The Hidden Symphony: Sonic Proxemics with AI
The Intimacy and playful politics in mixed reality

1 Abstract

In the wake of the COVID-19 pandemic, research on proxemics has become increasingly relevant yet remains underexplored. This study addresses this gap by proposing the use of immersive theatre to re-evaluate interpersonal interactions in public spaces post-pandemic. By integrating motion detection and biophysical sensors in smart suits as interactive triggers, this research explores new methods to enhance well-being. It focuses on the dynamic relationships between humans and non-organic entities such as robots and AI agents in mixed reality environments, allowing participants to engage through 'tele-presence'. By uncovering the invisible social connections—how individuals associate or isolate from each other—this study aims to contribute to public mental health, offering a playful and innovative approach to bringing people together.

2 Introduction and Objective

Recent developments in mental health care have heightened the need for re-examining the social support system and the influence of isolation. The 2022 OECD Health Statistics indicate a twofold increase in symptoms of depression in several European countries during the pandemic, attributed in part to anti-COVID policies like mandatory social distancing and quarantine, leading to heightened social isolation, a known precursor to depression (see Figure 1) [1]. Similarly, Balakrishnan et al.'s investigation on COVID-19 depression in Asia-Pacific shows that the isolation-related risk factor (i.e., 'living alone/isolation' and 'lack of social support/community support') is the third highest, following 'fear of COVID-19 infection' and 'gender' [19]. According to OECD report, social isolation is one of the main factors resulting in the increased spread of depression and anxiety across all age groups [1].
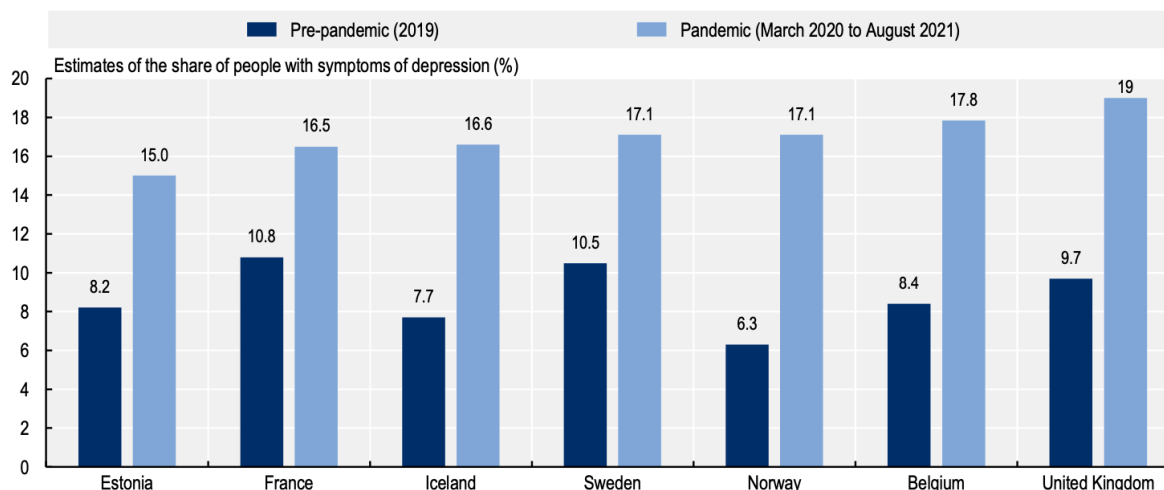

Figure 1. Symptoms of depression were double those of pre-pandemic levels in a number of European countries [1]

As societal dynamics shift, online meetings have become the predominant mode of communication, altering the notions of 'being there' and 'being with someone.' In response, this study seeks to reevaluate Edward T. Hall's proxemics model within the context of post-COVID life, where digital interactions hold equal importance to in-person relationships. Several studies investigating proxemics have been carried out on media and communication fields. However, far too little attention has been paid to 'tele-presence' or 'tele-participation', which shakes the definition of 'space' in the traditional sense. As highlighted by Drąg (2020), failure to consider this transformation of the role of space in communication using modern technologies can increasingly weaken the cognitive value of traditional communication models [2].

Moreover, the integration of social robots and artificial intelligent companions into daily life, as envisioned by Bruno Latour and Donna Haraway, highlights the growing presence of non-human entities. This is supported by Novice and Rodriguez's study (2021) which reveals that "while the real-world proxemics of human-human interaction have been well studied, the virtual-world proxemics of human-agent interaction are less well understood" [13]. Current literature includes only a few studies on 'proxemic interaction' and its visualisation, with a noticeable dearth of research on audio-related aspects. The study by Ghaimi et al. (2022) examined the application of proxemic map in virtual reality which points toward that "using proxemics to perform new interactions in an immersive environment has not been systematically explored" [14]. In addition, study by Camara and Fox (2022) found that "robot navigation in environments with static objects is largely solved, but navigating around humans in dynamic environments remains an active research question for autonomous vehicles (AVs)" [9]. In other words, Hall's proxemics model has become insufficient for explaining the evolving interaction dynamics between humans and objects. "The proxemic utility needs to be given in the form of continuous functions corresponding to the continuous motion of people. A review of the literature showed that there is no available method to infer the continuous proxemic functions," indicated Camara and Fox. Thus, this study incorporates autonomous robots and Artificial Intelligence (AI) agents into the experimental design, framing it as immersive theatre with a specific emphasis on sound. This approach aims to develop a more comprehensive understanding of proxemics, highlighting the continuous interactions among individuals in phygital spaces that mirror our mixed reality.

