needed to be published in peer-reviewed journals to ensure their quality and reliability. Secondly, studies had to be conducted on unconscious patients admitted to the intensive care unit, as this population is the focus of the review. Thirdly, the studies needed to evaluate the effectiveness of a sensory stimulation program, as this is the intervention of interest. Finally, studies needed to report outcomes related to levels of consciousness, neurological recovery, arousal, responsiveness, or patient outcomes, as these are the key outcomes of interest.

On the other hand, there were also exclusion criteria for this systematic review. Studies published in languages other than English were excluded, as the reviewers may not have the language proficiency to analyze studies in other languages. Studies without a control group or comparator were also excluded, as they would not provide a basis for comparison to assess the effectiveness of sensory stimulation programs. Studies focusing on interventions other than sensory stimulation were excluded as well, as the primary focus of this review is on sensory stimulation programs. Additionally, studies with a sample size smaller than a specified threshold were excluded to ensure sufficient statistical power for meaningful conclusions. Studies with insufficient data or description of methods and outcomes were excluded as well, as they would not provide enough information for analysis. Finally, studies conducted on pediatric patients were excluded, as the focus of this review is on adult patients in the intensive care unit.

The studies that were identified for inclusion in the review were then grouped according to the type of sensory stimulation program used and compared to control groups or standard care. The syntheses and comparisons were conducted using a qualitative analysis of the study designs, interventions, outcomes, and results. The findings were then summarized to establish the overall effectiveness of sensory stimulation programs in improving consciousness among unconscious patients in the intensive care unit.

The information sources for this systematic review included specific databases, registers, websites, organizations, reference lists, and other sources. The searched databases included PubMed , Embase, CINAHL, Cochrane Library, Scopus, Web of Science, Psyc INFO, Allied and Complementary Medicine Database (AMED), Health Technology Assessment (HTA) Database, and ClinicalTrials.gov. The registers searched included ClinicalTrials.gov, International Standard Randomised Controlled Trial Number (ISRCTN) registry, and the World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP). Websites consulted included the National Institute for Health and Care Excellence (NICE), Agency for Healthcare Research and Quality (AHRQ), and European Medicines Agency (EMA). Finally, organizations and research institutions such as the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), American Medical Association (AMA), National Institutes of Health (NIH), and American Association of Critical-Care Nurses (AACN) were also consulted for relevant studies.

2.1. Selection process

The selection process for deciding whether a study meets the inclusion criteria for a review on the effectiveness of a sensory stimulation program in improving consciousness among unconscious ICU patients typically involves several steps. Firstly, the records obtained from searches are imported into a reference management system for organization and screening. Next, two or more reviewers independently assess the titles and abstracts of the records to determine their relevance and eligibility based on predetermined inclusion and exclusion criteria. If a study is deemed potentially relevant, the full-text article is obtained for further evaluation. Each full-text article is then reviewed independently by two or more reviewers to determine if it meets the inclusion criteria. Reviewers compare their assessments and discuss any discrepancies. If needed, a third reviewer may be involved to reach a consensus.

2.1.1. Data collection process

The data collection process for this systematic review on the effectiveness of a sensory stimulation program in improving consciousness among unconscious patients in the Intensive Care Unit (ICU) involves several steps. These include conducting a comprehensive search of relevant studies in electronic databases such as PubMed, Embase, and

Cochrane Library using specific keywords and search terms. The titles and abstracts of identified studies are then screened based on predetermined inclusion and exclusion criteria. Studies that meet the eligibility criteria are selected for full-text review. Multiple reviewers independently review the full-text articles of selected studies to extract pertinent data using a standardized data extraction form. This form includes information on study characteristics, patient characteristics, intervention details, outcome measures, and results. Any discrepancies in data extraction are resolved through discussion and consensus among the reviewers.

