National Tainan Nursing College Research Project Application Form

Title	Chinese	PARO 團體介入對失智症長者之神經生物、認知功能和心理健康的變化			
	English	Effect of the Group-based Paro Intervention on Neurobiology, Cognitive Function, and Mental well-being on older adults with dementia			
Principle investigator		Shu-Chuan Chen	Position	Assistant Professor	
Department		Department of Nursing			
Team of research		Position	Nation	Affiliation	department
		Assistant Professor	Shu-Chuan Chen	National Tainan Junior College of Nursing	Department of Nursing
		Physician/ Assistant Professor	Wei-Hung Chang	National Cheng Kung University Hospital	Department of Psychiatry/ College of Medicine
		Registered Nurse	Chun-O Chien	National Cheng Kung University Hospital	Department of Nursing,
Contact mobile		(ext)707 (Mobile) 0979885339 (e-mail)sandra@ntin.edu.tw			

Budget

Item	Request
Research assistant salary	128,000 NTD
Materials and Supplies	80,000 NTD
Printing	12,000 NTD
Travel	22,000 NTD
Consultant	24,000 NTD
Equipment	34,000 NTD
Total Costs	300,000 NTD

Abstract：

1. Chinese Abstract

實證報告已指出智能寵物(Paro)可提供刺激以減少負面情緒並改善失智老年人的焦慮和生活品質。然而，在現有的研究報告亦指出智能寵物對於失智老年之成效呈現不一致的結果。先前研究亦發現智能寵物與人之間的不同的情感依附對老年人產生不同之心理健康的影響。然而此結論仍缺乏實證研究支持。在生物因子方面，催產素與依附，安全感，信賴等特質有相關，與多巴胺的交互作用在過去本團隊研究中也證實與焦慮特質相關。而焦慮等相關特質，也可透過心律變異性(HRV)的變化得知。但此生物特性在失智長輩使用智能寵物後是否有變化仍未知。故該整合型計畫將進行三個子計畫檢視 Paro 介入對特定依戀失智患者在生物醫學、認知及心理健康之改變。

子計畫一將採用隨機對照試驗檢視Paro介入對特定依戀失智患者之催產素，多巴胺及自主神經之變化。採前驅隨機對照、單盲、2組平行研究、及重複測量設計來檢視特定依戀失智老年人在智能寵物陪伴前、中、後之神經生理變化。120名65歲以上居住在長照機構的長者將邀請作為樣本長者將被隨機分派到2個組別，即實驗組或對照組，每組各60名。在介入前和第6周測量催產素。並在介入前、介入第3周、第6周，及介入結束後1個月進行多巴胺檢測(finger tapping test，FTT)以及心律變異檢測。子計畫二採混合質、量性研究設計，將針對60名實驗組的長者為研究對象，探討特定依附型的失智長者其參與 Paro 團體介入歷程、及其與心理健康改變的相關性。將六次、30分鐘之智能寵物團體介入於長者的互動過程進行錄影、現場摘記、轉為逐字稿後進行主題分析，並在第1、3及6次團體結束後評量其團體氣氛與滿意度，並與子計畫三在介入前、介入後的憂鬱和孤獨感之改變量進行相關性分析。子計畫三，長者在介入前、介入後第3周、第6周、和介入結束後1個月進行認知功能、認知執行功能、憂鬱，孤獨感和幸福感的測量。在介入前先使用依附類型量表（RAAS-C）對長者之依附類型進行分類，在介入後將進行次團體分析，進一步了解不同依附類型長者在接受 Paro 介入後身心健康之變化。該研究結果將成為使用智能寵物介入對失智老年人在神經生理變化、認知、執行功能和心理健康提供實徵證據，作為失智症照護醫療之強力證據，未來可推廣於長期照護的模式中。

2. Abstract

Social robots have been validated as a therapeutic modality to provide stimuli to reduce the negative emotions and to improve the quality of life for people with dementia.

However, existing research pointed out that the effectiveness of social robot (Paro) on people with dementia has shown inconsistent results. Previous studies have also found that different emotional attachments between human and Paro have shown different psychological effects for older adults. However, these conclusions still lack empirical research support. Therefore, the integrated project will conduct three sub-projects to examine the changes in biomedical, cognitive, and mental health of specific attachment older adults with dementia after receiving group-based Paro intervention. Study 1 will use a pilot randomized controlled trial to examine the effect of Paro intervention on oxytocin, dopamine and HRV variations for specific attachment older adults with dementia. A randomized controlled trail, single-blind, two parallel groups, and repeated measures design were used to examine the effects of Paro intervention on neurobiologically changes for specific attachment older adults with dementia at before, during and after the intervention. A sample of 120 older adults with dementia who are 65 years or older living in long-term care will be invited. Older adults will be randomly assigned to two groups: experimental group or control group. The outcomes will be assessed based on the change of dopamine and HRV at baseline, 3rd week during the Paro intervention, the end of intervention (6th week), and the 1 month after the Paro intervention. Furthermore, the change of oxytocin will be assessed at two time points: baseline and the end of Paro intervention. Study 2 will focus on the 60 participants of the 2 experimental groups. A mixed method combined qualitative and quantitative research design will be used to explore the participating experience, group interaction, and its' association with mental health. Based on study 1 design, the outcomes of study 3 will be assessed based on the change of cognitive, executive functions, loneliness, depression, and well-being at the same points of study 1.

In addition, the Revised Adult Attachment Scale Chinese version (RAAS-C) will be used to classify the attachment types of the elderly. A sub-group analysis will be conducted to further understand the changes in the physical and mental health of the elderly with different attachment types after receiving Paro intervention. The results of this study will be used to provide empirical evidence to identify the effectiveness of Paro intervention on neurobiologically changes, cognition, executive functions, and mental well-being for the older people with dementia. These results can be promoted as a care model in the long-term facilities in the future.

I. The significant of the study

1. Robot care - offering companionship and social-cognitive-functional support

A prior study indicated that when older adults moved into a nursing home, there is a reduced likelihood that family and friends will continue to visit (Siniscarco, Love-Williams & BurnettWolle, 2017). However, technologies such as robotics may be a solution to continue to offer companionship, social activities, cognitive stimulation and functional support to older adults who are socially isolated (Moyle et al., 2018). The literature showed that robotics could offer functional support and help older adults stay at home for longer times as they can offer services such as the monitoring and management of symptoms and behaviors (Moyle et al., 2017).

Furthermore, robots can connect the older adults to family and friends for companionship, and they can provide cognitive stimulation through games and entertainment. Given the shortage of manpower, many facilities mainly provide group format activities rather than individualized activities to promote mental health for older adults. However, there is still lacking evidence to prove that whether group activities could improve the depression or loneliness of older adults living in long-term care (LTC).

2. Promising psychological-social outcomes of social robots

In recent years, there has been an increasing interest in the use of social robots to act as a catalyst to alleviate psychological distress and encourage social interaction for older adults with dementia or depression (Chen, Jones & Wendy, 2018; Moyle et al., 2016). The evidence reviewed here seems to suggest a pertinent role of a social robot for older adults; however, its mechanism of human-robot has not reached the consistency and in-deep exploration.

Additionally, Chu et al. (2016) revealed that engagement with robot may be an important indicator of human-robot affecting outcomes of intervention for elderly. Therefore, an innovative and empirical intervention for older adults living in LTC in Taiwan, is warranted.

3. Social robot – PARO and its mechanism for mental health

PARO (Personal Assistive Robot), was developed by Dr. Takanori Shibata in Japan. It has the appearance of a baby harp seal; the current version (V9) weighs 2.5 kilograms

and is approximately the size of a new-born baby. PARO is equipped with an array of tactile sensors that monitor sound, light, temperature and touch via artificial intelligence software. PARO can show human-like emotional reactions when it feels surprised, happy, or angry, and it will cry when it is neglected or not receiving sufficient attention.

II. Innovation and novelty of the study

1. Innovative theme: Neurobiology evidences of attachment, security—oxytocin, dopamine and HRV

Although many studies focused on functional outcome of Paro accompany as above studies demonstrated, the intrinsic neurobiologically changes, with the accompany of Paro, is unclear. For human beings, oxytocin is a neuropeptide that originates from magnocellular neurons in the periventricular or supraoptic nucleus of the hypothalamus. Recently, evidence has demonstrated that emotion, cognitive processes and complex social behaviors, including discriminating subtle social cues and trusted behavior could be modulated by oxytocin (Kosfeld, Heinrichs et al. 2005, Domes, Heinrichs et al. 2007, Meyer-Lindenberg and Tost 2012). Furthermore, a dysregulated oxytocinergic system has also been noted in patients with social function impairments, such as autistic disorders (Domes, Heinrichs et al. 2013). Increasingly, literature reviews have indicated that oxytocin may interact with dopaminergic systems. Anatomically, oxytocin neurons express dopamine receptors in the hypothalamus (Baskerville, Allard et al. 2009). Moreover, the oxytocin fibers are close to mesolimbic dopamine cell bodies in the ventral tegmental areas (Melis, Melis et al. 2007). Investigation has shown that the dopamine and oxytocin pathways finally converge in the frontal cortex and ventral striatum (Meyer-Lindenberg, Domes et al. 2011). In addition, a recent study demonstrated dopamine D2 receptor-oxytocin receptors heteromers in the striatum, which might facilitate dopamine-oxytocin interaction (Romero-Fernandez, Borroto-Escuela et al. 2012). Physiologically, the centrally projecting oxytocin neurons and dopaminergic systems interact to maintain cardiovascular function homeostasis and even modulate penile erection (Succu, Sanna et al. 2008, Pyner 2009). Behaviorally, dopamine neurons transmit signals related to salient social cues in addition to the modulation of cognitive flexibility by reward anticipation (Aarts, Roelofs et al. 2010). Furthermore, oxytocin has been noted to activate the mesocorticolimbic and nigrostriatal dopamine pathways that are involved in social and pair bond formation in animal studies (Liu and Wang 2003, Young and Wang 2004). Human functional

imaging studies revealed that ventral tegmental areas that are involved in dopamine-mediated social reward activities and social cues processing could be activated after oxytocin administration (Schott, Minuzzi et al. 2008, Groppe, Gossen et al. 2013). In patients with schizophrenia, abnormal oxytocin-dopamine interactions in the amygdala have been proposed to be associated with impaired emotional salience processing with consequent social cognitive impairments (Rosenfeld, Lieberman et al. 2011). Dysfunctional dopamine-oxytocin interactions could also occur in autism (Baskerville and Douglas 2010) and attention deficit-hyperactivity disorder (Park, Willmott et al. 2010). Variation in dopamine-oxytocin interplays could also contribute to individual differences in personality traits (Love, Enoch et al. 2012).

Also, the above-mentioned neurobiological systems that manage stress under challenging environments may be clinically measurable by the autonomic nervous system (ANS) performance, which alters human psycho-physiological conditions directly in order to cope with stress (fight or flight).(Thayer, Ahs et al. 2012) For example, high frequency (HF) heart rate variability (HRV) predicts depressive symptoms in adolescents,(Vazquez, Blood et al. 2016) and reduction in HRV may lead to a greater risk of cardiovascular disease.(Kleiger, Miller et al. 1987) In addition, mentally perceived stress was found to be negatively correlated with the HF component of HRV.(Dishman, Nakamura et al. 2000)

For geriatrics subjects, dopamine could be measured by finger tapping test. Our previous study demonstrated that FTT is correlated with dopaminergic functions(Yang, Chiu et al. 2003), and more studies showed that FTT could be correlated with elder subjects' cognitive function(Rabinowitz and Lavner 2014).

Paro interventions are based on human-animal interactions aimed at providing physiological, psychological, and social benefits. Physiological effects are triggered through sensory stimulation with Paro such as stroking, hugging, and kissing, and can result in a reduction in stress-hormone levels (Shibata et al., 2004) and lower blood pressure and heart rates (Robinson et al., 2015). Psychological effects are experienced through the comfort and joy derived during close interaction (Chang et al., 2013). Social benefits are provided through engagement in activities (Cohen-Mansfield et al., 2010). In this study, Paro will be used as a psychosocial intervention with the aim to examine its effect on neurobiologically variations as well as cognitive functions and group

process changes in specific attachment older adults with dementia. We hypothesized the above biomarkers demonstrated in previous studies which would be correlated to cognitive functions, trust and stress relieving, would also present in geriatric dementia patients.