Through augmenting human senses during interactions and incorporating non-human agents, this study aims to leverage the COVID-19 experience as a catalyst for reimagining interpersonal interactions in public spaces. This study goes beyond

physical distance to explore the potential for cultivating meaningful connections and a sense of social closeness that promotes anticipation of trust through technology.[1]

3　中文摘要

本研究結合實驗劇場與社會人類學分析，探討後疫情時代下的人際互動距離，包含遠端臨場 (tele-presence) 和數位參與如何影響人與科技產物的空間行為學 (proxemics)。根據2022年經濟合作暨發展組織(OECD) 健康數據統計，新冠疫情後多數成員國民眾的抑鬱症傾向為新冠疫情前的兩倍。防疫政策下「保持社會距離」與「強制隔離」措施所造成的社會孤立，除易導致抑鬱、沮喪等情緒外更是引起自殺的成因之一。全球流行的新冠疫情長達三年，即便各國已陸續解除防疫措施，但疫情帶來的影響仍持續發酵，例如：遠端工作與線上會議已變成工作常態，數位學習亦成為與同儕互動的新模式。換言之，疫情催化了人們對「實體結合虛擬」的空間感知與人際互動方式，單純只研究物理空間中的社會關係並不足以解釋當代現狀。國外許多研究已指出防疫措施例如戴口罩，確已造成人們不敢任意侵擾他人領域的心理影響，又或是僅限於線上互動的交往模式將使真實世界中的人際溝通日漸衰微。

再者，隨著社交機器人在國際間普遍導入社福照護體系，以及人工智慧的崛興與廣泛應用，在在應證了行動者網絡理論開創者布魯諾・拉圖爾 (Bruno Latour)與後人類女權主義學者唐娜·哈洛威 (Donna Haraway)在九〇年代的洞見 — 需將非人類實體納入社會發展的整體脈絡中思考。因此本研究將以人類學家愛德華・霍爾(Edward T. Hall)的空間行為學為根基，運用智慧化紡織品設計一套能反應人際互動距離的智能泡泡裝作為實驗裝束。此泡泡裝內嵌移動偵測感應與眼動追蹤器，受試者若在霍爾定義下的personal zone，兩者的泡泡裝將會自動產生最豐富的聲響(如：七和弦)。若距離落在social zone, 兩者的泡泡裝會產生較單純的聲響(如：三和弦或單音)。當兩人距離落在public zone時，兩者的泡泡裝只會產生不同顏色的亮光，而無聲響。最後，當受試者的位置脫離public zone但仍在會場中，他的泡泡裝將保持透明，既不會改變顏色也不會產生任何聲音。所有受試者會配戴腦波偵測器(EEG)以及相關配備以搜集受試過程中的情緒與生理變化，例如體溫、心跳、喚醒反應等。這些即時數據將被同步輸入系統，取其平均值來決定機器人進入會場的移動速度與其他人類受試者的互動距離等。本互動實驗共有四階段，依參與對象區分為：(一)受試者全部為人類、(二)人類與機器人(程式操控)、(三)人類與「機器-人」(由無法親臨現場的人類遠端操控)、以及(四)人類與各種機器人(包含程式操控與遠端臨場操控)。互動實驗完成後，受試者將參與焦點小組座談。研究人員於團體討論結束後，會運用回溯放聲思考法 (retrospective Think Aloud Protocol) 與每位受試者進行最後的深度訪談。本研究將以唐・伊德 (Don Ihde)的科技現象學為觀察視角，在實體空間透過聽覺化與視覺化的方式測試人際與人機之間的互動，檢證霍爾理論; 同時，透過混合實境空間 (Mixed Reality) 的匿名性與遊戲性，消弭文化、年齡、性別等偏見，探討決定人際與人機之間互動的關鍵因素。透過對空間行為學嶄新的當代詮釋與在地展演、愛爾蘭與台灣的跨文化比較，進而提出促進人際交往以及人機共融的新取徑。

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[1] Jiménez, S., Mercadillo, R.E., Angeles-Valdez, D. *et al.* Social closeness modulates brain dynamics during trust anticipation. *Sci Rep* **12**, 16337 (2022). https://doi.org/10.1038/s41598-022-20827-y