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The Paro robot seal as a social mediator for healthy users

Natalie Wood[1] and **Amanda Sharkey**[2] and **Gail Mountain**[3] and **Abigail Millings**[4]

Abstract. Robots are being designed to provide companionship, but there is some concern that they could lead to a reduction in human contact for vulnerable populations. However, some field data suggests that robots may have a social mediation effect in human-human interactions. This study examined social mediation effects in a controlled laboratory setting. In this study 114 unacquainted female volunteers were put in pairs and randomised to interact together with an active Paro, an inactive Paro, or a dinosaur toy robot. Each pair was invited to evaluate and interact with the robot together during a ten minute session. Post-interaction questionnaires measured the quality of dyadic interaction between participants during the session. Our results indicate that the strongest social mediation effect was from the active Paro.

1 INTRODUCTION

Over the last decade robots have been developed as an alternative to companion animals for older-aged adults and people with dementia in care homes. These companion robots are designed to improve the physical and psychological health of users by calming them, providing companionship, and have the potential to help reduce loneliness and improve the well-being of their users [11, 2].

Despite the benefits these assistive robots bring, there are objections to their use with vulnerable populations. Sparrow and Sparrow [15] raise one main concern as the loss of human contact had by these populations as their human carers are replaced with robotic counterparts. They argue that robotic technology is not currently capable of meeting the social and emotional needs of their users. As the amount of human-human contact between patients and their carers decreases, this could lead to a reduction in the number and quality of their social relationships, and therefore their quality of life.

This concern is supported by Sharkey and Sharkey [13], who consider the negative effects of reduced social contact on the physical and psychological well-being of the elderly. They propose that access to human social contact must be considered before robotic technology is brought into elder-care.

However, a recent developing area of research has shown that robotics can have a role in improving human-human relationships. This small but growing body of field data suggests that a companion robot, the Paro robot seal, can be used to encourage social interaction between individuals, in addition to providing human-robot companionship.

The majority of these studies examined the social mediation effect of Paro using samples of people with cognitive impairment in care home settings.

This paper aims to contribute to this research by investigating whether the social mediation effect is present in healthy populations and under controlled conditions. Animals have been found to act as a social catalyst for healthy individuals as well as for people with dementia and older adults [5][9]. We propose that the same could be true of animal-like robots. Our study looks at the ability of Paro to mediate social interaction between strangers by providing an ice breaker effect in a controlled laboratory setting.

Section 1.1 of this paper introduces the existing work on social mediation with Paro. Section 2 details our hypotheses. This is followed by the methodology used for the study in section 3. Our analytic strategy and results are discussed in section 4. We discuss our findings and limitations of the work in section 5. Finally section 6 concludes the paper.

1.1 Background

Previous studies conducted in care homes have reported the ability of Paro as a social mediator. A randomised controlled trial by Robinson, Macdonald, Kerse, and Broadbent [12] showed a significant decrease in the loneliness reported by 17 residents of a retirement home after 12 weeks of regular activity with Paro. They also found an increase in social interaction between residents when they engaged in activity with Paro compared to during normal activities with and without the resident dog.

Wada and Shibata [19] found that the social network of 12 elderly residents in a care home increased after Paro was available in an open public space for two months.

In an ethnographic case study, Giusti and Marti [4] found that not only did the amount of social interaction increase, but the social dynamic between three residents of a nursing home changed from primarily one-to-one social interactions to group interaction involving all three during interactions with Paro.

Kidd, Taggart and Turkle [7] investigated the effect that a small number of interactions with Paro had on social activity in the nursing home setting. They found that the 23 residents reported more social interaction with others when they were with active Paro than when it was turned off. They also found that presence of more people, including caregivers and experimenters, improved the amount of social engagement.

These findings were supported in another nursing home where Šabanović et al. [18] observed that the social interactions increased between seven residents, including those who were not directly interacting with Paro, during robot-assisted therapy sessions.