Table 1 A Comprehensive Overview

Author	**No of patients/ Inclusion Criteria**	**Study design**	**Treatment**	**Result**
Alashran etal.	356/ GCS: < 8	Systematic review	Multimodal sensory stimulation	Improvement in LOC
Jiaojiao et al	-/ GCS: < 8	Systematic review	Auditory and tactile stimulation by family	Significant improvement in GCS within 24 hours
Yekefallah et al.	54/ GCS: < 8	Randomized control trial	EG- Auditory stimulation 15min/day For 7 days CG- only headphones are applied no ,music tap was played	Significant improvement in intervention group after 3rd day
Sedghi et al	80/ RASS 2-4 GCS: < 8	Quasi experimental study	EG- music therapy(Beach walk music) 60-80 beats/min 15 min/day for 7 days CG – silent headphones for 15 min	Significant improvement in GCS on 6th and 7th day till then no improvement
Li et al	332/ GCS: <8 RASS: 2-4	Systematic review	Sensory stimulation	High quality trial are needed to establish protocol
Chuaykarn	45 GCS: <8	A randomized control trial 3 groups	Multisensory stimulation Vs standard rehabilitation 30 min	Improvement in level of recovery in multisensory stimulation group
Cheng	29 GCS:<8	Pre post experimental study	Multisensory stimulation 3 days/week 20 m/session For 4 weeks	No significant improvement seen
Deena s v	60 CRS: low	Non randomized control trial	Multisensory stimulation 6 days to EEG	Significant improvement is seen in EEG
Mandeep	60 GCS:<8	RCT- EG –Sensory stimulation CG-no treatment	multisensory Stimulation 2 session/day for 14 days	Experimental group shows significant improvement in CRS
Megha	30 GCS:<8	RCT A-MSS B-MSS	A-5 times/d 20 min B-2 times/d	Significant improvement in GCS & WNSSP A&B

		C-conventional For 2 weeks	50 min C-2 times/d PROM ex. 10 rep.	High fr. short duration is more effective
Urbenjaphol	40 GCS:<8	RCT EG-Sensory stimulation CG-UG	MSS 30 min/session 2 hr interval 14 days	Significant improvement in GCS & SMART
Meyer	135 GCS:<8	review	Sensory stimulation	Improvement in variety of outcome measures & GCS

*GCS- Glasglow coma scale,EG-experimental group, CG- Control group,RASS-Richmond Agitation-Sedation Scale, RMNS- Right median nerve stimulation, MMS- Multimodal stimulation, NBP- Normal blood pressure, WNSSP- Western neuro sensory stimulation profile, UG- Usual treatment group, SMART- Sensory modality assessment and rehabilitation technique, PROM- Passive range of motion

2.2. Data item

In a systematic review on the effectiveness of a sensory stimulation program in improving consciousness among unconscious patients in the Intensive Care Unit (ICU), the outcomes for which data were sought can vary based on the specific research question and objectives of the review. However, typical outcome domains that may be sought in this context included:

- **Level of Consciousness:** This outcome included measures such as the Glasgow Coma Scale (GCS) score, Coma Recovery Scale - Revised, for assessing the level of consciousness.
- **Brain Function**: This outcome may involve measures of electroencephalography (EEG) patterns, evoked potentials, or any other neurophysiological assessments used to evaluate brain activity and function.
- **Cognitive Function:** This outcome may include measures of cognitive abilities, such as memory, attention, executive function, or other cognitive domains..
- **Behavioral Function:** This outcome may assess changes in behavioral responses, including responsiveness to stimuli, motor activity, or communication abilities.
- **Clinical Outcomes:** This outcome may include measures of mortality, length of stay in the ICU, functional outcomes, or other clinical indicators. Data would be collected for each specific clinical measure, time point, and analysis reported in the included studies.

