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Social Assistant Humanoid Robots for Dementia of the Elderly: A Scoping Review

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Abstract: In recent years, many cognitive care robots have been developed. There is also a form of the companion pet, and there are also robots that can be personified and talk with the elderly. Also, some telecommunications equipment can be replaced to help older people connect to the telecommunications community. However, the need for such robots is still unclear in the focus of this area of being able to interact, talk to, and connect with family and society. Although many studies in the existing literature that tell how to research to verify their efficacy, methods of defining effects can pave the way for future studies. This is what this article will show. The article included qualitative research searches and screenings, effect summaries, and research method analysis. The problem to be solved in this article is how to use and measure the effectiveness of conversational humanoids in nursing elderly patients with cognitive impairment. We also hope to provide some guidance for future research on cognitive impairment.

Keywords: Elderly care; Dementia; SAR; SAHR; Nursingrobot; Humanoid robot

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1 Introduction

The labor and industry shortages brought about by the pressure of an aging society are moving towards a more automated and mechanized society. Japan entered the super-aged society for the first time in 2007, and the proportion of the elderly population reached 28.7% in 2019(Japan MHLW.2019). Due to the super-aging rate and declining birth rate, Japanese society is facing a serious labor shortage. In the nursing care field, where the demand for labor human resources is expected to increase with the aging of society, the demand for nursing care services is expected to increase, especially due to the relationship between longevity and disabilities. According to statistics from the Ministry of Health, Labor and Welfare, about 8% to 10% of the total population of people with dementia (vascular dementia and Alzheimer's disease) are aged 65 and over(Japan MHLW.2019). The Ministry of Economy, Trade, and Industry estimates that it will face a shortage of 680,000 workers in the care sector until 2035. A survey on labor economic trends (2019) showed that about 40% of medical and nursing homes report staff shortages (including full-time and part-time therapies).

Elderly people with dementia are attacked by the behavioral and psychological symptoms of dementia (Behavioral and Psychological Symptoms of Dementia, BPSD), in addition to core symptoms such as memory disorders and disorientation due to brain lesions, and poor understanding and language ability. There are peripheral symptoms that cause problems such as physical behavior, wandering, and depression (Finkel S.2000). It is said that BPSD is occurring in a complex manner, and effective intervention and response include "to address both biological and psychosocial factors". Also, rather than the approach to "biological factors", the approach that supports the response to changes in the environment and social relationships, that is, the approach focusing on "psychosocial factors" was widely used(Hiroko Kase 2013). It is expected that the robot will be able to fulfill its role in a sufficiently effective manner if it is put into the care and non-pharmacological treatment of patients with dementia(Izumi Kondo 2018).

Traditional dementia and non-drug countermeasures of BPSD mainly rely on the treatment of medical staff and professional psychophysical therapists to conduct treatment. The key human factor of sociality cannot be separated from the treatment process. Since the year when machinery replaced part of manpower, we have made various attempts using industrial robots, such as robotic arms in the medical industry. After the year 2000, with the development of technical strength, more machines are used for manpower extension. For example, the early Telerobot. and the Suspension base that used the remote control to move medical communication equipment(F. Michaud.2007). Today, we have been able to use machines to simulate humans to perform tasks that had to be performed by humans. Most of the robots discussed in this article fall within this range. In modern society with a manpower shortage, many scholars and researchers have tried to find new ways in the field of robotics and artificial intelligence(Jordan Abdi.2008).

At present, conversational robots are widely used in the field of cognitive impairment. Unlike companion (pet) type robots, the important care assist of conversational robots is to fulfill social participation through dialogue and actions. This can relieve the symptoms of BPSD. Conversational robots mainly refer to robots that can realize conversational functions, and are functionally opposed to pet-type robots. (Socially assistive humanoid robots) As a relatively new concept, humanoid robots are different from pet robots at the beginning of their design, with fewer researches and deviations from the areas shared by pet robots. A large number of medical and pathological related researches on pet robots such as PARO have already existed(Shibata 2009). In comparison, research on humanoid robots is far from complete.

