Is computer field mature enough to be used as a tool in psychology?

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Abstract. *The last two decades have shown an increasing number of studies involving "virtual psychotherapists" and robot caregivers of humans with cognitive, social, behavioral deficits or some other type of disorder. A characteristic of these studies is the need to combine actors of the computer, psychology and psychiatry areas. To establish the needs and contributions of these actors we conducted searches in two different databases: PsycoInfo of the American Psychological Association (APA) and Web of Science of the Clarivate Analytics. If, on the one hand, this analysis reveals the fundamental contribution of psychology in the development of applications to meet the demand for virtual agents and social robots, on the other hand, the analysis also identified the contributions and factors that still need to be addressed to enable the widespread use of these agents as a support tool in psychology and psychiatry clinics.*

1. Introduction

The World Robotics 2021 [IFR Press Room 2021b] indicates that the service robot market reached a global turnover of 6.7 billion in 2021 with an increase of 12% compared to 2020. The global pandemic represented one of the catalysts of this expansion by limiting the direct contact between human beings. Despite this increase in revenue, the report also states that human-robot collaboration is still in its infancy [IFR Press Room 2021a].

From the moment that social robots begin to interact directly with humans, it is desirable that communication be performed at a cognitive level appropriate for the ongoing interaction. To achieve this goal, it is necessary to use an area of science that is almost unfamiliar to computer researchers: psychology. Only the understanding of human nature allows its modeling and implementation in computer systems present in social agents. The field of psychology that acts in this direction is "cognitive psychology", which includes the study of "how people perceive, learn, memorize and reflect on information" [Sternberg and Sternberg 2012, p. 3]. A cognitive psychologist can, for example, study how people recognize different forms, why they remember some facts and forget others or how they learn a language.

The common interests of cognitive psychology, artificial intelligence and linguistics created a new area called "cognitive science". This term appeared in 1975 in the book Explorations in Cognition [Norman and Rumelhart 1975, p. 409] and quickly spread.

Indeed, there is a natural connection between cognitive psychology and cognitive science causing these research topics to be often intertwined.However, it is important to note that these are areas have different interests: in cognitive psychology, the focus is directed to "how the human being learns, changes and recovers knowledge"; in cognitive science, the focus is directed to "model and reproduce the processes that lead to knowledge".

In light of the foregoing, we can say that psychology plays an essential role in the use of computer social agents in interactions with humans. Thus, a naturally born question is as follows:

"What is the contribution of computer area professionals in creating systems that can be used by professionals in the areas of psychology and psychiatry in the assessment, identification and monitoring of disorders? Also, what are the factors that inhibit the widespread use of these systems?"

This work seeks to answer these questions through systematic research in a specific database for psychology: PsycoInfo of the American Psychological Association (APA) [APA PsycoInfo 2023]. We also present the search result in the Web of Science database [Web of Science 2023] which has a broader technological scope than PsycoInfo.

The criteria used in this search are detailed in Section 2. The search result analysis is presented in Section 3. Finally, in the Section 4 we present the principal findings and the work conclusions.

2. Method

Our objective is to obtain the state of the art in the use of robots and virtual agents in applications involving "virtual psychotherapists" and robots capable of supporting the treatment of mental disorders. The method to obtain this information uses a search in two databases: PsycoInfo [APA PsycoInfo 2023] and Web of Science [Web of Science 2023].

This systematic research uses elements proposed by Gough et al. [Gough et al. 2012]. Basically, the following steps are defined: 1. Determine the search key from the question raised in the previous section (*What is the contribution of robotics ...*); 2. Obtain the list of references by searching the databases; 3. Export the references selected to generate a local database; 4. Analysis of each reference by classification according to the research focus.

The first step involves determining the search key. If the key is vague, we will have thousands of references, on the other hand, if very specific, the references number may be insufficient for the analysis. This study uses the following search key:

> *psychol* AND disorder AND (comput* OR "artificial intelligence" OR "Machine Learning" OR robot*)*

These terms were searched in the fields: Title, Abstract and Keywords. The search period covers 5 years (2017 to 2021).