2. Innovative design: A rigorous design to build an evidence-based randomized controlled study to fill the gap of knowledge on Paro intervention for older adults with dementia.

Much of the outcome research with social robots has been conducted in Japan and western countries (Moyle et al., 2017; Robinson, Broadbent, & MacDonald, 2016), but less rigorous research, such as RCT, has been conducted in Taiwan. So far, few studies have investigated the changes of biomarkers on Paro intervention to support the findings of well-being effects, which were found using paper instruments to investigate the outcomes of mental health such as depression, loneliness, and attachment. Hence, a RCT with a large sample size will enhance the level of evidence and overcome the weakness of the study. We are the first study to investigate the linkages between biomarkers and psychological effects on older adults with dementia after receiving Paro intervention in Taiwan.

3. Expected Impact of Research

This proposed study will thoroughly examine the effect of Paro intervention on biomarkers (such as oxytocin level, dopamine and HRV), and cognitive function, and mental well-being for specific attachment orientation older adults with dementia. This is the first study we know of to utilize a rigorous research design to examine the effect of Paro intervention and explore the linkages between biomarkers and psychological well-being for older people with dementia. The findings of this study will provide strong evidence and advance knowledge of the mechanism of Paro intervention in LTC of Taiwan and be able to link this result to international studies. The findings of the research will publish in international journals.

III. Background

Serious issues in the mental health of older populations have shown in LTC facilities worldwide. In Taiwan, the prevalence of dementia was 7.78% in older adults. Many older adults with dementia were admitted into long-term care due to BPSD. However, older adults moved into LTC would vitiate quality of life and mental health due to insufficiency of social network. These will increase loneliness. Evidence has shown

that there were positive correlations between depression and loneliness (Cacioppo, Hughes, Waite, Hawkley, & Thisted, 2006; Tiikkainen & Heikkinen, 2005). An empirical study has been demonstrated that loneliness is an important influence factor that increased depression for older adults (Chou, 2004). These issues merit to pay more attention to find effective strategies. Despite this, there is limited research to explore the mechanism of effective interventions on depression and loneliness among older adults living in LTC.

Regarding the development of the human emotional relationship, the attachment is an important mechanism for interpersonal interaction. An individual may have a higher risk to suffer from depression or loneliness when she/he cannot develop a close attachment relationship (i.e. presenting attachment anxiety or attachment avoidance) (Burnette, 2008; Schiffrin, 2014; Wei, 2005). Consequently, there is a significant correlation between interpersonal attachment orientations and mental health.

A social robot has been recognized as a potential new intervention for improving mental well-being in the older population. Empirical studies have shown that Robot-pet (Paro) can be an alternative as a live animal which can provide attachment functions such as proximity, secure base, and safe haven. An endeavor of studies in the two decades, promising results of social robot in improving mood, depression, loneliness, and quality of life have been reported (Jøranson, Pedersen, Rokstad, & Ihlebæk, 2015; Moyle et al., 2013; Petersen et al., 2017; Robinson et al., 2013). Social robots not only can alleviate mental distress of individuals, but also encourage social interaction for older people with psychological distress (Jøranson et al., 2015; Moyle et al., 2016; Roger et al., 2012).

No study aims to investigate the linkage between biomarkers and psychological well-being. The results of this study will be used to provide empirical evidence to identify the effectiveness of Paro intervention on neurobiologically changes for the older people with dementia. These results can be promoted as a care model in the long-term facilities in the future.

IV. Objective

The ultimate objectives of the study are to establish evidence-based Paro intervention to investigate the the effect of Paro intervention on biomarkers and psychological well-being for specific attachment older adults with dementia and to explore the linkages

between them. In this integrated study, we will expect to achieve three aims:

Study 1 will aim to examine the effect of the Paro intervention on oxytocin, dopamine and HRV for attachment-specific people with dementia. Study 2 will explore the relationship of group process and mental health undergoing group-based Paro intervention on attachment-specific people with dementia. Study 3 will examine the effect of the Paro intervention on cognitive, executive functions and mental well-being for attachment-specific people with dementia

V. Work frame

This integration project is entitled “Effect of the Group-based Paro Intervention on Neurobiology, Cognitive Function, and Mental well-being on older adults with dementia”. This project includes 3 sub-study, that is, study 1 “Effect of the Paro intervention on cognitive function, autonomic system, reward and attachment alternations on dementia subjects in dayward center —focusing on prefrontal cortical function, dopamine, oxytocin and heart rate variability(HRV)”; study 2 ” Exploring the interaction experience and its’ relationship with the change of mental health undergoing group-based Paro intervention on attachment-specific people with dementia: Group process analysis” ; and study 3” Effect of the Paro intervention on cognitive, executive functions and mental well-being for attachment-specific people with dementia – a pilot randomized controlled trial”. The aim is to establish evidence-based Robot-pet intervention for older adults with dementia in Taiwan.

The principal investigator (study 1 PI) of the integration project is Wei-hung Chang who is a Director in Department of Psychiatry, NCKU hospital, Dou-Liou and is an expert at psychiatric care, dementia and aged care. He is Assistant Professor in Department of Psychiatry, College of Medicine, National Cheng Kung University. He has more than 30 publications in psychiatric and geriatric fields obtained eight awards from Government and Association in Taiwan.

The PI of study 2 is Chun-O Chien, who is an advanced nurse in mental health with a master degree. She also received well-trained research skill to conduct this study. She also has many publications in Chinese and co-author paper in English. She is also a person in charge to connect between school and hospital, search papers, collect data and help analyze data.

The PI of study 3 is Shu-Chuan Chen who is an Assistant Professor in National Tainan Junior College of Nursing. The PI of integration project is expert at mental health, community care and aged care. She is working on a social robot intervention on

mental health for older adults in Taiwan for 4 years. She has competence and well-trained research skill available to conduct this integration project. She will cooperate and coordinate research matters between National Tainan Junior College of Nursing and Cheng-Kung Hospital, train research staff to conduct project, supervise progress the studies, as well as quality control during the implementation.

Our research team aims to explore intervention to investigate the effect of Paro intervention on biomarkers and psychological well-being for specific attachment older adults with dementia and to explore the linkages between them. A randomized controlled trail will conduct to build the strong evidence on Paro intervention for older adults with dementia. Figure 1 shows that the relationship and integrations among three studies. Study 1 is a randomized controlled trial, which aims to examine the effects of the Paro intervention on cognitive function, autonomic system, reward and attachment alternations on dementia subjects in dayward center —focusing on prefrontal cortical function, dopamine, oxytocin and heart rate variability (HRV)". The findings will be supported our hypothesis of study 3 to demonstrate Paro intervention improving psychological well-being. Study 2 is a mixed method study, which aims to exploring the interaction experience and its' relationship with the change of mental health undergoing group-based Paro intervention on attachment-specific people with dementia: Group process analysis. Based on the findings of Study 1 and 3, this RCT will be built a robust evidence to demonstrate that Paro intervention can improve cognitive functions and psychological well-being for older people with dementia.

Figure 1 The relationship and integrations among three studies

VII. Integration of resource

(1) All equipment will use in-kind in National Tainan College of nursing (NTJIN), National Cheng Kung University Hospital (NCKU-H), and National Cheng Kung University Hospital: Dou-Liou Branch.

(2) Study 1 will conduct at NCKU-H Dou-Liou Branch, NCKU-H related facilities, and senior centers to collect data and conduct Paro intrvention.

(3) NCKU will share the library to conduct systematic review and statistical software.

(4) Study 2 will mainly conduct in NUKU-H: Dou-Liou Branch, NCKU-H related facilities, and senior where will provide venue, computer, projector for research team to discuss the progress of project. Pilot testing of RAQ-C will conduct at NCKU-H. All equipment is provided by NCKU-H.

(5) Study 3 will conduct in at NCKU-H Dou-Liou Branch, NCKU-H related facilities, long-term care and day care center at Tainan independent facilities. Research member from NCKU-H will recruit participants and screening the participants. PI and two Co-PI will collect data and conduct intervention. Paro will provide by NTIN, other equipment are provided by NCKU-H.

(6) Monthly meeting will be held by research team members who will discuss progress of research, difficulties, and issues at NTIN or NCKU-H.

(7) The research outcome will present, poster, or publish in conference or seminar in National Tainan Jonior College of Nursing and National Cheng Kung University Hospital. The results will publish in SCI, SSCI, or TSSCI journals.

VIII. Work Projects

(1) Contact with the long-term care facilities and design a flyer for recruitment of research participants.

(2) Research assistants training, establishing standardized procedures of intervention, developing data collection steps, related knowledge of processes in Paro intervention.

(3) For research fidelity, monitoring experimental group and control group by weekly check, holding regular steering meetings to maintain the quality and consistency of program implementation.

(4) Conduct data collection by blood examination, HRV measurement and psychologically testing of FTT.

(5) To submit the manuscript to international conferences and health-related journals.

(6) To submit the final report for the project.

IX. **Expected the contribution of the Research**

This study will thoroughly examine the effect of Paro intervention on Biomarkers (oxytocin level, dopamine), HRV and psychological well-being for specific attachment orientation older adults with dementia. This is the first study we know of to utilize a rigorous research design to examine the effect of intervention and explore the relationship between different attachment orientation older people and Paro. The findings of this study will provide strong evidence and advance knowledge of the mechanism of Paro intervention in LTC of Taiwan and be able to link this result to international studies. The findings of the research will publish in international journals.

X. **Expected Contribution of Research to Personnel**

There are regular training and interdisciplinary meetings for all research staff to strengthen their research skills, as well as expand their knowledge for newly aged care model such as innovated technological devices and robots for older adults. The staff will conduct research capacity training prior to the study, including Paro intervention, and data analysis. Research members will recognize measurements of FTT and HRV and learn how to cooperate with interdisciplinary experts. These skills will help members to foster teamwork and interdisciplinary knowledge and expand integration of knowledge systems such as nursing, psychological and robotic technology. The above training will help members to advance capabilities to be an independent research, behavioral observer, and a competent analyzer.

Study 1:

Effect of the Paro intervention on cognitive function, autonomic system, reward and attachment alternations on dementia subjects in dayward center —focusing on prefrontal cortical function, dopamine, oxytocin and heart rate variability (HRV)

Abstract

Social robots have been validated as a therapeutic modality to provide stimuli to reduce the negative emotions and to improve the quality of life for people with dementia. However, existing research pointed out that the effectiveness of social robot (Paro) on people with dementia has shown inconsistent results. Previous studies have also found that different emotional attachments between human and Paro have shown different psychological effects for older adults. However, these conclusions still lack empirical research support. Furthermore, oxytocin is well known to be correlated with human attachment behaviour, security and trust feeling. Also, the interaction of dopamine and oxytocin is correlated with anxiety features in our previous study. The anxiety presentation, in previous studies indicated, could be measured physiologically by heart rate variability (HRV). Therefore, this study will use a pilot randomized controlled trial to examine the effect of Paro intervention on oxytocin, dopamine and HRV variations for specific attachment older adults with dementia. A randomized controlled trail, single-blind, two parallel groups, and repeated measures design were used to examine the effects of Paro intervention on neurobiologically changes for older adults with dementia at before, during and after the intervention. A sample of 120 older adults with dementia who are 65 years or older living in long-term care will be invited. Older adults will be randomly assigned to two groups: experimental group or control group. Sixty older adults will be recruited to each group. The outcomes will be assessed based on the change of dopamine, and HRV at baseline, 3rd week during the Paro intervention, the end of intervention (6th week), and the 1 month after the Paro intervention. Additionally, the change of oxytocin will be examined at two time points: baseline and the end of the Paro intervention. The results of this study will be used to provide empirical evidence to identify the effectiveness of Paro intervention on neurobiologically changes for the older people with dementia. These results can be promoted as a care model in the long-term facilities in the future.

I. Literature review

1. Robot care - offering companionship and social-cognitive-functional support

A prior study indicated that when older adults moved into a nursing home, there is a reduced likelihood that family and friends will continue to visit (Siniscarco, Love-Williams & BurnettWolle, 2017). However, technologies such as robotics may be a solution to continue to offer companionship, social activities, cognitive stimulation and functional support to older adults who are socially isolated (Moyle et al., 2018). The literature showed that robotics could offer functional support and help older adults stay at home for longer times as they can offer services such as the monitoring and management of symptoms and behaviors (Moyle et al., 2017).