[1] Sheffield Robotics, University of Sheffield, S1 3JD, UK. Email: natalie.wood@shef.ac.uk.
[2] Department of Computer Science, University of Sheffield, S1 4DP, UK. Email: a.sharkey@dcs.shef.ac.uk.
[3] School of Health and Related Research, University of Sheffield, S1 4DA, UK. Email: g.a.mountain@sheffield.ac.uk
[4] Centre for Assistive Technology & Connected Healthcare, and Department of Psychology, University of Sheffield, S10 2TP, UK. Email: a.millings@sheffield.ac.uk.

Although the results of these studies show support for Paro as a social mediator in the nursing home setting, they are limited by small sample sizes. In addition, the majority of these studies lack control conditions, such that the social meditation effect cannot be attributed specifically to the Paro. It is unclear whether any novel, robotic stimuli would produce the effects observed. In the current study, we examine the social mediation effect of an active Paro which is turned on and interactive, compared to that of an inactive Paro which is turned off and resembling a cuddly toy, and another interactive robotic toy, Pleo the dinosaur.

2 HYPOTHESES

This study aims to answer the following questions: Can the social mediation effect of Paro apply to a healthy population? Can the effect be measured under a controlled laboratory setting?

To investigate the social mediation effect of Paro we invited pairs of strangers to interact for the first time together, along with an active Paro, an inactive Paro, or a Pleo.

We anticipate that the social mediation effect of Paro when active will lead to participants enjoying interacting with the other participant more and having a better experience when interacting together, than with an inactive Paro and the Pleo. We also anticipate that interacting together with an active Paro will lead to a more positive opinion of the other participant compared to the other two conditions.

Secondary to this we also expect the Pleo to be a more effective social mediator than an inactive Paro. This leads to our hypotheses: Primary hypotheses:

- H1: Compared to the Pleo and inactive Paro conditions, the participants in the active Paro condition will report a:
  - (a): higher quality of interaction.
  - (b): higher opinion of the other participant.

Secondary hypotheses:

- H2: Compared to the inactive Paro condition, the participants in the Pleo condition will report a:
  - (a): higher quality of interaction.
  - (b): higher opinion of the other participant.

3 METHODOLOGY

3.1 Participants

Participants were recruited using a number of methods. Firstly, undergraduate psychology students were invited to participate through the University's research participation scheme in exchange for course credit. Secondly, an email was sent using volunteer mailing lists for University of Sheffield staff and students, inviting volunteers to participate in exchange for entry into a prize draw for one of two £30 Amazon vouchers. Female participants were chosen due to the availability of volunteers at the university which were predominantly female at the time.

In total 114 participants were recruited, aged from 15 to 59 ($M = 23.94, SD = 8.38$), and were paired according to availability. Pairs of participants were randomly allocated into conditions with 21 participant pairs in the active Paro condition, 19 participant pairs in the inactive Paro condition, and 17 participants pairs in the Pleo condition.

3.2 Materials

3.2.1 Paro

The Paro was developed in Japan by Shibata [21] as a therapeutic tool for use with people with dementia. It is a pet-like robot based on a harp seal pup and its body is covered in soft, white, and antibacterial fur. It uses a number of sensors for touch and sound to detect interaction. The robot responds to the stimulation of interaction by making noises and moving.

3.2.2 Pleo dinosaur robot

The Pleo [1] is a commercially available pet dinosaur toy which was designed to have a lifelike appearance and adaptive behaviours. The 2008 model used in the experiment has a number of touch sensors on its head, chin, shoulders, back and feet, and audio and light sensors in its head. A range of actuators means it can respond to different types of interaction in different ways. The Pleo is covered with plastic which feels rubbery to touch.

3.2.3 Measures

All measures except the pen-and-paper evaluation form were administered via an online questionnaire on a tablet.

Quality of interaction with the other This was measured using items about how the participant felt during the interaction with the other person, and how the participant perceived the interaction itself:

Participants reported feelings experienced during the interaction by rating eight items from Leary, Kowalski, & Bergen [8] on a 7-point Likert scale from 1 (*not at all*) to 7 (*very much*). Factor analysis [5] reduced these items to two composite measures: *'relaxed', 'awkward', 'nervous'*, and *'confident'* loaded highly onto a factor of 'Confidence' during the interaction ($\alpha = .81$). *'Accepted', 'respected', 'disrespected'*, and *'rejected'* loaded onto a factor of ' Feeling Acceptance' during the interaction ($\alpha = .76$).