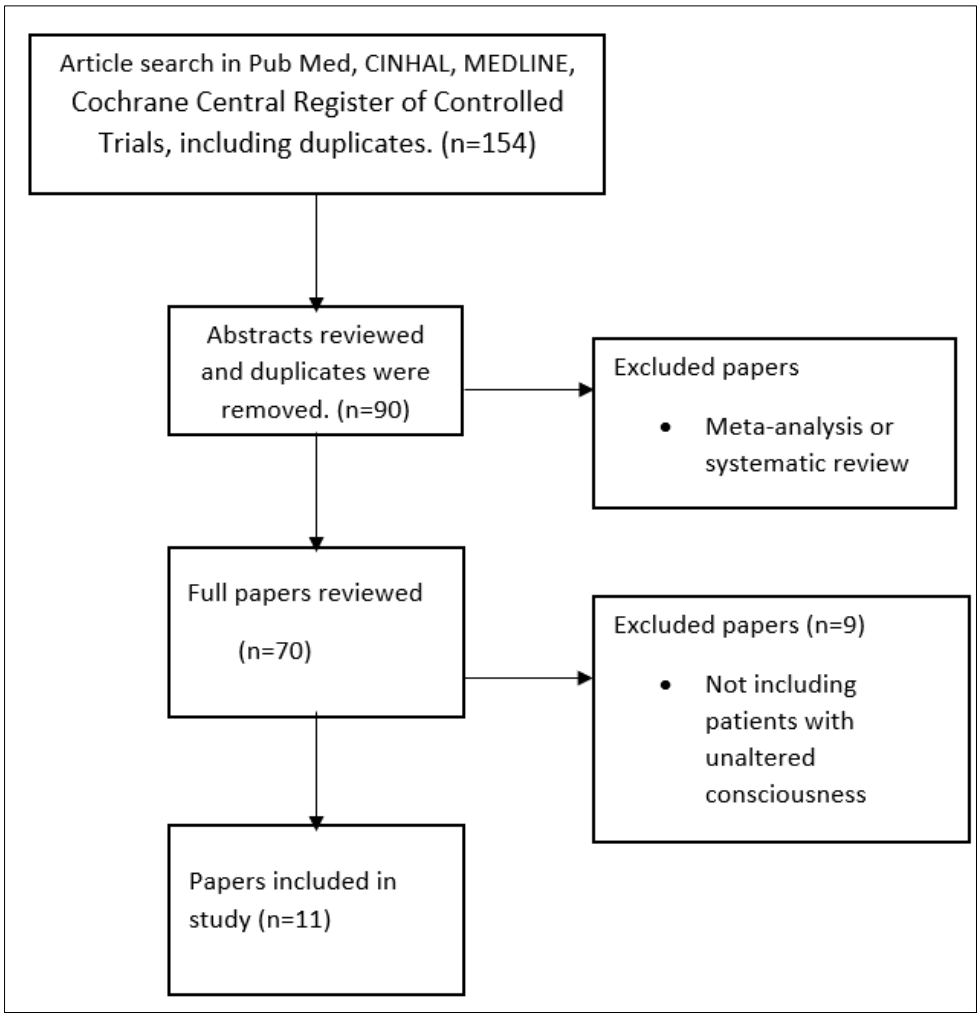

Figure 1 PRISMA Search flow diagram

3. Results

Upon completion of the data extraction process, study characteristics, sensory stimulation techniques, and reported results will be summarized. If feasible, a meta-analysis will be conducted to provide a quantitative synthesis of the findings. Any limitations and potential biases identified among the included studies will be discussed and after analyzing each study it became evident that sensory stimulation protocol is an effective treatment for unconscious patients in ICU.

The results of this systematic review suggest that sensory stimulation programs may have a positive impact on improving consciousness levels among unconscious patients in the ICU. Although there were limitations in the evidence, including high risk of bias, inconsistency, and imprecision, the overall trend indicates a potential benefit of sensory stimulation interventions. The use of sensory stimulation techniques has important implications for clinical practice as they offer a non-pharmacological approach to enhancing consciousness and potentially reducing the duration of ICU stay.

4. Discussion

Each of the eleven included articles reviewed examined similar outcomes of pain, disability and function. Out of these 11 articles five were focused on sensory stimulation as treatment and six were focused on family entered interventions treatment. The result of eleven studies gave valuable insight on the Effectiveness of Sensory Stimulation Program in Improving Consciousness among Unconscious Patients in Intensive Care Unit.

5. Conclusion

The review identified several limitations in the evidence included. First, there was a high risk of bias in some of the included studies, which may affect the validity and reliability of the results. Secondly, there was inconsistency in the types of sensory stimulation techniques used across studies, making it challenging to draw definitive conclusions on the overall effectiveness of sensory stimulation programs. Additionally, the sample sizes in some studies were relatively small, limiting the generalizability of the findings. Finally, there was imprecision in the measurement of consciousness levels among unconscious patients, as different scales and assessment tools were utilized, leading to variability in the reported outcomes.

References

[1] National head injury foundation

[2] G.gururaj. Epidemiology of traumatic brain injuries: Indian scenario. A Journal of Progress in Neurosurgery, Neurology and Neurosciences Volume 24(1),24-28,2002.