In various researches on how to discuss and define humanoid robots, this article will discuss under the framework of Social Assistant Robot(SAR). At present, the research on pet robots (PARO, etc.) has been very complete and a better model has been established to help us define and understand the role of robots in caring for the elderly(Jordan Abdi.2008). Therefore, This article continues to explore the role and efficacy of humanoid robots (SAHR) from the SAR model. In the conclusions of previous papers, we learned that humanoid robots are more effective than pet-type robots in the “cognitive training” project(Lihui Pu.2019). Therefore, under this premise, we focus on humanoid robots through dialogue and various other interactions (Functions that pet-type robots do not have) and other cognitive training effects under this framework.

2 Methodology

2.1 Aim and design

The study followed the method for carrying out scoping reviews as set out by the Joanna Briggs Institute (The Joanna Briggs Institute, 2015). We developed our research question using the PCC mnemonic (P = Population, C = Concept and C = Context). The research question is: “How to evaluate or define the effect of humanoid robots for people with dementia. The population of interest was people with dementia and caregivers. The use of humanoid robots is already a trend in the future. Obviously, everyone is very interested in how to evaluate future robots with a mature framework. The concept of the framework should be matured by researchers in the framework field and the context was the episode of using socially assistive humanoid robots.

SAR(Social Assistant Robot) framework has five roles. Affective therapy, Cognitive training, Social facilitation, Companionship and Physiological therapy. Among the discussion part, we used the SAR framework to look forward to a better representation of the performance of each research group in each role.

2.2 Paper search / selection method

In this article, we searched the following databases for publications on elderly care robots ranging from 2000 to 2020: NDL, IEEEXplore, CiNii, Web of Science, and google scholar (free).

The search target is as follows.: "Humanoidrobot" OR "Social assistant robot"AND "Elderly care" AND“dementia”, "Nursing robot"AND "dementia", “Humanoid” AND “elder care”, “Care robot” AND “elder care”,etc.

Table 1. Searching terms

Word1		Word2		Word3
Humanoid robot		Elder care		Dementia
Social assistant robot		Elderly care		MCI
Nursing robot	AND	Hospital care	AND	PWD
Humanoid		care		OAwD
Care robot				

Step1:Word1 AND Word2

Step2:Word1 AND Word3

Step3:Word1 AND Word2 AND word3

(Same language, dissimilarity, sensible search: older, elderly, robot, artificial intelligence)

These searches returned a total of 137 articles. Duplicate articles were removed in the initial screening.

Besides, the results restricted the discussion to self-designed or mass-produced humanoid robots (excluding animal robots) and applied inclusion criteria to reduce the number of articles, and obtained the remaining 7 papers.

Finally, attention was focused on humanoid robots that have been tested for a long time in an experimental environment designed at the facility. Seven experiments were drawn for comparison and discussion using six humanoid robots. We also present an assessment of the ease of use of these robots and some experimental feedback.

The first search time for the article was March 2019, and the latest search time was May 2020.