How the interaction was perceived was measured using 16 items adapted from Berry and Hansen[3], rated on a 7-point Likert scale from 1 (*not at all*) to 7 (*very much*). Factor analysis reduced these 16 items to four composite measures. First *'relaxed', 'smooth',* and *'natural'* loaded onto how 'Comfortable' the interaction felt ($\alpha = .84$). Secondly *'enjoyable', 'fun', 'pleasant', satisfying', 'intimate'*, and *'boring'* loaded onto a factor of the interaction 'Feeling Positive' ($\alpha = .86$). The third factor had loadings of *'upsetting', 'unpleasant'*, and *'annoying'* on a factor of the interaction 'Feeling Negative' ($\alpha = .65$). Finally *'forced', 'awkward', 'reserved'*, and *'strained'* loaded onto a factor of 'Difficulty' of the interaction ($\alpha = .86$).

Opinion of the other participant Participants answered the following questions adapted from Sprecher, Treger, Wondra, Hilaire, and Wallpe[16] about the interaction with the other participant and about the other participant on a 7-point Likert scale from 1 (*not at all*) to 7 (*very much*).

Liking of the other was measured with three items: '*How much did you like the other participant?*', '*How much would you like to interact with the other participant again?*', and '*How likeable did you find the other participant?*' ($\alpha = .86$)

Closeness to the other was measured with a single item: '*How close do you feel toward the other participant*?'

[5] Factor analysis for the purpose of dimension reduction was conducted using principal component analysis using oblimin rotation with each scale to create composite measures.

Perceived similarity was measured with two items: '*How much do you think you have in common with the other participant?*', and '*How similar do you think you and the other participant are likely to be?*'($\alpha = .86$)

Enjoyment of the interaction: This was measured with a single item:'*How much did you enjoy the interaction with the other participant*?'

Evaluation form The evaluation form consisted of a 10-item questionnaire about the robot which participants completed as a dyad. Five of the items were from Shibata, Wada, Ikeda, and Šabanović[14] and asked participants to indicate on a 7-point Likert scale how much they felt the words *'friendly', 'lively', 'expressive', 'natural',* and *'relaxing'* applied to the robot. The other five items were adapted from Wada, Shibata, Musha, and Kimura [20] and asked participants to answer on 7-point Likert scales the questions '*How cute/ugly do you find the robot?*', '*How much do you like the robot?*', '*How fun/boring is interacting with the robot?*', '*How much more would you want to interact with the robot?*' and '*How much do you want to touch the robot?*'.

3.3 Recording and coding behaviour

The interaction between the participants and the robot was covertly recorded in the experiment room with two Replay digital action cameras. Observed behavioural data will not be reported in this paper but will be detailed elsewhere.

3.4 Procedure

All participants were told that the study aimed to investigate people's opinions of different types of interactive robots, and that they would be asked to interact with and evaluate a robot. Participants were tested in dyads by a female experimenter. On arrival each participant was taken to a separate location to read the information sheet and provide consent to participate. Participants were told that they would meet another participant with whom they would evaluate a robot.

Both participants were first asked to complete a questionnaire (data not included in the current study). At this point the dyad was randomly assigned into either the active Paro, inactive Paro or Pleo conditions. Once both participants had completed the questionnaire, they were introduced to each other (as'the other participant you'll be evaluating the robot with') and together given an explanation of the robot evaluation task they were to undertake.

Participants were told that there would be a robot on the table in the room and were asked to interact with the robot together, in any way they wanted to, but to keep the robot off the floor. In the inactive Paro condition, participants were told that the robot would remain off for the duration of the task and that they would have the opportunity to see it turned on at the end of the session during individual debriefings. All participants were then told that there was an evaluation form on the table and were asked to complete the form together. The participants were told that they would be left and given 10 minutes to complete the task, after which the experimenter would knock on the door to the room and enter to take them to finish the experiment. The experimenter then took them into the room and before leaving, told them they could take a seat at the table.