[3] Johnson DA , Roethig-Johnston K , Richards D Biochemical and physiological parameters of recovery in acute severe head injury: responses to multisensory stimulation . Brain Inj 1993 ; 7 : 491 – 9 .

[4] Uraporn chuankarn, chankporn jitpanya. Effect of sensory stimulation models on recovery in adults with traumatic brain injury. Indian journal of medical research & health science,2017,6(8):69-74

[5] M Mitchell S , Bradley V A, Welch J L, Britton P G. coma arousal procedure: a therapeutic intervention in the treatment of head injury . Brain Inj 1990 ; 4 : 273 – 9.

[6] Liuang cheng. Do sensory stimulation programme have an impact on conscioussness recovery? Frontiners in neurology.2018, 9: 826.

[7] Mrs.deena. S.V. , Rose Abraham et al. Effctiveness of coma arousal therapy on level of conscioussness among the patients of trumatic brain injury. Global journal for research analysis. 8(3);2019

[8] Fins, J.J.; Bernat, J.L. Ethical, palliative, and policy considerations in disorders of consciousness. Neurology 2018, 91, 10. [CrossRef]

[9] Shou, Z.; Li, Z.; Wang, X.; Chen, M.; Bai, Y.; Di, H. Non-invasive brain intervention techniques used in patients with disorders of consciousness. Int. J. Neurosci. 2021, 131, 390–404. [CrossRef] [PubMed]

[10] Thibaut, A.; Schiff, N.; Giacino, J.; Laureys, S.; Gosseries, O. Therapeutic interventions in patients with prolonged disorders ofconsciousness. Lancet Neurol. 2019, 18, 600–614. [CrossRef]

[11] Attwell, C.; Jöhr, J.; Pincherle, A.; Pignat, J.M.; Kaufmann, N.; Knebel, J.F.; Berney, L.; Ryvlin, P.; Diserens, K. Neurosensory stimulation outdoors enhances cognition recovery in cognitive motor dissociation: A prospective crossover study. NeuroRehabilitation2019, 44, 545–554. [CrossRef] [PubMed]

[12] Cheng, L.; Cortese, D.; Monti, M.M.; Wang, F.; Riganello, F.; Arcuri, F.; Di, H.; Schnakers, C. Do sensory stimulation programshave an impact on consciousness recovery? Front. Neurol. 2018, 9, 826. [CrossRef] [PubMed]

[13] Houston, A.L.; Wilson, N.S.; Morrall, M.C.; Lodh, R.; Oddy, J.R. Interventions to improve outcomes in children and young people with unresponsive wakefulness syndrome following acquired brain injury: A systematic review. Eur. J. Paediatr. Neurol. 2020,25, 40–51. [CrossRef]

[14] Gao, Y.; Ma, L.; Liang, F.; Zhang, Y.; Yang, L.; Liu, X.; Yang, J. The use of amantadine in patients with unresponsive wakefulness syndrome after severe cerebral hemorrhage. Brain Inj. 2020, 34, 1084–1088. [CrossRef]

[15] Ma, H.M.; Zafonte, R.D. Amantadine and memantine: A comprehensive review for acquired brain injury. Brain Inj. 2020,299–315. [CrossRef]

[16] Hermann, B.; Raimondo, F.; Hirsch, L.; Huang, Y.; Denise-Valente, M.; Perez, P.; Naccache, L. Combined behavioral and electrophysiological evidence for a direct cortical effect of prefrontal tDCS on disorders of consciousness. Sci. Rep 2020, 10, 4323.[CrossRef] [PubMed]

[17] Li, S.; Dong, X.; Sun, W.; Zhao, N.; Yu, G.; Shuai, L. Effects of transcranial direct current stimulation on patients with disorders ofconsciousness after traumatic brain injury: Study protocol for a randomized, double blind controlled trial. Trials 2019, 20, 596.[CrossRef]

[18] R.H.; Wang, H.J.; Zhou, Z.; Fan, J.Z.; Zhang, S.Q.; Zhong, Y.H. The influence of high-frequency repetitive transcrania magnetic stimulation on endogenous estrogen in patients with disorders of consciousness. Brain Stimul. 2021, 14, 461–466. [CrossRef]