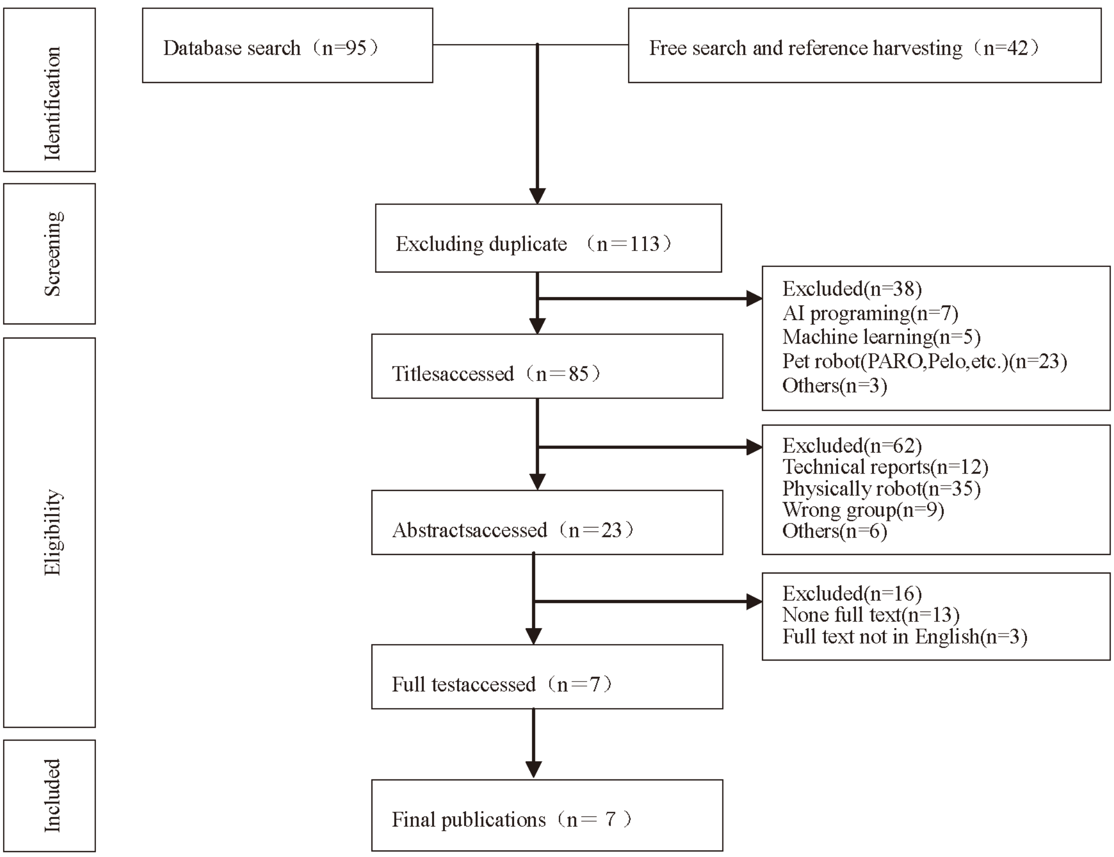

Figure 1. Flows diagram

2.3 Experimental target

There were a total of 135 participants, 5 were nursing support staff, 21 were institutional staff, and the others were elderly people (MCI and PWD, 65 years and older) with a degree of cognitive impairment (n = 109). In addition to the unlisted gender characteristics, the proportion of female subjects has reached 94.45%. Also, the presence or absence of a graphical userinterface (GUI) has some influence on the quantification and review of results. It also describes how to quantify the SAR review criteria for robots that do not with a GUI.

2.4 Robots

Brain2.1: Voice and various auxiliary functions, multiple programmable modules, immobile and no GUI, simple but flexible, and not mass-produced.

Telenoid: Voice and skin-friendly quality, high portability, minimal design language, easier to adapt to user scenarios.No GUI, operating software compatiblewithPC.

ED: Screen and reminder function Task assist. With simple GUI.

Giraff: Video calls Easy to move and support 4G access. GUI and mass-produced.

Kompai: Comprehensive intelligent robot equipment, easy to move, and highly expandable. Highly developed GUI and mass-produced.

Healthbots: Comprehensive Intelligent Nursing Robot Equipment Easy to move, highly scalable, and flexible access to medical equipment. Highly developed GUI and mass-produced.

Table 2. Characteristics of selected studies

No.	Title	Ref.	Robot	Intervention/study design	Setting
1	Brian 2.1 A Socially Assistive Robot for the Elderly and Cognitively Impaired	McColl (Canada)	Brian 2.1	The research measures the involvement of card games and time and interaction to measure robot feeding, acceptance, and attitude.	long-term care facility
2	Teleoperated android as an embodied communication medium: A case study with demented elderlies in a care facility	Yamazaki (Denmark)	Telenoid	Talk to Telenoid in 20 minutes and conducted a qualitative method with the dialogue recording data of the elderly	long-term care facility
3	Collaboration of an assistive robot and older adults with dementia	Begum (Canada)	Ed	behavioral observations, semi-structured interviews, and questionnaires which facilitated the collection of in-depth and diverse data to inform the design of an assistive robot for OAwDs.	iDAPTHomeLab
4	Connecting the person with dementia and family: a feasibility study of a telepresence robot	Moyle (Australia)	GIraff	Five people with dementia and their family member participated in a discussion via the Giraff robot for a minimum of six times over a six-week period.	long-term care facility (Queensland, Australia)
5	Robot services for elderly with cognitive impairment: Testing usability of graphical user interfaces	Granata (France)	Kompai	A group of 11 elderly persons with Mild Cognitive Impairment and a group of 11 cognitively healthy elderly individuals took part in this study. Performance measures (task completion time and the number of errors) were collected.	Broca Hospital
6	Acceptance of an assistive robot in older adults:a mixed-method study of human-robot interaction over a 1-month period in the living lab setting	Wu (France)	Kompai	Participants interacted with an assistive robot in the Living Lab once a week for 4 weeks. After being shown how to use the robot, participants performed tasks to simulate robot use in everyday life.	LUSAGE Gerontechnology Living Lab (located in a building of the Broca Hospital, Paris, France)
7	Improved robot attitudes and emotions at a retirement home after meeting a robot	Stafford (New Zealand)	Healthbots	Participants were given two questionnaires; one before and one after interacting with the robot. After using the robot, participants rated the overall quality of the robot interaction.	Selwyn Village