Furthermore, robots can connect the older adults to family and friends for companionship, and they can provide cognitive stimulation through games and entertainment. Given the shortage of manpower, many facilities mainly provide group format activities rather than individualized activities to promote mental health for older adults. However, there is still lacking evidence to prove that whether group activities could improve the depression or loneliness of older adults living in long-term care (LTC).

2. Promising psychological-social outcomes of social robots

In recent years, there has been an increasing interest in the use of social robots to act as a catalyst to alleviate psychological distress and encourage social interaction for older adults with dementia or depression (Chen, Jones & Wendy, 2018; Moyle et al., 2016). The evidence reviewed here seems to suggest a pertinent role of a social robot for older adults; however, its mechanism of human-robot has not reached the consistency and in-deep exploration.

Additionally, Chu et al. (2016) revealed that engagement with robot may be an important indicator of human-robot affecting outcomes of intervention for elderly. Therefore, an innovative and empirical intervention for older adults living in LTC in Taiwan, is warranted.

3. Social robot – PARO and its mechanism for mental health

PARO (Personal Assistive Robot), was developed by Dr. Takanori Shibata in Japan. It has the appearance of a baby harp seal; the current version (V9) weighs 2.5 kilograms and is approximately the size of a new-born baby. PARO is equipped with an array of

tactile sensors that monitor sound, light, temperature and touch via artificial intelligence software. PARO can show human-like emotional reactions when it feels surprised, happy, or angry, and it will cry when it is neglected or not receiving sufficient attention.

4. Neurobiology evidences of attachment, security—oxytocin, dopamine and HRV

Although many studies focused on functional outcome of Paro accompany as above studies demonstrated, the intrinsic neurobiologically changes, with the accompany of Paro, is unclear. For human beings, oxytocin is a neuropeptide that originates from magnocellular neurons in the periventricular or supraoptic nucleus of the hypothalamus. Recently, evidence has demonstrated that emotion, cognitive processes and complex social behaviors, including discriminating subtle social cues and trusted behavior could be modulated by oxytocin (Kosfeld, Heinrichs et al. 2005, Domes, Heinrichs et al. 2007, Meyer-Lindenberg and Tost 2012). Furthermore, a dysregulated oxytocinergic system has also been noted in patients with social function impairments, such as autistic disorders (Domes, Heinrichs et al. 2013). Increasingly, literature reviews have indicated that oxytocin may interact with dopaminergic systems. Anatomically, oxytocin neurons express dopamine receptors in the hypothalamus (Baskerville, Allard et al. 2009). Moreover, the oxytocin fibers are close to mesolimbic dopamine cell bodies in the ventral tegmental areas (Melis, Melis et al. 2007). Investigation has shown that the dopamine and oxytocin pathways finally converge in the frontal cortex and ventral striatum (Meyer-Lindenberg, Domes et al. 2011). In addition, a recent study demonstrated dopamine D2 receptor-oxytocin receptors heteromers in the striatum, which might facilitate dopamine-oxytocin interaction (Romero-Fernandez, Borroto-Escuela et al. 2012). Physiologically, the centrally projecting oxytocin neurons and dopaminergic systems interact to maintain cardiovascular function homeostasis and even modulate penile erection (Succu, Sanna et al. 2008, Pyner 2009). Behaviorally, dopamine neurons transmit signals related to salient social cues in addition to the modulation of cognitive flexibility by reward anticipation (Aarts, Roelofs et al. 2010). Furthermore, oxytocin has been noted to activate the mesocorticolimbic and nigrostriatal dopamine pathways that are involved in social and pair bond formation in animal studies (Liu and Wang 2003, Young and Wang 2004). Human functional imaging studies revealed that ventral tegmental areas that are involved in dopamine-mediated social reward activities and social cues processing could be activated after oxytocin administration (Schott, Minuzzi et al.

2008, Groppe, Gossen et al. 2013). In patients with schizophrenia, abnormal oxytocin-dopamine interactions in the amygdala have been proposed to be associated with impaired emotional salience processing with consequent social cognitive impairments (Rosenfeld, Lieberman et al. 2011). Dysfunctional dopamine-oxytocin interactions could also occur in autism (Baskerville and Douglas 2010) and attention deficit-hyperactivity disorder (Park, Willmott et al. 2010). Variation in dopamine-oxytocin interplays could also contribute to individual differences in personality traits (Love, Enoch et al. 2012).

Also, the above-mentioned neurobiological systems that manage stress under challenging environments may be clinically measurable by the autonomic nervous system (ANS) performance, which alters human psycho-physiological conditions directly in order to cope with stress (fight or flight).(Thayer, Ahs et al. 2012) For example, high frequency (HF) heart rate variability (HRV) predicts depressive symptoms in adolescents,(Vazquez, Blood et al. 2016) and reduction in HRV may lead to a greater risk of cardiovascular disease.(Kleiger, Miller et al. 1987) In addition, mentally perceived stress was found to be negatively correlated with the HF component of HRV.(Dishman, Nakamura et al. 2000)

For geriatrics subjects, dopamine could be measured by finger tapping test. Our previous study demonstrated that FTT is correlated with dopaminergic functions(Yang, Chiu et al. 2003), and more studies showed that FTT could be correlated with elder subjects' cognitive function(Rabinowitz and Lavner 2014).

Paro interventions are based on human-animal interactions aimed at providing physiological, psychological, and social benefits. Physiological effects are triggered through sensory stimulation with Paro such as stroking, hugging, and kissing, and can result in a reduction in stress-hormone levels (Shibata et al., 2004) and lower blood pressure and heart rates (Robinson et al., 2015). Psychological effects are experienced through the comfort and joy derived during close interaction (Chang et al., 2013). Social benefits are provided through engagement in activities (Cohen-Mansfield et al., 2010). In this study, Paro will be used as a psychosocial intervention with the aim to examine its effect on neurobiologically variations as well as cognitive functions and group process changes in specific attachment older adults with dementia. We hypothesized the above biomarkers demonstrated in previous studies which would be correlated to cognitive functions, trust and stress relieving, would also present in geriatric dementia

patients.

II. Method

1. Aims

The aims of this study is to examine the effect of the Paro intervention on oxytocin, dopamine and HRV for attachment-specific people with dementia.

2. Objectives

(1) To examine the effect of Paro intervention on oxytocin level for the older people with dementia.

(2) To examine the effect of Paro intervention on dopaminergic activities in terms of FTT for older people with dementia.

(3) To examine the effect of Paro intervention on HRV changes, naming autonomic functions for older people with dementia.

(4) To examine the effect of Paro intervention on the associations of the above neurobiologically variations and cognitive functions

(5) To examine the effect of Paro intervention on the associations of the above neurobiologically variations and group process

3. Research design

This is a repeated measures study that is a pilot randomized controlled trail, four parallel groups, and double-blind design. It is used to examine the effects of Paro intervention on cognition, executive functions, and mental well-being for specific attachment older adults with dementia at before, during and after the intervention. A mixed between-within subjects analysis of variance design will be used to assess the immediate effects of the 6-week Paro intervention on cognitive, executive and three mental well-being related variables for different attachment orientations of older adults living LTC facilities. Outcomes of interest measures will include dopaminergic activities variations by FTT and HRV changes at three time points: before the intervention (T0), middle of intervention (week-3, T1), the end of intervention (week-6, T2), and 1 month after the intervention (T2). Furthermore, the change of oxytocin level will be assessed at baseline and the end of the intervention.

The purpose of this study is to examine the effect of Paro intervention on neurobiologically changes for older adults with dementia in LTC. The research design is shown in Table1.

Table 1 Research design for Paro intervention

Group	Subgroup	T0	Intervention	T1	T2	T3
Security	Experiment	O_1	X	O_2	O_3	O_4
	Control	O_1		O_2	O_3	O_4

Experiment group: Paro intervention; Control group; O_1: Baseline; O_2: Week 3; O_3: Week 6; O_4: Week 10

4. Sample size, Sampling, Settings, and Participants Recruitment

There are 120 participants will be recruited into this pilot randomized controlled trial from LTC facilities in southern Taiwan. Older adults will be randomly assigned to four groups: experimental group or control group. The purpose of sampling will be used to allocate 60 participants either to the experimental group or the control group using computer generated sampling. Contact has been made with the Directors of the LTC facilities who have expressed their interest in being involved in the study. Directors will invite older adults who meet the inclusion criteria to participate in this study.

The inclusion criteria of elderly participants will be: (1) aged 65 years or over; (2) Mild to moderator dementia (3) an ability to communicate in Mandarin or Taiwanese; and (4) has been living in the LTC facility at least 3 months. Older adults who: (1) have severe difficulty in communication; (2) are totally dependent on carers for daily activity; (3) have a diagnosed infectious disease, severe dementia, and severe mental illness such as schizophrenia and delusional disorder, will be excluded from the study.

5. Intervention

Participants in the experimental group will receive a group (6-8 people as a group) , facilitated, and 30-minute weekly session Paro intervention for 6 weeks. The control group will receive care as usual activities, such as painting, drawing, and craft, which are provided by each facility.

6. Paro

Paro (Personal Assistive Robot), was developed by Dr Takanori Shibata in Japan. It has the appearance of a baby harp seal; the current version (V9) weighs 2.5 kilograms and is approximately the size of a new-born baby. Paro is equipped with an array of tactile sensors that monitor sound, light, temperature and touch via artificial intelligence software. Paro can show human-like emotional reactions when it feels surprised, happy, or angry, and it will cry when it is neglected or not receiving sufficient attention.

In this study, Paro will be used as a Robot-pet companionship intervention with the aim to improve mental health in terms of different attachment orientations. Robot-pet companionship interventions are based on human-animal interactions aimed at providing physiological, psychological, and social benefits (Robinson et al., 2015; Chang et al., 2013; Cohen-Mansfield et al., 2010; Shibata et al., 2004).

Figure 1. The images of Paro

7. Procedure of interaction records

Participants in experimental groups will receive a group, facilitated, 30-minute weekly session of Paro intervention. A trained research assistant (RA) give the Paro to the participants at the start of each session, repeating the same introductory script each time. The RA facilitate the participant interact with the Paro during the intervention, after 30 minutes RA will use the same ending script to end the session and goodbye to participants.

8. Outcome measures

The process and outcome of measurement will be blinded and assessed by another RA at four time points: baseline (T0), Week 3(T1), Week 6 (T2), and 1 month after the end of intervention(T3). The primary outcomes are oxytocin level, FTT results and HRV tests.

Table 2 Measurement time points and measurements

Instrument	Week-0 (T0)	Week-3 (T1)	Week-6 (T2)	Follow-up (T3)
Demographics/disease	√			

information				
Outcome measure				
-oxytocin level	√		√	
-FTT	√	√	√	√
-HRV	√	√	√	√

Note. √, collect data; FTT: finger tapping test HRV: heart rate variabiility

(1) Demographic data

Participants' demographics such as age, gender, education level, religion, number of children, and previous pet ownership will be collected. Disease-related information will include the length of stay in the LTC, type of depressive disorder, any other chronic disease, a medication audit including antidepressants and other medications, and Barthel index of Activities of Daily Living.

(2) Oxytocin measurement

Blood samples for the oxytocin assay were collected from the antecubital vein into pre-chilled 5 ml EDTA tubes with 250 KIU of apoprotinin, and refrigerated until processing. Plasma was isolated by centrifugation at 1800 × *g*for 15 minutes at 4℃ and stored in aliquots at −70℃. The oxytocin immunoreactivity level was quantified in duplicate using a commercial oxytocin ELISA kit (Enzo Life Sciences, NY, USA, formerly Assays Designs, MI, USA).