Participants were given 10 minutes, which would provide sufficient time to complete the task and enable them to interact together beyond the scope of the evaluation. After the 10 minutes the experimenter entered the room and told the participants that the evaluation task was over. The participants were then taken to separate locations to complete a questionnaire to measure the quality of the interaction with the other and their opinion of the other participant. Subsequently the participants were individually thanked, debriefed, and informed of the covert recording which took place before providing their consent for use of the video data. In the inactive Paro condition participants were finally offered the opportunity to have a short interaction with the active Paro.

4 RESULTS

In this paper we report the quantitative data from the post-interaction questionnaire.

Table 1. Multilevel model of robot condition on quality of initial interactions and liking of other. $(*)$ indicates significance ($p < 0.05$), $(+)$ indicates a trend ($p < 0.1$)

	b	SE_b	p	95% CI
Feelings during interaction				
Confidence				
Active Paro vs Inactive Paro	0.26	0.26	0.335	-0.28,0.80
Active Paro vs Pleo	0.33	0.28	0.237	-0.22,0.89
Pleo vs Inactive Paro	-0.07	0.28	0.807	-0.64,0.50
Accepted				
Active Paro vs Inactive Paro	0.17	0.15	0.248	-0.12,0.47
Active Paro vs Pleo	0.18	0.15	0.247	-0.13,0.48
Pleo vs Inactive Paro	-0.01	0.15	0.970	-0.31,0.30
Perception of interaction				
Comfortable				
Active Paro vs Inactive Paro	0.16	0.29	0.585	-0.43,0.75
Active Paro vs Pleo	0.28	0.30	0.358	-0.33,0.89
Pleo vs Inactive Paro	-0.12	0.31	0.700	-0.74,0.50
Positive				
Active Paro vs Inactive Paro	0.46	0.23	0.049 $(*)$	0.00,0.92
Active Paro vs Pleo	0.42	0.24	0.083 $(+)$	-0.06,0.89
Pleo vs Inactive Paro	0.04	0.24	0.855	-0.44,0.53
Negative				
Active Paro vs Inactive Paro	-0.01	0.16	0.965	-0.33,0.31
Active Paro vs Pleo	-0.05	0.16	0.768	-0.38,0.28
Pleo vs Inactive Paro	0.04	0.17	0.804	-0.29,0.38
Difficult				
Active Paro vs Inactive Paro	-0.43	0.31	0.175	-1.05,0.20
Active Paro vs Pleo	-0.35	0.32	0.281	-0.99,0.29
Pleo vs Inactive Paro	-0.08	0.33	0.809	-0.73,0.58
Opinion of other				
Liking				
Active Paro vs Inactive Paro	0.33	0.22	0.135	-0.11,0.77
Active Paro vs Pleo	0.32	0.22	0.165	-0.13,0.76
Pleo vs Inactive Paro	0.01	0.23	0.948	-0.44,0.47
Closeness				
Active Paro vs Inactive Paro	-0.15	0.33	0.658	-0.81,0.52
Active Paro vs Pleo	0.36	0.34	0.297	-0.32,1.04
Pleo vs Inactive Paro	-0.51	0.35	0.150	-1.20,0.19
Similarity				
Active Paro vs Inactive Paro	0.00	0.31	0.992	-0.63,0.63
Active Paro vs Pleo	0.67	0.32	0.044 $(*)$	0.02,1.31
Pleo vs Inactive Paro	-0.66	0.33	0.049 $(*)$	-1.32,-0.00
Enjoyment of interacting				
Active Paro vs Inactive Paro	0.34	0.26	0.203	-0.19,0.86
Active Paro vs Pleo	0.60	0.67	0.031 $(*)$	0.61, 0.14
Pleo vs Inactive Paro	-0.26	0.27	0.350	-0.81,0.29

Dyadic analysis was required to account for the non-independence inherent in dyadic data [6]. This is due to the hierarchical structure

of the data, with individuals nested into dyads. We used multilevel modelling in SPSS with the three robotic interaction conditions as predictors of the quality of interaction and liking of the other. The results are reported in table 1.