No.	Participants	Duration	Measure	Outcome
1	MCI(n = 40)	2 days	Questionnaire DNSS nonparametric Mann–Whitney test Cronbach's alpha (a) Spearman's P	1. the participants had a positive experience with the robot, which influenced their motivation to use it again. 2. both the male and female participants, regardless of their computer experience, found the robot easy to use. 3. HRI study presented show promise for the use of a humanlike robot for cognitive interventions and motivate further development and long-term testing of the robot.
2	PWD (n=30)	20 minutes	Questionnaire CIRCA, Networked Interaction Therapy, ECT	1. elderly become more willing to have conversations with Telenoid, the operator can easily communicate with them by responding to their positive reactions based on their growing affection for it. 2. It slowly elicited their spontaneity to communicate with others; whereas the symptoms of dementia include apathy
3	PWD (n = 5) MMSE scores 9,24,25,25,18	2.5 hours	Questionnaire MMSE, semi-structured interview	1. Hard to use the information provided by the human partner with limited perception and cognition 2. Most of the OAwDs showed some level of situational awareness 3. failure to develop a correct mental model of the robot 4. Robot for HRI needs to offer enough sophistication
4	PWD (n = 5) five residents, six family, and seven staff	six times over a six-week period	Questionnaire The semi-structured interviews OERS NoldusObserverXT 11.5 program	1. Positive emotions tended to taper off in the middle of the call 2. dyads used the opportunity for visual cues 7.26 times (SD = 4.59) in each call session to engage with the family member. 3. Participants perceived Giraff as a positive and therapeutic option to engage people with dementia with their family members.
5	MCI(n = 11)11 and 11 cognitively healthy elderly	One session	Wilcoxon signed-rank Kruskal-Wallis chi-squared tests Observer R XT	1. participants in the MCI group (M = 375.16 s) were slower than HC (M = 355.76 s) at completing tasks 2. results showed that speed of performance improved significantly in both groups when adding a product to the list for the second time (MCI: z = 2.38, p = 0.009; HC: z = 2.2, p = 0.01) 3. These findings suggest that two trials were enough to see initial speed differences between age groups disappear.
6	MCI(n=6) and CIH(n=5)	once a week for 4 weeks	Questionnaire Semi-structured interview Wilcoxon matched-pairs test	1. in the CIH group, there was a tendency (P■0.07) toward a decrease of scores in the "attitudes toward robots" dimension. 2. Completion time increased significantly in the MCI group (P=0.028). Errors (P=0.27) and help (P=0.67) in the MCI group, and completion time (P=0.50), errors (P=0.79), and help (P=0.59) in the CIH subjects remained unchanged.
7	Residents (n = 32) and staff (n = 21)	30 minutes	Questionnaire MANOVA PANAS,RAS	1. three of the eight pre- and post-interaction attitudes and emotions were significantly correlated with robot rating.pre-interaction attitudes and emotions are important for robot acceptance 2. after meeting the robot, there were significant improvements in participants'attitude towards robots (F (1, 27) = 25.04, partial eta squared = .48,) as well as decreases in negative affect (F (1, 27) = 4.30, partial eta squared = .14.).

3 RESULT

3.1 Affectivetherapy

Evaluations from 113 participants in six studies in this area revealed that a series of experimental studies on humanoid robots could improve overall mood. A total of six studies reported positive results from the experiment, including a decrease in depression score, an increase in agitation score, and a quality of life score.