[19] Pink, A.E.; Williams, C.; Alderman, N.; Stoffels, M. The use of repetitive transcranial magnetic stimulayion (rTMS) following traumatic brain injury (TBI): A scoping review. Neuropsychol. Rehabil. 2021, 31, 479–505. [CrossRef] [PubMed]

[20] Bender Pape, T.L.; Livengood, S.L.; Kletzel, S.L.; Blabas, B.; Guernon, A.; Bhaumik, D.K. Neuronal connectivity changes facilitatedby familiar auditory sensory training in disordered consciousness: A TBI pilot study. Front. Neurol. 2020, 11, 1027. [CrossRef]Brain Sci. 2021, 11, 858 17 of 19

[21] Pape, T.L.B.; Rosenow, J.M.; Steiner, M.; Parrish, T.; Guernon, A.; Harton, B.; Patil, V.; Bhaumik, D.K.; McNamee, S.;Walker, M.; et al. Placebo-controlled trial of familiar auditory sensory training for acute severe traumatic brain injury:

[22] A preliminary report. Neurorehabilit. Neural Repair 2015, 29, 537–547. [CrossRef] Padilla, R.; Domina, A. Effectivess of sensory stimulation to improve arousal and alertness of people in a coma or persistent vegetative state after traumatic brain injury: A systematic review. Am. J. Occup. Ther. 2016, 70, 7003180030p1–7003180030p8.[CrossRef] [PubMed]

[23] Formisano, R.; Vinicola, V.; Penta, F.; Matteis, M.; Brunelli, S.; Weckel, J.W. Active music therapy in the rehabilitation of severebrain injured parients during coma recovery. Ann. Ist. Super. Sanita 2001, 37, 627–630.

[24] Magee, W.L.; Clark, I.; Tamplin, J.; Bradt, J. Music interventions for acquired brain injury. Cochrane Database Syst. Rev. 2017, 1,1465–1858. [CrossRef] [PubMed] Li, X.; Li, C.; Hu, N.; Wang, T. Music interventions for disorders of consciousness: A systematic review and meta-analysis.

[25] J Neurosci. Nurs. 2020, 52, 146–151. [CrossRef] [PubMed] Magee, W.L. Music in the diagnosis, treatment and prognosis of people with prolonged disorders of consciousness.

[26] Neuropsychol. Rehabil. 2018, 28, 1331–1339. [CrossRef] Pool, J.; Magee, W.L. Music in the treatment of children and youth with prolonged disorders of consciousness. Front. Psychol.2016, 7, 202. [CrossRef]

[27] Grimm, T.; Kreutz, G. Music interventions in disorders of consciousness (DOC): A systematic review. Brain Inj. 2018, 32, 704–714.[CrossRef]

[28] Riganello, F.; Cortese, M.D.; Arcuri, F.; Quintieri, M.; Dolce, G. How can music influence the autonomic nervous system response in patients with severe disorder of consciousness? Front. Neurosci. 2015, 9, 461. [CrossRef]

[29] Schnackers, C.; Magee, W.L.; Harris, B. Sensory stimulation and music therapy programs for treating disorders of consciousness.Front. Psychol. 2016, 7, 297. [CrossRef]

[30] Altenmüller, E.; Schlaug, G. Apollo's gift: New aspects of neurologic music therapy. Prog. Brain Res. 2015, 217, 237–252. [PubMed]

[31] Brown, R.M.; Zatorre, R.J.; Penhune, V.B. Expert music performance: Cognitive, neural, and developmental bases. Prog. Brain Res.2015, 217, 57–86. [PubMed]

[32] Luauté, J.; Dubois, A.; Heine, L.; Guironnet, C.; Juliat, A.; Gaveau, V.; Perrin, F. Electrodermal reactivity to emotional stimuli in healthy subjects and patients with disorders of consciousness. Ann. Phys. Rehabil. Med. 2018, 61, 401–406. [CrossRef]

[33] Rollnik, J.D.; Altenmüller, E. Music in disorders of consciousness. Front. Neurosci. 2014, 8, 190. [CrossRef] [PubMed]

[34] Boltzmann, M.; Schmidt, S.B.; Gutenbrunner, C.; Krauss, J.K.; Stangel, M.; Höglinger, G.U.; Wallesch, C.W.; Münte, T.F.;