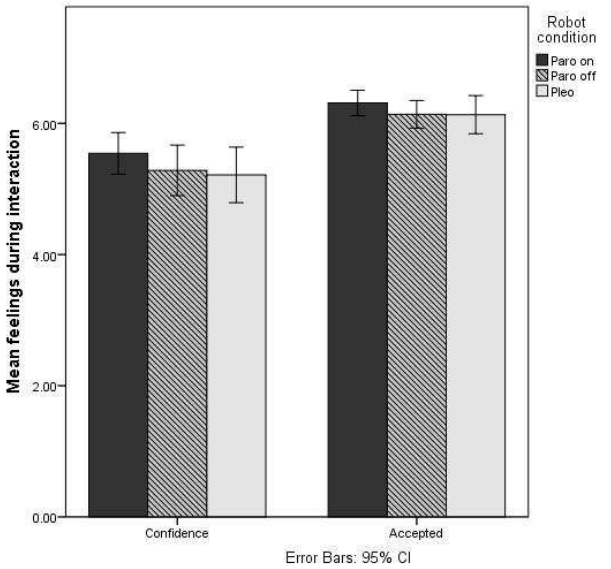

Figure 1. Feelings experienced by participants during the interaction for each robot condition

For the two factors measuring how participants felt during the interaction, no statistically significant differences between conditions were found, as seen in figure 1.

We found a significant difference between the active Paro and inactive Paro conditions for one quality of interaction factor, how positive the interaction felt. Participants in the active Paro condition had a significantly higher rating for positivity than those in the inactive Paro condition, $(b = 0.46, t(57.09) = 2.01, p = 0.049)$. In addition there was a positive trend toward significance for how positive the interaction felt for participants in the active Paro condition compared to those in the Pleo condition, $(b = 0.42, t(57.05) = 1.76, p = 0.083)$. There were no significant differences for how comfortable the interaction felt, how negative the interaction felt, and the difficulty of interaction. Figure 2 illustrates these results.

From the factors measuring participants' opinions of the other in Figure 3, perceived similarity to the other participant was significantly higher in the active Paro condition than in the Pleo condition $(b = 0.67, t(56.78) = 2.06, p = 0.044)$ but was significantly lower than the inactive Paro condition $(b = -0.66, t(56.16) = -2.01, p = 0.049)$. Participants in the active Paro condition had a significantly higher rating of enjoying interacting with the other than those in the Pleo condition, $(b = 0.60, t(56.89) = 2.21, p = 0.031)$

5 DISCUSSION

The results from this study suggest that participants found the interaction with their partner more positive and had a higher opinion of their partner when interacting together with the active Paro, than with the inactive Paro or with the Pleo. This supports the hypotheses H1a and H1b.

However no results were found to support the hypotheses H2a or H2b, that participants who interact with the Pleo would have a stronger social mediation effect than the inactive Paro.