Derek McColl and colleagues found that 82% of participants smiled as they showed when the robot performed a fun performance. Of the seven participants who were distracted at least once during the interaction, the robot was then sad, with 57% of the participants looking at the robot and verbally responding to the robot's emotions. I returned to the experiment again. The remaining 43% returned by refocusing on robots and activities.

Yamazaki et al. Have difficulty in continuing verbal communication and nonverbal interactions with Telenoids in people with moderate or severe dementia. It slowly caused spontaneous communication with others, and the symptoms of dementia, including indifference, were alleviated to varying degrees.

Residents tend to show the most positive emotions at the beginning of a call when they first locate their family on Giraffe's screen. The position of the positive emotional call tends to diminish gradually during the call, and the emotional response of the resident is highly dependent on the nature and content of the conversation. (Giraffe)

Besides, a study of Healthbots by Race Queen Stafford et al. showed that more than 80% of subjects were willing to accept robot care and companionship, with robots being most similar to humans in their emotional impact. It was found that there was a correlation.

3.2 Cognitive training

There are four intervention methods for the six types of robots summarized, and it was understood that dialogue is the most important intervention method in the role of humanoid robots in cognitive training.

Table 3. Intervention method summary

Robot	Assign task	Dialogue	game	Dietassistant
Brian 2.1	+	+	+	+
Telenoid (R1)	-	+	-	-
ED	+	-	-	-
Giraff	-	+	+	-
Kompai	+	+	+	-
Healthbots	-	+	-	-

The above intervention methods were categorized by us in the role of cognitive training, and a total of 5 studies, including 103 MCI and PWD, participated with positive results. In the Brain2.1, Ed, kompai, and Healthbot experiments, we found that the experimental project required participants to complete the task with the help of a robot. For example, he performed some parts of modern social life such as card games (Brain2.1), making tea (Ed) under the guidance of robots, sending and receiving e-mails, and online shopping (Kompai). Two of the three studies are based on healthy adults and have repeatedly learned and validated that MCI and PWD can reduce the time to complete tasks and reduce the number of post-learning errors. did. (Kompai) A related study found that under relatively reasonable graphical user interface (GUI) settings, there was no significant difference in the time required for young people with the same learning cost status to complete task operations in MCI. The MCI group took a long time to perform complicated tasks, but given the aging and the existence of physiological conditions, it is certain that elderly people with cognitive impairment can use the robot smoothly.

Table 4. Intervention method summary 2

Interventionmethod	NumberofPapers	Feasibility	Quantify	completion
Assign task	2	+	+	+
Dialogue	4	+	+	+
game	3	+	+	-
Dietassistant	1	-	-	+

Such studies are considered to be very effective, with researchers detailing the workflow and testing when the robot is unnecessary and when it is assisted. Next, the two datasets were compared. As a result, various studies have found that such cognitive training items have been significantly improved.

Besides, the "recognized usefulness" of the questionnaire related to the Brain 2.1 experiment reached 4.37 (out of 5.0, SD=0.96).

3.3 Social promotion

101 participants in five studies evaluated the role of humanoid robots in social promotion and played a good role. Brain research on social existence "When interacting with a robot, I feel like I'm talking to real people," and "sometimes it feels like the robot is

really looking at me," this project also 3.46 (maximum score 5.0, standard deviation 1.46). At the same time, Kompai's survey also received 3.17 feedback (out of 4.0, standard deviation 1.19) in the "social impact" section.

Furthermore, according to Yamazaki et al., Telenoids may be a useful tool for understanding others, especially in dementia care, which could be a training ground for understanding the needs and desires of such elderly people. Nonverbal interaction with Telenoid. It slowly triggered spontaneous communication with others; at the same time, when it comes to dialogue, older people usually do not talk much with anyone, including dolls. However, they used Telenoid to interactively develop conversational topics, incorporating more topics than usual. It was true that there were a few common topics in the dialogue between residents. Elderly people with mild dementia (HSR-D = 19.1 ± 5.0) especially liked talking about Telenoid and seemed to like talking to it. They seemed to have a special interest in Telenoids, which also turned out to be worth discussing.

Telenoid is a means of providing a temporary "conversational stepping stone", working toward improving quality of life and regaining conversational and social confidence to seek and interact socially with others.