(3) Finger tapping test

The FTT consists of tapping with the index finger on a computer mouse as many times as possible within 10 s. The test was repeated three consecutive times and performed randomly across subjects, and the order was kept constant in each subject at each session. The average number of taps was then calculated

(4) HRV measurements

ANS activity. A full 20-minute period of recumbent acclimatization in a quiet room that was maintained at a comfortable temperature (25–27℃) preceded the cardiovascular measurements, which started at 10 AM. Subjects were asked to relax and breathe normally to avoid hyperventilation. Cardiac autonomic function was

calculated by the geometric method, which is based on short-term measurements of the interbeat interval (IBI).(Toichi, Sugiura et al. 1997) Briefly, the sequence of IBI (IBI_1, IBI_2, …, IBI_n) was transformed into a figure on a two-dimensional plane by plotting IBI_{k+1} against IBI_k. The length of the transverse axis (T) is affected by both the sympathetic and parasympathetic blockades, whereas the length of the longitudinal axis (L) is affected only by the parasympathetic blockade. Thus, log10 (L × T) is a cardiac vagal index, whereas the L/T ratio is a cardiac sympathetic index. These two indices have been demonstrated to be more reliable than conventional measures including spectral analysis.(Toichi, Sugiura et al. 1997) This geometric method has been found to be a sound measurement,(Kamen, Krum et al. 1996) and its advantages include: (i) controlled respiration or other maneuvers are not required, and (ii) as few as 100 IBIs are sufficient for the assessment.(Toichi, Sugiura et al. 1997)

Power spectral density analysis of HRV was performed by fast Fourier transformation.(Task force of the European society of cardiology and the North American society of pacing and electrophysiology 1996) Several spectral components were defined as follows: low frequency (LF) (0.04 to 0.15 Hz), HF (0.15 to 0.40 Hz), and total power (≤ 0.4Hz). The very low frequency (VLF) data were excluded, because the available VLF data in short-term recording is dubious and should be avoided.(Task Force of the European Society of Cardiology the North American Society of Pacing 1996) The total power represents the total autonomic activity. The HF power of HRV represents an index of cardiac parasympathetic (vagal) activity, whereas the LF power represents an index of vasomotor sympathetic activity, or both sympathetic and vagal activities. The LF/HF ratio has been proposed as an index of the relative balance of sympatho-vagal influences on the heart, with higher LH/HF ratios reflecting increased sympathetic activity or decreased parasympathetic modulation.(Malliani, Lombardi et al. 1990) These indexes were ln-transformed to correct the skewness.

Autonomic function during resting. The beat-to-beat blood pressure (BP) of the left radial artery and the heart rate were monitored for 5 minutes while subjects remained in the supine position. BP and heart rate were continuously monitored using a Tonometry BP Monitor (Colin BP-508, Colin Co., Komaki-City, Aichi, Japan) and input into a computer console. The referential BP was recorded using a sphygmomanometer cuff over the right brachial artery and measured at intervals of 2.5 minutes. Whenever the tonometry BP measurement was questionable or failed, cuff measurement for calibration was automatically started.

Autonomic function during the respiratory challenge test. The subjects were asked to take a deep breath and the heart rate was continuously recorded. Each deep breath cycle contained a five-second inspiration and a five-second expiration; 5 successive breath cycles were measured in one assessment. We subtracted the minimum HR during expiration from the maximum HR during inspiration for each cycle of breathing, the time interval between two cycles being one minute, and then determined the mean of the differences. The differences were recorded as the mean heart rate range (MHRR), which is one of the most widely-used methods by which to assess HRV under respiratory challenge testing.(Shields 2009)

III. Expectation Outcome

We expect to identify positive effect of Paro intervention on neurobiologically changes for older adults with dementia.

IV. Ethical Considerations

Ethics approval for both phases of the study will be sought from Cheng-Kung University Human Research Ethics Committee and prior to the commencement of the study. Ethics approval for the study will also be sought from the participating LTC facilities in Taiwan prior to the commencement of the study. The researcher will inform the participants about the aims and objectives of the research study and what their participation will involve. Participants will be assured that (a) their participation will be on a voluntary basis and they are under no obligation to participate; and (b) they are free to withdraw from the study at any time without explanation, penalty or compromising their relationship with the LTC. A signed consent form will be sought from each participant. There are no foreseeable risks associated with participation in the intervention for participants.

All collected data will be stored electronically with password-protection to prevent unauthorised access to the data. All data and related documents will be kept in a key-locked cabinet for 5 years before being destroyed. Although demographic data will be requested, participants will remain anonymous. For quantitative data, all data will be de-identified at data entry and results will be reported in general terms. For qualitative data, the digital interview files will be deleted after transcription. Data will be de-identified with codes and content separated. Anonymity will be maintained via pseudonyms for direct interview quotes used in the reporting of findings.

For ethical consideration, our research team will provide opportunity for the elderly in the control group who receiving plush toy. They can choose to partake two 50-minute sessions of group-based Paro interventions to experience interactions with Paro after completing their intervention and follow up.

V. Expected difficulties encountered and solutions

1. Difficulties for participant's recruitment and active engagement data collection

This study will conduct 6 weekly sessions of Paro intervention in LTC facilities. Older adults may feel anxious about interaction with a Paro or withdraw from the intervention. For dealing with this potential problem, the possible solutions are as below:

(1) The research team will hold a briefing to explain the research process to the participating institutions in order to attract the participation of the heads of the institutions.

(2) Introducing the Paro to family and encourage family and workers interacting with the Paro. Also, encouraging participants share their experiences with his/her friends.

(3) Provide incentives or motives for participants and explaining the research procedure and potential benefits for them. The research team will show a Paro video or demonstrate Paro interaction to participants and facilities to introduce how the Paro interact with other older adults and share with experiences to using it.

2. Difficulties in quality assurance and quality control in Paro research

As a limited number of Paro, each round will plan to recruit 6 participants. The research team will extend the study periods to recruit enough participants. For controlling the research quality, the possible solutions are as below:

(1) *To increase the quality and consistency of interaction with Paro.* Each facility will recruit two volunteering care staff to participate in the study. Staff will receive 1 hour of Paro interactive training. Each care staff will provide incentives and motives to increase motivation to partake this study.

(2) *For reducing the interference or contamination among the four groups*. This study will recruit control group and experimental groups in different levels to prevent interference among groups receiving intervention at the same time in

the same facility.

(3) *To reduce the human interferences.* In order to establish a research consensus among institutional staff, we will provide a 60-minute course to workers in participating facilities, the purpose of which is to help them to familiarize with our programs and procedures

VI. Expected the contribution of the Research

This study will thoroughly examine the effect of Paro intervention on oxytocin level, dopamine and HRV for specific attachment orientation older adults with dementia. This is the first study we know of to utilize a rigorous research design to examine the effect of intervention and explore the relationship between different attachment orientation older people and Paro. The findings of this study will provide strong evidence and advance knowledge of the mechanism of Paro intervention in LTC of Taiwan and be able to link this result to international studies. The findings of the research will publish in international journals.

VII. Expected Contribution of Research to Personnel

There are regular training and interdisciplinary meetings for all research staff to strengthen their research skills, as well as expand their knowledge for newly aged care model such as innovated technological devices and robots for older adults. The staff will conduct research capacity training prior to the study, including Paro intervention, and data analysis. Research members will recognize measurements of FTT and HRV and learn how to cooperate with interdisciplinary experts. These skills will help members to foster teamwork and interdisciplinary knowledge and expand integration of knowledge systems such as nursing, psychological and robotic technology. The above training will help members to advance capabilities to be an independent research, behavioral observer, and a competent analyzer.

Study 2:

To explore the interaction experience and its' relationship with the change of mental health undergoing group-based Paro intervention on people with dementia: Group process analysis

Abstract

Social robots have been validated as a therapeutic modality to provide stimuli to reduce the negative emotions and to improve the mental health for people with dementia. Different psychological effects for older adults those who had different emotional attachments styles between human and Paro had been found. However, these conclusions still lack empirical evidence and consistent results about the effectiveness of group-based social robot (Paro) on people with dementia.

Therefore, this integrated study will use a randomized controlled trial (RCT) to examine the process and outcomes of a weekly 6-session group-based Paro intervention. The association of group process and mental health for specific attachment older adults with dementia will be validated. A RCT, single-blind, four parallel groups, and repeated measures design were used to examine the effects of Paro intervention at before and after the intervention. Sixty older adults will be randomly assigned to two groups: experimental group or control group. In the subproject 2, we particularly focus on the 60 participants of the experimental group with dementia who are 65 years or older living in long-term care. A mixed method combined qualitative and quantitative research design will be used to explore the participating experience, group interaction, and its' association with mental health.

Thematic analysis will be conducted by the video-recorded, group process, memo and verbatim of 6 weekly 30-minute session Paro intervention after obtaining the inform consent of the participants. The group climate and satisfaction will be assessed at the end of 1st, 3rd, 6th session by group observers, and participants, respectively. The corelation will be examined between the group process with the change of loneliness and depression at pre- and post- intervention that conducted by subproject 3. We expect to assure and contrast the process and group effectiveness in this subproject. The study findings will provide empirical result to utilize the group-based Paro intervention for the older people with dementia. A strong evidence will be established to promote the alternative therapy into different attachment styles of dementia care, combining the

artificial-intelligence product as a care model in the long-term facilities in the future.

I. Literature Review

1.Robot care - offering companionship and social-cognitive-functional support

Older adults living in Long Term Care(LTC) may alienate their social connections. When older adults moved into a nursing home, there is a reduced likelihood that family and friends will continue to visit (Siniscarco, Love-Williams & BurnettWolle, 2017). Therefore, even older adults adapt to their new living environment, often the feeling of loneliness and isolation does not abate over time as they find it difficult to form new relationships with the surrounding people (Robinson et al., 2013). Past studies have found that there is a positive correlation between depression and loneliness. Older adults with high levels of loneliness tend to experience higher levels of depression and more negative emotions (Chen et al., 2020; Mendes, 2015)。

However, technologies such as robotics may be a solution to continue to offer companionship, social activities, cognitive stimulation and functional support to older adults who are socially isolated (Moyle et al., 2018). Social robots have much positive help to the elderly, in long-term care institutions, social animal robots can become social "ice breakers", providing companionship, meaning and comfort. Through interaction with animals to enhance social interaction, reduce depression and loneliness, and improve the standard of quality of life(Chen et al., 2020; Hung et al., 2019; 胡慧芳 et al., 2014).

In addition, robots can connect the accompany of the elderly with family and friends, and they can provide cognitive stimulation through games and entertainment. The most common social robot, Paro, enables people to have an emotional attachment to the robot through interaction with the robot. (Chen et al., 2020)。

Furthermore, robots can connect the older adults to family and friends for companionship, and they can provide cognitive stimulation through games and entertainment. Given the shortage of manpower, many facilities mainly provide group format activities rather than individualized activities to promote mental health for older adults. However, there is still lacking evidence to prove that whether group activities could improve the depression or loneliness of older adults living in long-term care (LTC).

2.Promising psychological-social outcomes of social robots

In recent years, there has been an increasing interest in the use of social robots to act as a catalyst to alleviate psychological distress and encourage social interaction for older adults with dementia or depression (Chen, Jones & Wendy, 2018; Moyle et al., 2016). The evidence reviewed here seems to suggest a pertinent role of a social robot for older adults; however, its mechanism of human-robot has not reached the consistency and in-deep exploration.

Additionally, Chu et al. (2016) revealed that engagement with robot may be an important indicator of human-robot affecting outcomes of intervention for elderly. Therefore, an innovative and empirical intervention for older adults living in LTC in Taiwan, is warranted.

3.Group-based PARO intervention and its mechanism for mental health

PARO (Personal Assistive Robot), was developed by Dr. Takanori Shibata in Japan. It has the appearance of a baby harp seal; the current version (V9) weighs 2.5 kilograms and is approximately the size of a new-born baby. PARO is equipped with an array of tactile sensors that monitor sound, light, temperature and touch via artificial intelligence software. PARO can show human-like emotional reactions when it feels surprised, happy, or angry, and it will cry when it is neglected or not receiving sufficient attention.

Group activities provide a promising venue to address social needs as well as the need for meaningful engagement for persons with dementia within a limited fiscal framework. The presentation of a theoretical framework for such group activities and the validation of an assessment of engagement during group activities provide a first step in examining the parameters affecting group processes in this population(Cohen-Mansfield et al., 2017).