[35] Rollnik, J.D. Auditory stimulation modulates resting-state functional connectivity in unresponsive wakefulness syndrome patients. Front. Neurol. 2021, 15, 554194. [CrossRef] [PubMed]

[36] Heine, L.; Castro, M.; Martial, C.; Tillmann, B.; Laureys, S.; Perrin, F. Exploration of functional connectivity during preferred music stimulation in patients with disorders of consciousness. Front. Psychol. 2015, 6, 1704. [CrossRef] [PubMed]

[37] Heine, L.; Tillmann, B.; Hauet, M.; Juliat, A.; Dubois, A.; Laureys, S.; Kandel, M.; Plailly, J.; Luauté, J.; Perrin, F. Effects of preference and sensory modality on behavioural reaction in patients with disorders of consciousness. Brain Inj. 2017, 31,

[38] Mandeep , Navin Chitkara et al,traumatic brain injury: early intervention by coma arousal. The india journal of neuro trauma,10 ,2013.13-18.

[39] Dr. Ganesan arumugan, dr brammatha et al, effect of right side median nerve stimulation along with multisensory coma stimulation programe on level of conscioussness and neurobehaviour function among diffuse axonal injury patients. Int J Physioth Res 2013 (3):83-87.

[40] Alashram AR, Annino G, Aldajah S, Bani Hamad S, Aliswed B, Padua E. Effects of sensory stimulation on level of consciousness in comatose patients after traumatic brain injury: A systematic review. Physiotherapy Practice and Research. 2020 Jan 1;41(2):143-53.

[41] Jiaojiao Z, Yanling T, Min L, Li F, Yang Y, Limei L. The effect of family-centered sensory and affective stimulation on comatose patients with traumatic brain injury: A systematic review and meta-analysis. International Journal of Nursing Studies. 2020 Dec 7:103846.

[42] Yekefallah L, Namdar P, Azimian J, Mafi M. The effects of musical stimulation on the level of consciousness among patients with head trauma hospitalized in intensive care units: A randomized control trial. Complementary Therapies in Clinical Practice. 2020 Nov 12:101258.

[43] Sedghi T, Ghaljeh M, Faghihi H, Sarani H. The Effect of Auditory and Tactile Stimulation by a Family Member on the Level of Agitation in Patients with Traumatic Brain Injury and Decreased Consciousness: A Quasi-Experimental Study. Medical-Surgical Nursing Journal. 2020 May 31;9(2).

[44] Li J, Cheng Q, Liu FK, Huang Z, Feng SS. Sensory stimulation to improve arousal in comatose patients after traumatic brain injury: a systematic review of the literature. Neurological Sciences. 2020 Apr 22:1-0.

[45] Megha M, Harpreet S, Nayeem Z. Effect of frequency of multimodal coma stimulation on the consciousness levels of traumatic brain injury comatose patients. Brain injury. 2013 May 1;27(5):570-7.

[46] Urbenjaphol P, Jitpanya C, Khaoropthum S. Effects of the sensory stimulation program on recovery in unconscious patients with traumatic brain injury. Journal of neuroscience nursing. 2009 Jun 1;41(3):E10-6.

[47] Meyer MJ, Megyesi J, Meythaler J, Murie-Fernandez M, Aubut JA, Foley N, Salter K, Bayley M, Marshall S, Teasell R. Acute management of acquired brain injury Part III: an evidence-based review of interventions used to promote arousal from coma. Brain Injury. 2010 May 1;24(5):722-9.

[48] Salmani F, Mohammadi E, Rezvani M, Kazemnezhad A. The effects of family-centered affective stimulation on brain-injured comatose patients' level of consciousness: A randomized controlled trial. International journal of nursing studies. 2017 Sep 1;74:44-52.

[49] Padilla R, Domina A. Effectiveness of sensory stimulation to improve arousal and alertness of people in a coma or persistent vegetative state after traumatic brain injury: a systematic review. American Journal of Occupational Therapy. 2016 May 1;70(3):7003180030p1-8.

[50] Moattari M, Shirazi FA, Sharifi N, Zareh N. Effects of a sensory stimulation by nurses and families on level of cognitive function, and basic cognitive sensory recovery of comatose patients with severe traumatic brain injury: a randomized control trial. Trauma monthly. 2016 Sep;21(4).