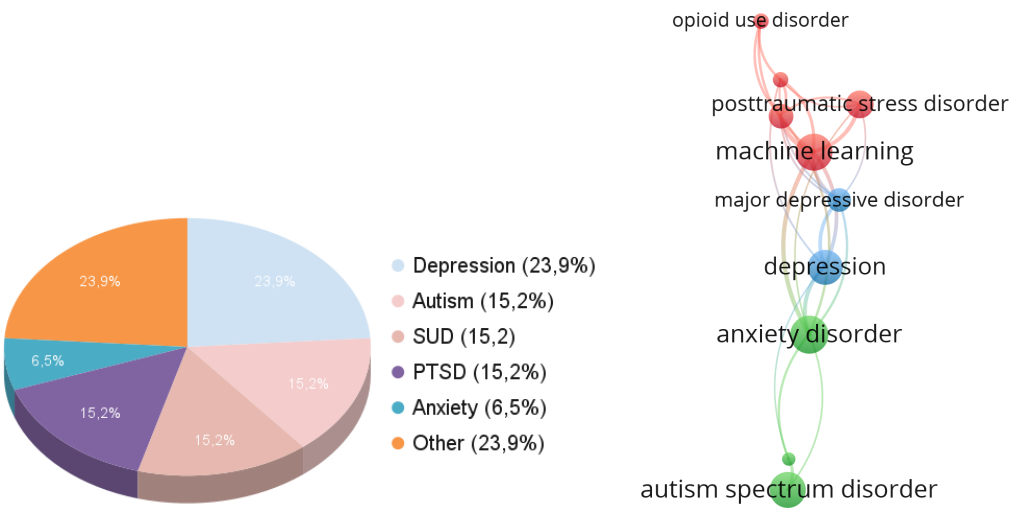
3. Search Result Analysis

3.1. Analysis of PsycoInfo results

The search revealed 259 references. Of this total, 46 references were accepted, and 213 were rejected (out of scope=176, reviews=34 and duplicates=3). The result analysis requires the definition of groups to classify each accepted reference considering the scope of our research. In the Table 1 is presented the groups defined, as well as a brief description of their objective. The detailed result of this classification can be seen in the spreadsheet available in the Google Drive [Larissa Braga Mota and Daniel Yuji Hosomi 2023].

Table 1. Reference classification groups.

Group	Observation
Focus	Class of disorder: Autism Spectrum Disorder (ASD), Depression, Anxiety, Posttraumatic Stress Disorder (PTSD), Substance Use Disorder (SUD), Other.
Procedure	Type of intervention: Psychological Assessment, Therapy, Observation, Other.
Resource	Resource used to address the problem: Machine Learning, Artificial Intelligence, Ontology, Knowledge Base, Procedural, Statistical, Other.
Characteristic	Defines the characteristics captured by the sensors to perform the study: Response Time, Gesture, Physiological Signals, Body Posture, Prosody, Facial Expression, Interview, Other.
Dataset	Did the research group provide the results of the study?: Available, Unavailable, Absent.
Subject	Number of participants used in the study.
Age	Participants age.
Interface	Interface used to communicate with the participant: Robot, Screens, Depth Camera, Leap Motion, Augmented Reality, Virtual Reality, Other, Absent.
Duration	Presents the duration of the experiment in weeks.



(a) Most common disorders in references (b) Map with frequent terms

Figure 1. Focus of the disorders identified in the references

Focus Group: Regarding the terms most present in the articles, we have depression, anxiety disorder, autism spectrum disorders, machine learning and post-traumatic stress disorder (see Fig. 1(b)).

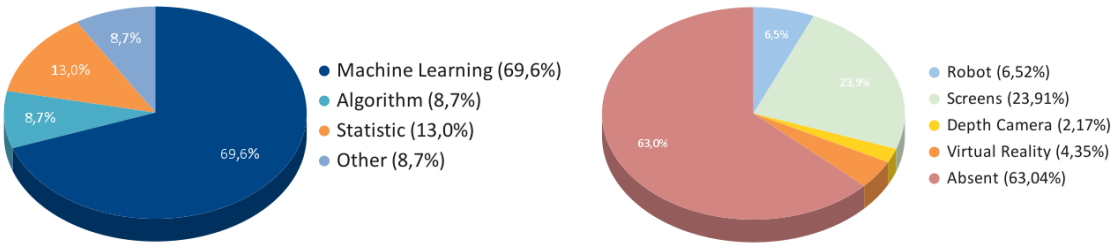
Depression was the most common disorder, corresponding to 23.9% of the articles, followed by Autism Spectrum Disorder (ASD), Post Traumatic Stress Disorder (PTSD) and Substance Use Disorder (LDS) corresponding to 15.2% each. Anxiety disorder appeared in only 6.52% of the articles. The remainder of the articles (23.91%) were classified as "Other" because they did not designate a specific disorder or because they were articles with different themes (see Fig. 1(a)).