Paro interventions are based on human-animal interactions aimed at providing physiological, psychological, and social benefits. Physiological effects are triggered through sensory stimulation with Paro such as stroking, hugging, and kissing, and can result in a reduction in stress-hormone levels (Shibata et al., 2004) and lower blood pressure and heart rates (Robinson et al., 2015). Psychological effects are experienced through the comfort and joy derived during close interaction (Chang et al., 2013). In the study of Wan-Ling Chang and Selma Španović (2013), it was found that within the progress of Paro group activities, the more it can cause patients with dementia to be more willing to actively interact with Paro, and it can promote patients' motivation

physical activity(Chang et al., 2013). Although many studies have pointed out the positive impact of Paro intervention on patients with dementia on the physical, psychological and social interaction levels, there is no research focusing on the impact of group-based Paro intervention on patients with dementia. ◦ Social benefits are provided through engagement in activities (Cohen-Mansfield et al., 2010). In this study, Paro will be used as a psychosocial intervention with the aim to examine its effect on cognitive, executive, depression, loneliness, and mental well-being in specific attachment older adults with dementia.

Group robotic pet-assisted therapy has been proven to improve the mood and behavior of the elderly with dementia. Chen et al. (2020) search nine electronic databases（ [CINAHL], MEDLINE, PsycINFO, PubMed, Web of Science, Scopus, Cochrane Library, Embase and Proquest）for related research, the search terms used were older adults, social robot, and depression ◦ The search aimed to identify published and full-text articles from January 2000 to April 2017, a total of 7 articles was included, including 6 RCTs and 1 systematic literature review. Five studies contained people with dementia, and two recruited people from LTC facilities ◦ The social robot interventions with each session lasting from 10 mins to 60 mins，The number of interventions is twice a week and the duration is 5-12 weeks. The results of the study confirm that the group intervention of Paro can improve the depression and restlessness of the elderly with dementia (Chen, 2018).

Hu et al. (2014) Use social robot (Paro) for group robot-assisted therapy of elderly people with dementia, a total of 12 elderly people with dementia. The leaders guided the elderly with dementia to interact with robot seals in language and body, 2 times a week, 40 minutes each time, for 4 weeks. It was found that the elderly with dementia had depression and agitated behaviors after receiving group robot pet-assisted treatment All have significant meaning.

Hu et al. (2012) used group robot-assisted therapy, adopts 8-10 person in one group and uses Paro as auxiliary device to integrate into the care process, twice a week, 30 minutes each time, a total of 8 times, guiding face-to-face dialogue with pets, petting interactive. Analyzing the behavior of an elderly with dementia in the group process, it was found that the case had less interaction and vituperate and other negative behaviors at the beginning of the group. Until the third time the group began to show positive behaviors, actively greeted and greeted and praised the pet. After attending group robot-assisted therapy, this case had reduction on his day-time drowsiness, night-time sleep

interruption, and occurrence of behavioral and psychological symptoms. The elder also had improvement on his cognitive function, orientation, emotion, and social interaction.

Jøranson et al. (2015) randomly assigned for group robotic pet-assisted therapy in Ten adapted units in nursing homes. A total of 53 elderly people with dementia (27 in the Intervention group; 26 in the control group), twice a week, 30 minutes each for 12 weeks, the study found the significant effect on depression and agitation by using Paro in activity groups for elderly with dementia in nursing homes. However, in the study of Jøranson et al. (2016), it was found that the group robot pet-assisted treatment had less significant improvement effect on the quality of life.

The literature of Abrams (2020) pointed out that observing the interaction of robot care mode and the human interaction group, it is necessary to explore the group dynamics generated during the group process and the individual feelings of group members, including ingroup Identification, Cohesion and Entitativity. The process needs to examine whether everyone can enter the group goal to generate group cohesion, so that the group can generate positive and negative experiences due to the intervention of robot care, and whether members are satisfied with the tasks assigned in the group.

Most studies have explored the effects of robotic pet-assisted treatment based on the emotions, symptoms and behaviors of elderly people with dementia, but there is no research related to robotic pet-assisted therapy that explores the correlation between personality traits and group history. The study will design from the perspective of the elderly with dementia to analyze the group journey accompanied by robot pets.

II. Method

1. Aims

The aim of this study is to explore the relationship of group process and mental health undergoing group-based Paro intervention on attachment-specific people with dementia

2. Objectives

(1) To explore the positive and negative interaction experience of the 6-session group-based Paro intevention process from the viewpoints of participants.
(2) To examine the change and differience of group climate in the Paro intervention process from the viewpoints of group observers by groups.
(3) To examine the change and differience of group satisfaction in the Paro

intervention process from the viewpoints of group participants by groups.

(4) To exmine the relationship between changes of group process and group outcomes (loneliness and depression) by groups.

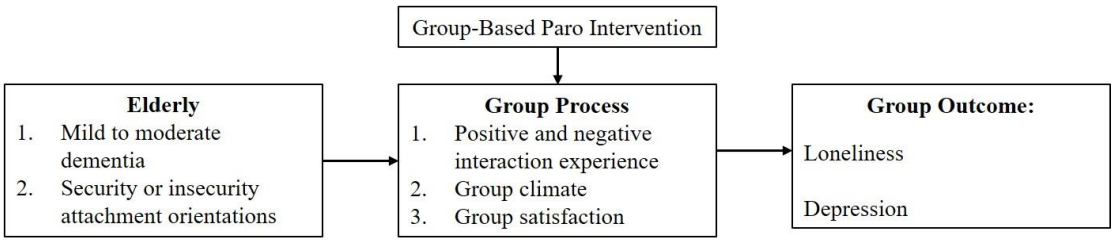

Figure 1. The conceptual framework of group process and mental health undergoing group-based Paro intervention

3. Research design

This is a mixed method study that combined a qualitative and quasi-experimental design with two parallel groups. In the experimental groups, content analysis will be used to explore the group interaction experience with vedio-recorded and transcribe verbatim. A between-within subjects analysis of variance design will be used to assess the 6-session Paro intervention on the group process variables which include group climate and group satisfaction. Relationship between changes of group process and mental health by groups will be examined with a correlation analysis. Outcomes of interest measures will include group process at three time points: the first, third, and sixth session intervention; and mental health will be measured before the intervention and (T0) the end of intervention (6-session, T1).

The purpose of this study is to explore the relationship of group process and mental health undergoing group-based Paro intervention on older adults with dementia in LTC. The research design is shown in Table1.

Table 1 Research design for exploring the group process and outcomes of group-based Paro intervention

Group	T0	Intervention / Group process	T1
Experiment group	O_1	X (1^{st}, 3^{rd} , 6^{th} session)	O_2

Note: T0 (before the intervention); T1 (after 6^{th} session intervention); X (the group-based Paro intervention will be video-record, the group process will be analyzed by content analysis, and the group climate and satisfaction at session 1^{st}, 3^{rd} , and 6^{th} will be assessed); O1, O2: Outcomes of measurement include the loneliness and depression assessment.

5. Sample size, Sampling, Settings, and Participants Recruitment

In the subproject 2, will focus on the participants in the experimental group (n=60). Contact has been made with the Directors of the LTC facilities who have expressed their interest in being involved in the study. Directors will invite older adults who meet the inclusion criteria to participate in this study.

The inclusion and exclusion criteria of elderly participants will be the same study 1.

6. Intervention

The Paro intervention will be the same study 1.

7. Outcome measures

Each group interaction experience will be video-recorded and measured. The group process will be assessed at the first, third and sixth intervention. The group outcomes of mental health will be assessed at two time points: before the intervention (baseline, T0) and after the final session(T1). The primary outcome is group experience which will be transcribed verbatim and assessed with a content analysis. Group climate and satisfaction will be analyzed as the group process. Loneliness and depression will be assessed and the relationship of the change between mental health and group process will be examined.

Table 2 Measurement time points and measurements

Instrument	Baseline (T0)	Intervention	6th Session (T1)
Demographics/disease information	√		
Group process measure			
-Experience of group participants		√ (each session)	
-Group climate		√(1st, 3rd, 6th session)	
-Group satisfaction		√(1st, 3rd, 6th session)	
Outcome measure			
-Loneliness (UCLA)	√		√
-Depression (GDS-SF)	√		√

8. Data analysis

(1) Qualitative data analysis

Qualitative data analysis was guided by the method of thematic analysis (Braun & Clarke, 2006) to provide an insight into the understanding of participants' experiences and perception when receiving the Paro intervention. A software N-Vivo 12.0 will be used to analyze the six sessions of group interaction verbatim initially. The focus of this study is to discover the positive and negative experience of group process from the participants. Chinese version of Yalom's Therapeutic Factors (Chung et al., 2011), anti-therapeutic factors (Lin & Wang, 1998), and therapeutic effectiveness (Lin et al., 1999) will be used as a coding framework. Additionally, the change of group process during 6-session Paro intervention will be extracted into themes, subthemes and behavior units, such as beneficial/ hindering experience sharing, participating or interacting behaviors with Paro or peers and etc.

Qualitative data analysis was guided by the method of thematic analysis (Braun & Clarke, 2006) to provide an insight into the understanding of participants' experiences and perception when receiving the group-based Paro intervention. The themes and subthemes will be coded by using the following six steps: (i) familiarization with data; (ii) generation of initial codes; (iii) identification of themes; (iv) reviewing themes; (v) defining and naming themes; and (vi) producing the report.

(2) Trustworthiness

The rigor of research refers to the degree of confidence in data, interpretation, and methods used to ensure the quality of a study (Polit & Beck, 2014). In this study, several strategies were used to ensure trustworthiness. First, monitoring of the rigor of the study was carried out by peer debriefing at regular meetings with the research team. Second, persistent weekly observation was used as a strategy to ensure trustworthiness during the data analyses (Korstjens & Moser, 2018). Third, an audit trail, which was a transparent description of the qualitative research steps taken from the commencement of the study to the development and reporting of the findings, was used to establish confirmability of the qualitative results.

(3) Quantitative data analysis

Data will be analyzed using the Statistical Package for Social Science (SPSS) for Windows software version 26 (IBM Corp.). Data collected will be reviewed for completeness and consistency within a single data form. Approximately 10% of the data entry will be checked for accuracy and consistency (Gad & Taulbee, 1996). Last observation carried forward method will be used to manage missing data at random (Kang, 2013). An intention-to-treat approach (Gupta, 2011) will be used in which all participants will be analyzed according to their enrolment.

Descriptive statistics will be used to analyses demographic data where normality of data distribution for the outcome variables will be examined using probability plots and Kolmorgorov-Smironov tests. Frequency and percentages will be used to summarize categorical variables such as gender and educational level. Mean, standard deviation, and range will be reported to present continuous variables such as age and the score of all scales. Demographic characteristics and baseline data of participants will be compared with different subgroups, using chi-square for categorical variables or t-test (or Mann-Whitney U test) for continuous variables. Relationships between demographic characteristics and outcome measures will be explored using Pearson's correlations. Cronbach's alpha will be used to check the reliability of all instruments.

Differences between the pre and post-test in relation to outcome measures (loneliness and depression) will be used a mixed between-within subjects analysis of variance design to assess the immediate effects of the 6-week Paro intervention on mental health. The association of group process variables (group climate and satisfaction) and mental health will be examined for different attachment orientations of older adults living LTC facilities. A p value < .05 will be taken as the level of

statistical significance. The 95% confidence interval around the differences will be calculated.

III. Expectation Outcome

We expect to explore the group process and its' relationship with mental health (depression and loneliness) of 6-session group-based Paro intervention, and beneficial and hindering group experience of older adults with dementia.

IV. Ethical Considerations

Ethics approval for both phases of the study will be sought from Cheng-Kung University Human Research Ethics Committee and prior to the commencement of the study. Ethics approval for the study will also be sought from the participating LTC facilities in Taiwan prior to the commencement of the study. The researcher will inform the participants about the aims and objectives of the research study and what their participation will involve. Participants will be assured that (a) their participation will be on a voluntary basis and they are under no obligation to participate; and (b) they are free to withdraw from the study at any time without explanation, penalty or compromising their relationship with the LTC. A signed consent form will be sought from each participant. There are no foreseeable risks associated with participation in the intervention for participants.

All collected data will be stored electronically with password-protection to prevent unauthorised access to the data. All data and related documents will be kept in a key-locked cabinet for 5 years before being destroyed. Although demographic data will be requested, participants will remain anonymous. For quantitative data, all data will be de-identified at data entry and results will be reported in general terms. For qualitative data, the digital interview files will be deleted after transcription. Data will be de-identified with codes and content separated. Anonymity will be maintained via pseudonyms for direct interview quotes used in the reporting of findings.

For ethical consideration, our research team will provide opportunity for the elderly in the control group who receiving plush toy. They can choose to partake two 50-minute sessions of group-based Paro interventions to experience interactions with Paro after completing their intervention and follow up.