Also, the surveys of all five studies reflect the degree of anthropomorphization of the robot by the subject and confidence in the robot, and whether the robot can serve as a good companion for subsequent long-term use. Can be decided to some extent. Although limited by the time of the experiment, the data of the short-term experiment shows the actual effect of long-term use of the humanoid robot, because the experiment produces more positive results mainly due to the freshness (PE) provided by the robot itself. There is a risk that it does not reflect.

4 Companion

Three studies (78 participants) primarily evaluated their effectiveness in overcoming loneliness and social isolation. This result is closely related to social promotion and usually leads to the same conclusion. It should be noted that in the two studies, Giraff and Kompai's experimental time exceeded one month. This may reflect some extent an objective reflection of long-term use. However, as a long-term experiment, some of the studies we included in the discussion did not follow the experiment for more than 4 months. More long-term survey experiments may be needed to avoid data errors caused by the hawthorn effect.

Furthermore, Yamazaki et al. Pointed out that when receiving robot support, some elderly people have disabilities such as not being able to receive robot support. He thinks he is unlikely to be a robot user and shows feelings of rejection and fear. This reflects how difficult it is to quantify companions. Therefore, it also suggests the need for the role that robots play in companions.

5 Physiological therapy

In the past robot evaluation research, PARO and Nao series robots have a lot of RCT research as a reference. Pet-type robots can have good data to represent under the framework of 'physiological indicators' in the SAR framework. But for SAHR, there is not enough research to support us to effectively draw sufficient conclusions under this framework.

In summary, we still need a framework that can correctly evaluate and compare to reflect the advantages, disadvantages, and effects of robots, or sufficient SAHR-related RCT studies to enrich physiological index data to avoid misleading readers or researchers

6 Discussion

6.1 Limitation

6.1.1 Characteristics of selected studies

Since the articles described in this article are limited to the topic of humanoid robots, there are many drawbacks to the consistency of research data and direction. Compared to traditional companion pet robots (such as PARO), we and our researchers face many challenges. Of the six robots described in this article, there are only three mass-produced models, except for two special customizations and low-volume production. The use of these robots is the theme of improving robot products through more exploratory experiments or experimental research. For future research, the application of more mature mass-pro robots will effectively change this situation.

6.1.2 SAR framework restrictions

The SAR framework used in this article did not fully apply to all seven studies. It is unfair to compare a robot that uses a GUI with a robot that directly provides emotional and communication functions without using a GUI, and it is not possible to clearly evaluate the merits of a robot that has a specific function. Currently, humanoid robots that we can define can classify humanoids by appearance and user attitude, but the design intent of these robots did not exactly match the application scenario. For example, both feature phones and smartphones are mobile phones, but they are a little subtle when compared with the same framework. To avoid misleading more readers and researchers, there is still a need for a framework that can correctly assess the advantages and disadvantages of robots and their effectiveness and reflect them horizontally.

6.1.3 The impact of culture and gender on evaluation

Cultural differences also need to be noted, except for one study conducted in Japan, the rest of which is distributed in Europe and North America. It is also necessary to consider the influence of the language used by the robot (English) and the language used by the operator on emotions.

We learned that multiple SAHRs with GUI have built-in multi-language support. For remotely operated robots that require an operator, the operator can use the same language to correspond. Also, in some of the studies included in the discussion, the proportion of female subjects was very high (nearly 95%), and the conclusions described in this article need to avoid errors caused by such factors.

6.2 The future of the field

SAR provides an evaluation framework for humanoid robots at the current point in time, but limitations and deficiencies still exist. In the SAR framework proposed by Jordan Abdi and other researchers, there is also a physiological indicator measurement standard, but we have not found any research that can be quantified by this indicator in the current research on humanoid robots. In the future, with the extensive use of humanoid robots, we are bound to usher in more complete data and more objective evaluations. We can expect that research on humanoid robots like RCT around pet robot researches will greatly promote the development of this field.

On the other side, the speed of communication technology development will also directly affect the application of humanoid robots, voice interaction in the 5G era, and video interaction with lower latency and clearer pictures. Even humanoid robots that can directly display remote operator actions without delay will be able to add more body language to communicate to increase the complexity of communication. The improvement of robot technology can also make the robot's needs such as human imitation, social interaction, and companionship more perfect.

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