Procedure Group: Regarding the means by which the study was directed, we have "psychological assessment" and "therapy". The psychological assessment process was present in 80.4% of the articles analyzed. It can be said that most researchers have appropriated computational approaches such as ML to enhance and favor psychological assessment processes in a clinical context. As examples we have studies to predict the course of a disorder, search for determinants for prognosis, or still clinical support for a diagnosis. On the other hand, the therapy intervention type covered 19.6% of the articles analyzed and designated the interest field of researchers who sought to implement and use new technologies and interfaces in psychotherapy processes, especially with regard to Cognitive Behavior Therapy (CBT) [American Psychological Association (APA) 2023], highlighting this form of treatment for individuals with autism or depression.

Characteristic Group: Most of the articles were classified as "Other" (65.2%) because they used questionnaires and/or scales as the main input data for the studies. However, it is worth highlighting the interviews which correspond to 9 of the 46 articles analyzed (19.5%). In this case the objective is the construction of new datasets.

Subjects Group: With regard to subjects, we identified a wide variety in the number of participants among the references analyzed. We have studies with only 1 participant and national studies with up to 40,000. However, more than two-thirds of the studies (71.1%) used 1 to 999 participants, and 28.8% used more than 1000.

Age Group: Most articles (95.4%) focused on a population of young people and adults, ranging from 18 to 64 years of age.



(a) Resource distribution (b) Interface distribution

Figure 2. Resource and interface distribution of the references.

Interface Group: In Fig. 2(b) we present that the use of questionnaires for further automated analysis predominates with 63.04%. Second, with 23.91%, we have screens (monitors, touch screen and web). Next, Robots (6.52%) and Virtual Reality (4.35%).

Resource Group: Regarding resources, that is, the computational tools and approaches used for each problem, machine learning (ML) technology is the most frequent with a correspondence of 69.6%. In addition to ML, we also have other computational methods, such as statistical models and procedural programming, each corresponding to 13% and 8.7%, respectively. (see Fig. 2(a)). The first is generically present in practically all studies, since statistical analysis is a very important technique in the survey of a dataset. On the other hand, procedural programming is more commonly found in works that use computer or smart phone application. Finally, 4 studies (8.7%) were classified as "Other" because they use other types of computational approaches that are not described above.

Dataset Group: An important aspect of a study is the dataset access by other groups, either to validate the results or to use the dataset as a basis for a new research. Unfortunately, only 10.8% of the studies provided access to research data.

Duration Group: Finally, when considering the duration of the studies, 43.5% built a new dataset for analysis and 23.9% used a consolidated dataset. Of the studies that built a new dataset, 50% consumed less than 8 months for its elaboration.

3.1.1. Synthesis of quantitative results

In our analysis, we have nine views of the same article produced from the groups classification defined in Table 1. From these views we can affirm that:

- A total of 95.4% of the studies used adults as their main focus.
- Ninety-seven percent of (first) authors wrote only one article as first author on the topic in the last 5 years. This fact indicates that either this is a very recent topic, or the original work has not been continued.
- A total of 80.4% of the studies use psychological assessment in the clinical context as a type of intervention.
- A total of 69.6% of the implementations use machine learning techniques as a computational resource.
- A total of 82.6% of the implementations do not provide the dataset.
- A total of 63.0% did not use a concrete interface, such as robots or screens.

3.1.2. Highlighted works

In our study some interesting relationships were identified between the classification groups, mainly among the fields Subjects, Duration, and Procedure.

Studies using a smaller number of participants have a short duration ranging from one week to a maximum of one year. In this case, the most common interfaces involve robots and virtual reality. The main focus is autism disorder and the most common type of intervention is therapy. In this group, two important studies are noteworthy.