V. Exected difficulties encountered and solutions

1. Difficulties for participant's recruitment and active engagement data collection

This study will conduct 6 weekly sessions of Paro intervention in LTC facilities. Older adults may feel anxious about interaction with a Paro or withdraw from the intervention. For dealing with this potential problem, the possible solutions are as below:

(4) The research team will hold a briefing to explain the research process to the participating institutions in order to attract the participation of the heads of the institutions.

(5) Introducing the Paro to family and encourage family and workers interacting with the Paro. Also, encouraging participants share their experiences with his/her friends.

(6) Provide incentives or motives for participants and explaining the research procedure and potential benefits for them. The research team will show a Paro video or demonstrate Paro interaction to participants and facilities to introduce how the Paro interact with other older adults and share with experiences to using it.

2. Difficulties in quality assurance and quality control in Paro research

As a limited number of Paro, each round will plan to recruit 6 participants. The research team will extend the study periods to recruit enough participants. For controlling the research quality, the possible solutions are as below:

(1) *To increase the quality and consistency of interaction with Paro.* Each facility will recruit two volunteering care staff to participate in the study. Staff will receive 1 hour of Paro interactive training. Each care staff will provide incentives and motives to increase motivation to partake this study.

(2) *For reducing the interference or contamination among the four groups*. This study will recruit control group and experimental groups in different levels to prevent interference among groups receiving intervention at the same time in the same facility.

(3) *To reduce the human interferences.* In order to establish a research consensus among institutional staff, we will provide a 60-minute course to workers in

participating facilities, the purpose of which is to help them to familiarize with our programs and procedures

3. Difficulties in assure the rigor in analyzing group process.

The rigor of research will be the challenge of the qualitative data analysis. We will invite senior qualitative researchers to provide coding demonstration, scheduled training, and supervision. Several strategies during the data analyses will be used to ensure trustworthiness: peer debriefing at regular meetings with the research team, persistent weekly observation, and member check. Additionally, triangulating method will be used to establish confirmability of the quantitative results.

4. Expected the contribution of the Research

This study will thoroughly examine the relationship of Paro intervention on the change of group interaction and mental health for specific attachment orientation older adults with dementia. This is the first study we know of to utilize a rigorous research design to examine the effect of intervention and explore the relationship between different attachment orientation older people and Paro. The findings of this study will provide strong evidence and advance knowledge of the mechanism of group-based Paro intervention in LTC of Taiwan and be able to link this result to international studies. The findings of the research will publish in international journals.

5. Expected Contribution of Research to Personnel

There are regular training and interdisciplinary meetings for all research staff to strengthen their research skills, as well as expand their knowledge for newly aged care model such as innovated technological devices and robots for older adults. The staff will conduct research capacity training prior to the study, including questionnaire administration, Paro intervention, and data analysis. Research members will recognize measurements of cognitive function tools, mental well-being, depression, and loneliness distress symptoms and learn how to cooperate with interdisciplinary experts. These skills will help members to foster teamwork and interdisciplinary knowledge and expand integration of knowledge systems such as nursing, psychological and robotic technology. The above training will help members to advance capabilities to be an independent research, behavioral observer, and a competent analyzer.

Study 3:

Effect of the Paro intervention on cognitive, executive functions and mental well-being for attachment-specific people with dementia – a pilot randomized controlled trial

Abstract

Social robots have been validated as a therapeutic modality to provide stimuli to reduce the negative emotions and to improve the quality of life for people with dementia. However, existing research pointed out that the effectiveness of social robot (Paro) on people with dementia has shown inconsistent results. Previous studies have also found that different emotional attachments between human and Paro have shown different psychological effects for older adults. However, these conclusions still lack empirical research support. Therefore, this study will use a pilot randomized controlled trial to examine the effect of Paro intervention on the cognitive, executive function and mental health for specific attachment older adults with dementia. A randomized controlled trail, single-blind, two parallel groups, and repeated measures design were used to examine the effects of Paro intervention on cognition, executive functions, and mental well-being for specific attachment older adults with dementia at before, during and after the intervention. A sample of 120 older adults with dementia who are 65 years or older living in long-term care will be invited. Older adults will be randomly assigned to 2 groups: experimental group or two control group. Sixty older adults will be recruited to each group. The outcomes will be assessed based on the change of cognitive, executive functions, loneliness, depression, and well-being at baseline, 3rd week during the Paro intervention, the end of intervention (6th week), and the 1 month after the Paro intervention. A mixed between-within subjects analysis of variance design will be used to assess the immediate effects of the 6-week Paro intervention on cognitive, executive and three mental well-being related variables for different attachment orientations of older adults living LTC facilities. The results of this study will be used to provide empirical evidence to identify the effectiveness of Paro intervention on the cognitive, executive function and mental well-being for the older people with dementia. These results can be promoted as a care model in the long-term facilities in the future.

I. Method

1. Aims

The aims of this study is to examine the effect of the Paro intervention on cognitive, executive functions and mental well-being for older people with dementia.

2. Objectives

(6) To examine the effect of Paro intervention on cognitive and executive functions functions for older people with dementia.
(7) To examine the effect of Paro intervention on depression for older people with dementia.
(8) To examine the effect of Paro intervention on loneliness for older people with dementia.
(9) To examine the effect of Paro intervention on mental well-being for older people with dementia.

3. Research design

This is a repeated measures study that is a randomized controlled trail, four parallel groups, and single-blind design. It is used to examine the effects of Paro intervention on cognition, executive functions, and mental well-being for older adults with dementia at before, during and after the intervention. A mixed between-within subjects analysis of variance design will be used to assess the immediate effects of the 6-week Paro intervention on cognitive, executive and three mental well-being related variables for different attachment orientations of older adults living LTC facilities. Outcomes of interest measures will include cognitive and executive functions, and depression, loneliness, and mental well-being at three time points: before the intervention (T0), middle of intervention (week-3, T1), the end of intervention (week-6, T2), and 1 month after the intervention (T2). Secondary outcome is interest in the impacts of the Paro intervention on psychological outcomes for different attachment style of older adults with dementia. The Revised Adult Attachment Scale Chinese version (RAAS-C) will be used to classify the attachment types of the elderly. A sub-group analysis will be conducted to further understand the changes in the physical and mental health of the elderly with different attachment types after receiving Paro intervention.

The purpose of this study is to examine the effect of Paro intervention on cognitive, executive, depression, loneliness, and mental well-being depression and loneliness for

older adults with dementia in LTC. The research design is shown in Table1.

Table 1 Research design for Paro intervention

Group	T0	Intervention	T1	T2	T3
Experiment	O_1	X	O_2	O_3	O_4
Control	O_1		O_2	O_3	O_4

4. Sample size, Sampling, Settings, and Participants Recruitment

The same with study 1.

5. Intervention

Participants in the experimental group will receive a group (6-8 people as a group) , facilitated, and 30-minute weekly session Paro intervention for 6 weeks. The control group will receive care as usual activities, such as painting, drawing, and craft, which are provided by each facility.

6. Procedure of interaction records

Participants in experimental groups will receive a group, facilitated, 30-minute weekly session of Paro intervention. A trained research assistant (RA) will give the Paro to the participants at the start of each session, repeating the same introductory script each time. The RA facilitate the participant interact with the Paro during the intervention, after 30 minutes RA will use the same ending script to end the session and goodbye to participants.

7. Outcome measures

The process and outcome of measurement will be blinded and assessed by another RA at four time points: baseline (T0), Week 3(T1), Week 6 (T2), and 1 month after the end of intervention(T3). The primary outcomes are global cognitive function and executive functions. The Mini-Mental State Examination (MMSE) will be used to assess participants' global cognitive function. The executive functions include two components such as working memory (WM) and response inhibition, which will use computerized tasks to assess the changes of executive functions for order adults before and after intervention. Working memory will be assessed using verbal WM and visuo-spatial WM tasks. Response inhibition will be assessed employing color word stroop

(CWS), stop signal (SS), and go/no-go (GNO) tasks. The secondary outcome measures are loneliness (UCLA version-3), Depression (GDS-SF), and Mental well-being (WEMWBS).

Table 2 Measurement time points and measurements

Instrument	Week-0 (T0)	Week-3 (T1)	Week-6 (T2)	Follow-up (T3)
Demographics/disease information	√			
RAAS-C	√			
Outcome measure				
-MMSE	√	√	√	√
-Executive Functions	√	√	√	√
-Loneliness (UCLA)	√	√	√	√
-Depression(GDS-SF)	√	√	√	√
-Mental well-being (WEMWBS)	√	√	√	√

Note. √, collect data; MMSE; executive function; UCLA, the University of California Los Angeles Loneliness Scale version 3; GDS-SF, Geriatric Depression Scale - Short Form; WEMWBS, Warwick-Edinburgh Mental Well-being Scale.

(1) Demographic data

Participants' demographics such as age, gender, education level, religion, number of children, and previous pet ownership will be collected. Disease-related information will include the length of stay in the LTC, type of depressive disorder, any other chronic disease, a medication audit including antidepressants and other medications, and Barthel index of Activities of Daily Living.

(2) The Chinese version of Mini-Mental State Examination (MMSE)

The Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) is a widely used tool that screens for levels of cognitive impairment, using the concepts of orientation, registration, attention and calculation, recall, and language. The MMSE has been translated into Chinese with small modifications based on the sociocultural differences of the Chinese population, and has been utilised as a dementia screening instrument for epidemiological studies (Zhang et al., 1990). The MMSE has good internal consistency with a Cronbach alpha of .91 (Marioni, Chatfield, Brayne, & Matthews, 2011). In a previous study, the MMSE has shown good sensitivity of 78.4% and a specificity of 87.8 % in primary care (Mitchell, 2008). The Cronbach alpha was .83 to .84 in older Taiwanese populations (Chung, Chiou, & Chou, 2009; Lou, Dai,

Huang, & Yu, 2007). The MMSE score ranges from 0 to 30. In general, a cut-off point higher than 24 indicates normal cognition; 20–23 mild cognitive impairment; 10–19 moderate cognitive impairment; and 0–9 severe cognitive impairment. In this study, the cut-off point was based on a study by Zhang et al. (1990) in which the level of cognitive impairment varies according to educational level: 17⁄18 for older people without formal education, 20⁄21 for those with 1–6 years of education (primary school), and 24⁄25 for participants with more than six years of education (middle school or higher) in Chinese older adults.

(3) Core components of executive functions- WM and response inhibition

The two core executive functions, WM and inhibition, were assessed using computerized tasks. Working memory was assessed using verbal WM and visuo-spatial WM tasks. Response inhibition was assessed using CWS, SS and GNG tasks. All older adults with dementia will be individually tested in a quiet room. The order of task administration is the same for all participants and they will receive a practice session prior to all the tasks. A period of rest is given between two tasks.

Color word Stroop task (Stroop, 1935; Macleod, 1991): In this task different colour words will appear on the computer screen one at a time. The task is to name the color the word is printed, disregarding what the color word reads. The colour of the word printed is in the same color as the meaning of the word (congruent trials, eg; "red" is printed in red colour), or it is different from the meaning (incongruent trials, eg; word "green" is printed in blue colour). There are 75 congruent trials and 25 incongruent trials for one test session. Incorrect responses on incongruent trials are taken to assess the level of inhibitory control. The higher the errors the lower the interference control is.

Visuo-spatial WM task: A 4 × 4 matrix with 16 squares is displayed on the computer screen as a pig house with a pig appearing in each window one at a time. The task is to recall in reverse order the locations where each target (pig) has appeared. The test start with a span length of two, that is, two pigs appear one after another. Each span consist of two trials and the test is concluded when the participant failed both trials at that same span length. Each correct location is given one point with a maximum score of 88. The score is taken as the measure of Visuo-spatial WM. At the end of the test, obtain score is automatically displayed on the computer screen.

Stop signal task: It assess the ability to inhibit ongoing responses. This is like a

car game (Tillman, Thorell, Brocki & Bohlin, 2007) where a car appears on the computer screen. Every time the car appear, the participant is supposed to press a designated key as fast as possible to drive the car away. But when a stop-sign board appeared next to the car, participants has to refrain from pressing for the car to stand still. Each session in this task consist of 24 trials with six stop-signs-trials. Number of incorrect presses in stop sign (commission errors) is considered as the measure of inhibition and it is automatically displayed on the screen at the end of the task.

Verbal WM task (adapted from Towse, Hitch & Hutton, 1998): These are power point slides. Each slide has different numbers of red circles with squares as distracters. The task is to count the total number of red circles in each slide, keep total in memory and recall the numbers in the correct order. The test start with a length of memory recall (span) of two, that is, the participant had to recall two slides first. Each level of memory recall consist of three trials and the test is concluded when the participant failed two trials out of three at that same length of recall. If the participant is successful in 2 out of three trials, he/ she is allowed to go to the next span. A total score is calculated after adding a mark for each correct recall (Towse, Hitch & Hutton, 1998).

Go/no-go task (two versions: colour and shape): It assess ability to inhibit pre potent responses. The subject is presented with four different stimuli on the screen, one at a time in random order. There are two squares and two circles in blue and red. In the first session, the subject is instructed to respond by pressing a key each time when a blue figure appeared (go-trials) regardless of the shape, and not to respond when a red figure appear. In the second session, the subject is instructed to respond each time when a square appear, regardless of the color, and not to respond when a circle appear (Berlin & Bohlin, 2002). Together the two consecutive sessions include 60 stimuli with 77% go-trials. The number of incorrect responses (commission errors) is used as a measure of inhibition and it is automatically displayed on the screen at the end of the task.

(4) The UCLA Loneliness Scale version 3

The UCLA Loneliness Scale Version 3, a 20-item scale, was developed by Russell (1996). It is used to measure a person's subjective feelings of loneliness and feelings of isolation. Each item on the scale is rated from 1 (Never) to 4 (Often) with a total score ranging from 20 to 80. The scale does not identify a cut-off score that defines loneliness. The higher the score, the more severe a person's feelings of loneliness. This scale has good reliability with Cronbach's alpha of internal consistency ranging from 0.89 to 0.94

in the original scale (Russell, 1996). Moreover, studies also have established good reliability when using UCLA Loneliness with older adults in LTC facilities with a Cronbach alpha ranging from 0.86 to 0.90 (Adams et al., 2004; Bergman-Evans, 2004; Hawthorne et al., 2008).

The UCLA Loneliness has been translated into Chinese by Zhang and Yang (1999) who has completed the evaluation of the content validity with CVI of .85. Regarding reliability, the Cronbach's α is measured by the elderly is between .82 and .89. The internal consistency for the UCLA Loneliness was acceptable with Cronbach's α of ranging from .82 to .89, which can be used in Taiwanese older adults.

(5) Geriatric Depression Scale - Short Form (GDS-SF)

The GDS-SF, developed by Yesavage and Sheikh (1986), consists of 15 items with 10 positive items and 5 negative items. GDS-SF has been found to be a useful tool to detect depressive symptoms in older populations (Greenberg, 2007). Each item has a yes or no answer response, and one point is scored for each bolded answer selected. The scores range from 0–21 and a cut-off point of 6 or more indicates the presence of depression (Chan, 1996). The sensitivity and specificity of the original scale were 84% and 95%, respectively (Yesavage & Sheikh, 1986).

This scale has good reliability with Cronbach's α of internal consistency with 0.89 in the original version and 0.81 in the Chinese version. Wang (2001) measured the depression of older adults in Taiwan by the GDS-SF.

(6) Warwick-Edinburgh Mental Well-being Scale (WEMWBS)

The W**EMWBS** scale was developed by researchers at the Universities of Warwick and Edinburgh (2006), including 14 items of mental well-being covering subjective well-being and psychological functioning. The scale is scored by summing responses to each item answered on a 5 points Likert scale and the scores range from 14 – 70. The higher the score, the better the mental well-being. This original scale has good reliability with Cronbach's alpha of internal consistency with 0.89, test-retest reliability with .83.

The Chinese version of WEMWBS was used in community-dwelling elderly by Liu, Guo and Liu (2016) with Cronbach's α = .93 and test-retest reliability of .79. Therefore, we will further examine the reliability and validity of the Chinese version of WEMWBS for older adults in Taiwan.

8. Data analysis

Data will be analyzed using the Statistical Package for Social Science (SPSS) for Windows software version 26 (IBM Corp.). Data collected will be reviewed for completeness and consistency within a single data form. Approximately 10% of the data entry will be checked for accuracy and consistency (Gad & Taulbee, 1996). Last observation carried forward method will be used to manage missing data at random (Kang, 2013). An intention-to-treat approach (Gupta, 2011) will be used in which all participants will be analyzed according to their enrolment.

Descriptive statistics will be used to analyses demographic data where normality of data distribution for the outcome variables will be examined using probability plots and Kolmorgorov-Smironov tests. Frequency and percentages will be used to summarize categorical variables such as gender and educational level. Mean, standard deviation, and range will be reported to present continuous variables such as age and the score of all scales. Demographic characteristics and baseline data of participants will be compared with different subgroups, using chi-square for categorical variables or t-test (or Mann-Whitney U test) for continuous variables. Relationships between demographic characteristics and outcome measures will be explored using Pearson's correlations. Cronbach's alpha will be used to check the reliability of all instruments.

To probing the change of the markers, a series of paired sample t-test will be used for each group. To testing the research hypothesis, a mixed designed generalized linear model (GLM) will be employed to test the effects of arms on the differences between the pre and post-test in relation to outcome measures, including oxytocin level, dopamine and HRV changes for different attachment orientations of older adults living LTC facilities. In order to increase precision in estimating the effect of interest, the possible confounding effects of the covariates, such as age, education, etc, will be used to take into account as covariate in the model. The effect size will be calculate to show the magnitude and direction of the effect in the attachment-specific group relative to the control for each outcome variable. In order to identify the optimal duration of clinical application for this intervention, a trend analysis will be conducted. Explorary additional analysis will be conducted to test the interaction between intervention, and potential biomarker on clinical evaluation. A p value $< .05$ will be taken as the level of statistical significance. The 95% confidence interval around the differences will be calculated.

II. Expectation Outcome

We expect to identify positive effect of Paro intervention on cognitive, executive functions, depression, loneliness, and mental well-being for older adults with dementia.

III. Ethical Considerations

Ethics approval for both phases of the study will be sought from Cheng-Kung University Human Research Ethics Committee and prior to the commencement of the study. Ethics approval for the study will also be sought from the participating LTC facilities in Taiwan prior to the commencement of the study. The researcher will inform the participants about the aims and objectives of the research study and what their participation will involve. Participants will be assured that (a) their participation will be on a voluntary basis and they are under no obligation to participate; and (b) they are free to withdraw from the study at any time without explanation, penalty or compromising their relationship with the LTC. A signed consent form will be sought from each participant. There are no foreseeable risks associated with participation in the intervention for participants.

All collected data will be stored electronically with password-protection to prevent unauthorised access to the data. All data and related documents will be kept in a key-locked cabinet for 5 years before being destroyed. Although demographic data will be requested, participants will remain anonymous. For quantitative data, all data will be de-identified at data entry and results will be reported in general terms. For qualitative data, the digital interview files will be deleted after transcription. Data will be de-identified with codes and content separated. Anonymity will be maintained via pseudonyms for direct interview quotes used in the reporting of findings.

For ethical consideration, our research team will provide opportunity for the elderly in the control group who receiving plush toy. They can choose to partake two 50-minute sessions of group-based Paro interventions to experience interactions with Paro after completing their intervention and follow up.

IV. Expected difficulties encountered and solutions

1. Difficulties for participant's recruitment and active engagement data collection

This study will conduct 6 weekly sessions of Paro intervention in LTC facilities. Older adults may feel anxious about interaction with a Paro or withdraw from the

intervention. For dealing with this potential problem, the possible solutions are as below:

(1) The research team will hold a briefing to explain the research process to the participating institutions in order to attract the participation of the heads of the institutions.

(2) Introducing the Paro to family and encourage family and workers interacting with the Paro. Also, encouraging participants share their experiences with his/her friends.

(3) Provide incentives or motives for participants and explaining the research procedure and potential benefits for them. The research team will show a Paro video or demonstrate Paro interaction to participants and facilities to introduce how the Paro interact with other older adults and share with experiences to using it.

2. Difficulties in quality assurance and quality control in Paro research

As a limited number of Paro, each round will plan to recruit 6 participants. The research team will extend the study periods to recruit enough participants. For controlling the research quality, the possible solutions are as below:

(1) *To increase the quality and consistency of interaction with Paro.* Each facility will recruit two volunteering care staff to participate in the study. Staff will receive 1 hour of Paro interactive training. Each care staff will provide incentives and motives to increase motivation to partake this study.

(2) *For reducing the interference or contamination among the four groups*. This study will recruit control group and experimental groups in different levels to prevent interference among groups receiving intervention at the same time in the same facility.

(3) *To reduce the human interferences.* In order to establish a research consensus among institutional staff, we will provide a 60-minute course to workers in participating facilities, the purpose of which is to help them to familiarize with our programs and procedures

1. Work Projects

(1) Contact with the long-term care facilities and design a flyer for recruitment of research participants.

(2) Research assistants training, establishing standardized procedures of intervention, developing data collection steps, related knowledge of processes in Paro intervention.
(3) For research fidelity, monitoring experimental group and control group by weekly check, holding regular steering meetings to maintain the quality and consistency of program implementation.
(4) Conduct data collection using questionnaires.
(5) To submit the manuscript to international conferences and health-related journals.
(6) To submit the final report for the project.

2. Expected the contribution of the Research

This study will thoroughly examine the effect of Paro intervention on cognitive, executive functions, mental well-being for specific attachment orientation older adults with dementia. This is the first study we know of to utilize a rigorous research design to examine the effect of intervention and explore the relationship between different attachment orientation older people and Paro. The findings of this study will provide strong evidence and advance knowledge of the mechanism of Paro intervention in LTC of Taiwan and be able to link this result to international studies. The findings of the research will publish in international journals.

3. Expected Contribution of Research to Personnel

There are regular training and interdisciplinary meetings for all research staff to strengthen their research skills, as well as expand their knowledge for newly aged care model such as innovated technological devices and robots for older adults. The staff will conduct research capacity training prior to the study, including questionnaire administration, Paro intervention, and data analysis. Research members will recognize measurements of cognitive function tools, mental well-being, depression, and loneliness distress symptoms and learn how to cooperate with interdisciplinary experts. These skills will help members to foster teamwork and interdisciplinary knowledge and expand integration of knowledge systems such as nursing, psychological and robotic technology. The above training will help members to advance capabilities to be an independent research, behavioral observer, and a competent analyzer.

Reference

Aarts, E., A. Roelofs, B. Franke, M. Rijpkema, G. Fernandez, R. C. Helmich and R. Cools (2010). "Striatal dopamine mediates the interface between motivational and cognitive control in humans: evidence from genetic imaging." Neuropsychopharmacology **35**(9): 1943-1951.

Adams, K. B., Sanders, S., & Auth, E. (2004). Loneliness and depression in independent living retirement communities: risk and resilience factors. Aging & Mental Health, 8(6), 475-485.

Baskerville, T. A., J. Allard, C. Wayman and A. J. Douglas (2009). "Dopamine-oxytocin interactions in penile erection." Eur J Neurosci **30**(11): 2151-2164.

Baskerville, T. A. and A. J. Douglas (2010). "Dopamine and oxytocin interactions underlying behaviors: potential contributions to behavioral disorders." CNS Neurosci Ther **16**(3): e92-123.

Berlin L, Bohlin G. Response inhibition, hyperactivity, and conduct problems among preschool children. J Clin Child Adolesc Psychol. 2002;31:242–51.

Bergman-Evans, B. (2004). Beyond the basics: Effects of the Eden Alternative model on quality of life issues. Journal of gerontological nursing, 30(6), 27-34.

Chan, A. C.-M. (1996). Clinical validation of the geriatric depression scale (GDS) Chinese version. Journal of aging and health, 8(2), 238-253.

Chen, S.-C., Jones, C., & Moyle, W. (2018). Social Robots for Depression in Older Adults: A Systematic Review. Journal of nursing scholarship : an official publication of Sigma Theta Tau International Honor Society of Nursing. doi:10.1111/jnu.12423

Blair (2000). "Heart rate variability, trait anxiety, and perceived stress among physically fit men and women." International Journal of Psychophysiology **37**(2): 121-133.