Maskey et al. [Maskey et al. 2019] used virtual reality (VR) to perform interventions with autistic children who have some type of fear or specific phobia. In each Cognitive Behavior Therapy (CBT) session [American Psychological Association (APA) 2023], the child receives relaxation and breathing techniques; then, accompanied by the

psychologist, the child is exposed to VR scenes involving specific phobia. After the CBT sessions, the child reports his/her anxiety and confidence level and receives coping strategies. In the work of David et al. [David et al. 2018], the study involved the use of robots in therapy to verify the differences in the levels of attention of autistic children. During the sessions, the children were invited to interact separately with both humans (psychologist) and robotic agents (mediated by the therapist).

On the other hand, studies with a large number of participants use psychological assessment with the use of machine learning. Thus, the duration of the study is not easily identified due to the use, for the most part, of an already consolidated dataset. In this context, many articles do not use technological interfaces (e.g. robots, augmented reality, etc.) but focus on predicting the prognostic trajectory of a given disorder in a large number of participants present in the dataset. The work by Bokma et al. [Bokma and et.al 2020] is noteworthy, in which the authors aimed to describe the course of anxiety disorder for two years of 887 subjects using clinical, psychological, sociodemographic, lifestyle and biological factors. In another interesting study, Wardenaar et al. [Wardenaar and et al. 2021] proposed an ML approach to predict the main determinants that influence the depression course over 9 years from previously collected clinical data.

Despite not being present in our analysis base, two reviews deserve to be highlighted. In the first, Trevisan et al [Trevisan and et al. 2019] presented a review on the use of computational technologies in Applied Behavior Analysis (ABA) [American Psychological Association (APA) 2023], which seeks to increase helpful behaviors and reduce harmful ones. The researchers found that most articles in this area are conducted in children, with autism being the main investigated disorder, and the main computational technologies used are robots and touch devices. In addition, they state that most of the studies were under development phase and did not reach user tests.

In the second featured review, Sartorato et al. [Sartorato et al. 2017] present a review on the use of social robots as a therapeutic tool in the diagnosis and treatment of Autism Spectrum Disorder (ASD). The authors state that "robotic interactions are inherently more controlled, predictable and simplistic, generating less frustration for individuals with ASD who may have difficulty interpreting and responding to human social interactions".

3.2. Analysis of "Web of Science" results

As a way to counteract the search conducted in the PsycoInfo database, an additional search was performed in the Web of Science databaseWeb of Science 2023. This search revealed 1,243 references with the same key and the same period used in the previous search. When comparing the results, we identified 156 common references between both databases.

The Web of Science defines categories for research areas grouping: Arts & humanities, Life Sciences & Biomedicine, Physical Sciences, Social Sciences and Technology. Special attention should be given to the "Social Sciences" category, which is directly associated with the field of psychology. The references classified in this category represent only 23.45% of the results achieved. On the other hand, the categories "Technology" and "Life Sciences & Biomedicine" represent 33.90% and 66.99%, respectively.

The "Technology" category includes research areas such as Artificial Intelli-

gence, Engineering Electrical Electronic, Computer Science Theory Methods, Cybernetics, Telecommunications, Engineering Biomedical and Robotics. In this case, the objective is to develop technologies that allow modeling psychological aspects for the implementation of systems, robots and virtual agents.

The category "Life Sciences & Biomedicine" includes the following research areas: Psychiatry, Neurosciences, Medicine General Internal, Public Environmental Occupational Health, Health Care Sciences Services, Medical Informatics and Clinical Neurology. In this case, the objective is the use of technology for the analysis and classification of medical examination results with the use of statistical and machine learning techniques.

The lower concentration of references in the "Social Sciences" category confirms that the concrete use of robots and virtual agents such as "virtual psychotherapists" or robot caregivers is still in a maturing phase.

Considering the acceptance of the robots use by psychologists, we have the work of Conti et al. [Conti et al. 2019], who investigated the cultural influences of English and Italian psychology students on the perception of the robots use as a tool for future clinical practices. The study with 158 psychology students concluded that the acceptance of the use of a social robot in psychological practice in the near future is positive for Italians and negative for English. However, most respondents, both English and Italian, revealed that they did not have the necessary skills to make good use of the robot.

In an interesting article on the subject, Provoost et al.Provoost et al. 2017 conducted a review on the use of Embodied Conversational Agents (ECA) in psychotherapeutic applications. After selection, the search revealed 49 studies associated with the following mental disorders: autism, depression, anxiety disorder, posttraumatic stress disorder, psychotic disorder and substance use. According to the author, "ECA applications are very interesting and show promising results, but their complex nature makes it difficult to prove that they are effective and safe for use in clinical practice". The strategy suggested by Provoost et al. involves increasing the evidence base through interventions with the use of low-tech agents that are rapidly developed, tested and applied in responsible clinical practice.

4. Discussion

The main focus of our analysis was intelligent agents capable of interacting autonomously with patients through an autonomous robot or a virtual agent. This guideline excludes, for example, the "Wizard of Oz" technique [Riek 2012] or robotic telemedicine where the agent is teleoperated by a human who effectively assumes the system's cognition.

Our research indicates that the use of social robots as support in psychotherapy is still in its initial stage. However, these types of systems represent the latest addition to psychotherapeutic practice, supporting a series of emotional, cognitive and social processes [Eichenberg and Kusel 2018].

4.1. Principal Findings

Currently, some technological issues represent one of the limitations in the use of social robots as a tool in psychology. In particular, cognitive science seeks to model aspects of human cognition in computational systems. The most commonly used methods for this

modeling involve artificial intelligence, machine learning and ontologies. Unfortunately, due to the technological limitations of these methods, some quality attributes are not fully met, in particular reliability, usability, efficiency and maintainability.

These quality limitations compromise the confidence of psychologists in the use of robots or virtual agents as a tool. According to Fiske et al. [Fiske et al. 2019], the main points of skepticism are as follows:

- Ethical issues: The use should be subject to the same type of privacy, risk assessment and supervision to which the professionals of the area undergo during their clinical practice.
- Gaps in regulatory legislation: The dynamics of development creates difficulties in the creation of legislation that incorporates the peculiarities of new technologies. This difference in speed creates the risk of updating the legislation only after the patient has been harmed.
- Omissions in the protection of confidential data: The privacy of patient data should be the basic premise in the system design and development phases.
- Lack of clarity in the actions performed by the algorithms: Every action performed by the system should be auditable by a supervising psychologist.
- Political use of the solution: The difficulty in accessing public mental health treatment can be used as a justification for the rapid automation of care. In this case, the risk is to relieve an inefficient mental health system at the expense of service quality.
- Risk assessment: Health professionals are required to inform the authorities when the patient may put themselves or others at risk. This is a feature that should be incorporated into the agent.
- Long-term use: The human may develop affection for the agent that accompanies him. In this case, the approach can mask the problem and further exacerbate the human relationships that catalyze the disorder.
- Failure of discernment in AI algorithms: AI algorithms may not necessarily be wrong. The point is that they are trained from data collected in a world that is intrinsically prejudiced, unfair and superficial. Thus, AI algorithms simply reproduce this world without offering opportunities for evolution considering empathy and compassion.

It is noteworthy that the interventions of robotic or virtual agents can be potentially more successful than traditional modalities, either because they address populations of difficult access or because patients respond better to them.

4.2. Identify the Headings

The distrust signaled by psychologists regarding the use of robots in psychology clinics can be minimized with a change in the behavior of roboticists during the development of the system. The following questions should be addressed.

- Transparency of the algorithms: The system should always be able to justify the action taken by a “supervising psychologist”.
- Joint development: The user of the system is a patient of the psychologist; thus, it is only natural that a psychologist is present in all stages of the system development.

- Longitudinal studies: technology professionals are used to restricted development deadlines. When development involves social science, studies need to be longitudinal with a test period that can involve years. The release for commercial use of a product quickly tested in a laboratory is not appropriate in the psychology field.

4.3. Future trends

In recent years, the pressure of society to discipline the use of technology, especially artificial intelligence and robotics, has catalyzed movements to ensure that safety and ethics are considered basic requirements in systems. This movement ranges from documentaries on polarization in algorithms [Kantayya 2020] to expert forums [ETHICS IEEE 2021, ICRES 2022]. Clearly, the more systems invade human beings' privacy, the more developers need the contribution of psychologists, psychiatrists, sociologists and lawyers to address ethical and social aspects.

The results presented in this study indicate that, in the short term, robotic agents will not reach the cognitive levels necessary for autonomous interactions in the field of human psychology. However, the difficulties in modeling autonomy and cognition did not reduce the volume of work in the area. In fact, currently research seeks to build a solid knowledge base to meet the requirements of robotic and virtual agents acting as relevant tools in the areas of psychology and psychiatry.

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