Cohen-Mansfield, J., Marx, M. S., Dakheel-Ali, M., Regier, N. G., & Thein, K. (2010). Can persons with dementia be engaged with stimuli? The American Journal of Geriatric Psychiatry, 18(4), 351-362.

Chu, M. T., Khosla, R., Khaksar, S. M., & Nguyen, K. (2016). Service innovation through social robot engagement to improve dementia care quality. *Assist Technol*, 1-11. doi:10.1080/10400435.2016.1171807

Chung, P.-J., Chiou, C.-J., & Chou, F.-H. (2009). Relationships between health status, depression and cognitive functions of institutionalized male veterans. *Archives of Gerontology and Geriatrics, 49*(2), 215-219. doi:10.1016/j.archger.2008.08.002

Dishman, R. K., Y. Nakamura, M. E. Garcia, R. W. Thompson, A. L. Dunn and S. N.

Domes, G., M. Heinrichs, E. Kumbier, A. Grossmann, K. Hauenstein and S. C. Herpertz (2013). "Effects

of Intranasal Oxytocin on the Neural Basis of Face Processing in Autism Spectrum Disorder." Biol Psychiatry: (In press).

Domes, G., M. Heinrichs, A. Michel, C. Berger and S. C. Herpertz (2007). "Oxytocin improves "mind-reading" in humans." Biol Psychiatry **61**(6): 731-733.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*(3), 189-198.

Gad, S. C., & Taulbee, S. M. (1996). Handbook of data recording, maintenance, and management for the biomedical sciences: CRC Press.

Greenberg, S. A. (2007). Why Use the GDS: SF Instead of Other Tools? AJN The American Journal of Nursing, 107(10).

Groppe, S. E., A. Gossen, L. Rademacher, A. Hahn, L. Westphal, G. Grunder and K. N. Spreckelmeyer (2013). "Oxytocin Influences Processing of Socially Relevant Cues in the Ventral Tegmental Area of the Human Brain." Biol Psychiatry: (In press).

Gupta, S. K. (2011). Intention-to-treat concept: a review. Perspectives in clinical research, 2(3), 109.

Hawthorne, G. (2008). Perceived social isolation in a community sample: its prevalence and correlates with aspects of peoples' lives. Social psychiatry and psychiatric epidemiology, 43(2), 140-150.

Kamen, P. W., H. Krum and A. M. Tonkin (1996). "Poincare plot of heart rate variability allows quantitative display of parasympathetic nervous activity in humans." Clinical Science **91**(2): 201-208.

Kleiger, R. E., J. P. Miller, J. T. Bigger, Jr. and A. J. Moss (1987). "Decreased heart rate variability and its association with increased mortality after acute myocardial infarction." Am J Cardiol **59**(4): 256-262.

Kosfeld, M., M. Heinrichs, P. J. Zak, U. Fischbacher and E. Fehr (2005). "Oxytocin increases trust in humans." Nature **435**(7042): 673-676.

Liu, Guo, & Liu. (2016). Validity and reliability of Warwick-Edinburgh Mental Well-being Scale in older adults. Chinese Mental Health Journal, 30(3), 174-178.

Liu, Y. and Z. X. Wang (2003). "Nucleus accumbens oxytocin and dopamine interact to regulate pair bond formation in female prairie voles." Neuroscience **121**(3): 537-544.

Love, T. M., M. A. Enoch, C. A. Hodgkinson, M. Pecina, B. Mickey, R. A. Koeppe, C.

Love, T. M., M. A. Enoch, C. A. Hodgkinson, M. Pecina, B. Mickey, R. A. Koeppe, C. S. Stohler, D. Goldman and J. K. Zubieta (2012). "Oxytocin gene polymorphisms influence human dopaminergic function in a sex-dependent manner." Biol Psychiatry **72**(3): 198-206.

Lou, M. F., Dai, Y. T., Huang, G. S., & Yu, P. J. (2007). Identifying the most efficient items from the Mini-Mental State Examination for cognitive function assessment in older Taiwanese patients. *Journal of Clinical Nursing, 16*(3), 502-508. doi:10.1111/j.1365-2702.2005.01551.x

Macleod CM. Half a century of research on the Stroop effect: an integrative review. Psychol Bull. 1991;109:163–203.

Malliani, A., F. Lombardi, M. Pagani and S. Cerutti (1990). "Clinical exploration of the autonomic nervous system by means of electrocardiography." Annals of the New York Academy of Sciences **601**: 234-246.

Marioni, R. E., Chatfield, M., Brayne, C., & Matthews, F. E. (2011). The reliability of assigning individuals to cognitive states using the mini mental-state examination: A population-based prospective cohort study. *BMC Medical Research Methodology, 11*(1), 127. doi:10.1186/1471-2288-11-127

Melis, M. R., T. Melis, C. Cocco, S. Succu, F. Sanna, G. Pillolla, A. Boi, G. L. Ferri and A. Argiolas (2007). "Oxytocin injected into the ventral tegmental area induces penile erection and increases extracellular dopamine in the nucleus accumbens and paraventricular nucleus of the hypothalamus of male rats." Eur J Neurosci **26**(4): 1026-1035.

Meyer-Lindenberg, A., G. Domes, P. Kirsch and M. Heinrichs (2011). "Oxytocin and vasopressin in the human brain: social neuropeptides for translational medicine." Nat Rev Neurosci **12**(9): 524-538.

Meyer-Lindenberg, A. and H. Tost (2012). "Neural mechanisms of social risk for psychiatric disorders." Nat Neurosci **15**(5): 663-668.

Mitchell, A. J. (2008). A meta-analysis of the accuracy of the mini-mental state examination in the detection of dementia and mild cognitive impairment. *Journal of Psychiatric Research, 43*(4), 411-431. doi:10.1016/j.jpsychires.2008.04.014

Moyle, W., Jones, C., Pu, L., & Chen, S.-C. (2018). Applying user-centred research design and evidence to develop and guide the use of technologies, including robots, in aged care. Contemporary Nurse, 54(1), 1-3. doi:10.1080/10376178.2017.1438057

Moyle, W., Jones, C., Sung, B., Bramble, M., O'Dwyer, S., Blumenstein, M., & Estivill-Castro, V. (2016). What Effect Does an Animal Robot Called CuDDler Have on the Engagement and Emotional

Response of Older People with Dementia? A Pilot Feasibility Study. International Journal of Social Robotics, 8(1), 145-156. doi:10.1007/s12369-015-0326-7

Moyle, W., Jones, C. J., Murfield, J. E., Thalib, L., Beattie, E. R. A., Shum, D. K. H., . . . Draper, B. M. (2017). Use of a Robotic Seal as a Therapeutic Tool to Improve Dementia Symptoms: A Cluster-Randomized Controlled Trial. Journal of the American Medical Directors Association, 18(9), 766-773. doi:https://doi.org/10.1016/j.jamda.2017.03.018

Park, J., M. Willmott, G. Vetuz, C. Toye, A. Kirley, Z. Hawi, K. J. Brookes, M. Gill and L. Kent (2010). "Evidence that genetic variation in the oxytocin receptor (OXTR) gene influences social cognition in ADHD." Prog Neuropsychopharmacol Biol Psychiatry 34(4): 697-702.

Pyner, S. (2009). "Neurochemistry of the paraventricular nucleus of the hypothalamus: implications for cardiovascular regulation." Journal of Chemical Neuroanatomy 38(3): 197-208.

Rabinowitz, I. and Y. Lavner (2014). "Association between finger tapping, attention, memory, and cognitive diagnosis in elderly patients." Percept Mot Skills **119**(1): 259-278.

Robinson, H., MacDonald, B., & Broadbent, E. (2015). Physiological effects of a companion robot on blood pressure of older people in residential care facility: A pilot study. Australasian Journal on Ageing, 34(1), 27-32.

Romero-Fernandez, W., D. O. Borroto-Escuela, L. F. Agnati and K. Fuxe (2012). "Evidence for the existence of dopamine d2-oxytocin receptor heteromers in the ventral and dorsal striatum with facilitatory receptor-receptor interactions." Mol Psychiatry: (In press).

Rosenfeld, A. J., J. A. Lieberman and L. F. Jarskog (2011). "Oxytocin, dopamine, and the amygdala: a neurofunctional model of social cognitive deficits in schizophrenia." Schizophr Bull **37**(5): 1077-1087.

Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, validity, and factor structure. Journal of personality assessment, 66(1), 20-40.

Schott, B. H., L. Minuzzi, R. M. Krebs, D. Elmenhorst, M. Lang, O. H. Winz, C. I. Seidenbecher, H. H. Coenen, H. J. Heinze, K. Zilles, E. Duzel and A. Bauer (2008). "Mesolimbic functional magnetic resonance imaging activations during reward anticipation correlate with reward-related ventral striatal dopamine release." Journal of Neuroscience **28**(52): 14311-14319.

Shibata, T. (2004). An overview of human interactive robots for psychological enrichment. Proceedings of the IEEE, 92(11), 1749-1758.

Shields, R. W., Jr. (2009). "Heart rate variability with deep breathing as a clinical test of cardiovagal

function." Cleveland Clinic Journal of Medicine **76 Suppl 2**: S37-40.

Siniscarco, M. T., Love-Williams, C., & Burnett-Wolle, S. (2017). Video conferencing: An intervention for emotional loneliness in long-term care. Activities, Adaptation & Aging, 41(4), 316-329.

Stroop JR. Studies of interference in serial verbal reactions. J Exp Psychol. 1935;18:643–61.

Succu, S., F. Sanna, C. Cocco, T. Melis, A. Boi, G. L. Ferri, A. Argiolas and M. R. Melis (2008). "Oxytocin induces penile erection when injected into the ventral tegmental area of male rats: role of nitric oxide and cyclic GMP." Eur J Neurosci **28**(4): 813-821.

Task force of the European society of cardiology and the North American society of pacing and electrophysiology (1996). "Heart rate variability. Standards of measurement, physiological interpretation, and clinical use." European Heart Journal **17**(3): 354-381.

Task Force of the European Society of Cardiology the North American Society of Pacing (1996). "Heart rate variability. Standards of measurement, physiologic interpretation, and clinical use." Circulation **93**(5): 1043-1065.

Thayer, J. F., F. Ahs, M. Fredrikson, J. J. Sollers, 3rd and T. D. Wager (2012). "A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health." Neurosci Biobehav Rev **36**(2): 747-756.

Tillman CM, Thorell LB, Brocki KC, Bohlin G. Motor response inhibition and execution in the stop-signal task: development and relation to ADHD behaviors. Child Neuropsychol. 2007;14(1):42–59.

Toichi, M., T. Sugiura, T. Murai and A. Sengoku (1997). "A new method of assessing cardiac autonomic function and its comparison with spectral analysis and coefficient of variation of R-R interval." Journal of the Autonomic Nervous System **62**(1-2): 79-84.

Towse JN, Hitch GJ, Hutton UA. Re-evaluation of working memory capacity in children. J Mem Lang. 1998;39:195–217.

Vazquez, L., J. D. Blood, J. Wu, T. M. Chaplin, R. E. Hommer, H. J. Rutherford, M. N. Potenza, L. C. Mayes and M. J. Crowley (2016). "High frequency heart-rate variability predicts adolescent depressive symptoms, particularly anhedonia, across one year." J Affect Disord **196**: 243-247.

Yang, Y. K., N. T. Chiu, C. C. Chen, M. Chen, T. L. Yeh and I. H. Lee (2003). "Correlation between fine motor activity and striatal dopamine D2 receptor density in patients with schizophrenia and healthy controls." Psychiatry Res **123**(3): 191-197.

Young, L. J. and Z. Wang (2004). "The neurobiology of pair bonding." Nat Neurosci 7(10): 1048-1054.

Yesavage, J., & Sheikh, J. (1986). 9/Geriatric Depression Scale (GDS). *Clinical Gerontologist, 5*(1), 165-173. doi:10.1300/J018v05n01_09

Zhang, & Yang. (1999). The relationship between the elderly loneliness and it's factors of personal attributes, perceived health status and social support. The Kaohsiung Journal of Medical Sciences, 15(6), 337-347.

Zhang, M., Zhang, M., Zhang, M., Katzman, R., Katzman, R., Katzman, R., . . . Liu, W. T. (1990). The prevalence of dementia and Alzheimer's disease in Shanghai, China: Impact of age, gender and education. *Annals of Neurology, 27*(4), 428-437. doi:10.1002/ana.410270412