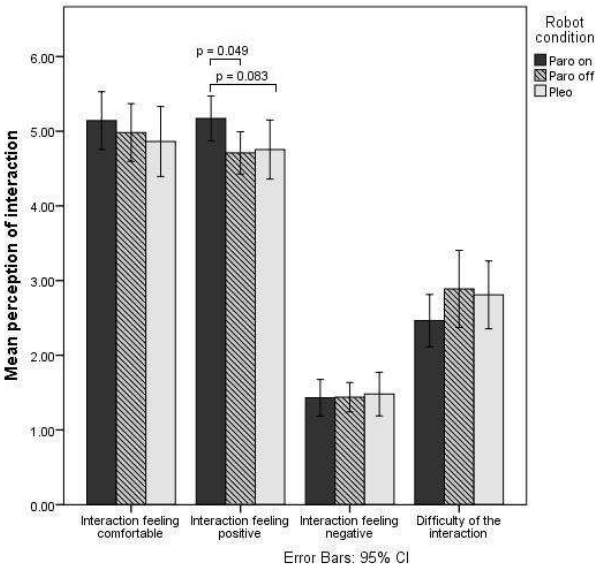

Figure 2. How the interaction was perceived for each robot condition

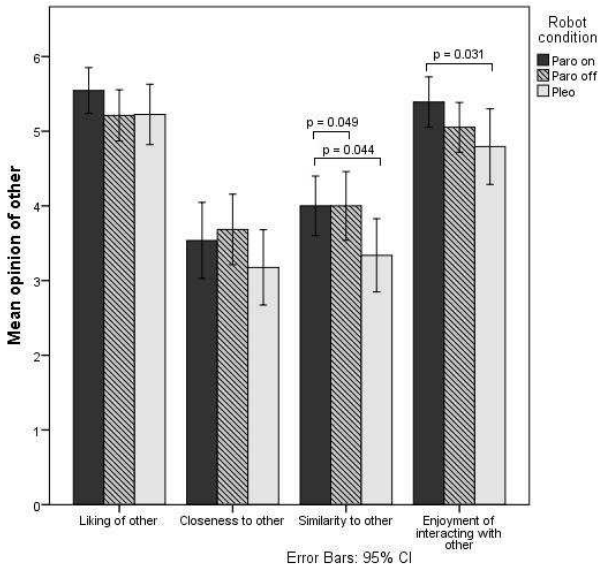

Figure 3. Participants' opinion of the other participant for each robot condition

Of the hypotheses in H1, we found a significant result to partially support hypothesis 1a which concerns the quality of the interaction. The results show that participants who interacted with the active Paro had a greater generally positive feeling about the interaction with their partner than those who interacted with the inactive Paro. The trend between the active Paro and the Pleo, while still positive, was only near significant. A possible explanation for this is that when the Paro is active and interactive it is much more stimulating for both participants than when it was inactive, and provides a stronger focus for their interaction. The interactive Pleo may have been less effective due to the different appearance and texture, which is less cuddly and tactile and therefore less engaging.

Of the four factors to measure participants' opinions of the other two factors, similarity and enjoyment of interacting with the other person, show a significant effect. The significant effect was found between the active Paro condition and the inactive Paro and Pleo conditions which supports hypothesis 1b.

It is known that perceived similarity predicts interpersonal attraction [10], and has been found to predict long term attraction and the development of relationships in newly acquainted dyads[17]. Because interacting with the Paro, when active or inactive, has a larger impact on perceived similarity within pairs in this study, they may be judged as more likely to go on to form relationships than those with the Pleo. We suggest that this is because the Pleo has a more polarising effect than Paro, in which some people dislike it whereas others find it appealing, and is more likely to divide opinions during the interaction.

The higher ratings for the enjoyment of interacting with their partner for participants in the active Paro condition show that the experience of interacting together was improved by the presence of active Paro compared to the Pleo and inactive Paro.

In accordance with our primary hypothesis, these results show that the Paro, when active, is more effective as a social mediator and an ice-breaker for first-time interactions that the Pleo or inactive Paro. The lack of significant differences between the Pleo and inactive Paro conditions show that the second hypothesis is unsupported, and there is no difference between them as social mediators. This research suggests that the interactivity and the tactile texture are important factors of Paro which make it an and engaging and appealing object for individuals to interact over for the first time.

5.1 Limitations

A number of limitations need to be acknowledged in this study: the sample size did not provide the power to verify the findings with confidence. A number of results displayed the trend we hypothesised, and it is possible that larger numbers of participants would affect the significance values of these results.

The current study has only examined the social mediation effect of Paro with female participants and these results cannot be extended to male-male or female-male dyads. The response of males participants must be investigated as due to gender role norms, it is possible that males may respond more positively towards a robot which resembles a dinosaur to one resembling a seal.

One of the questions we posed was'Can the social mediation effect of the Paro be measured under laboratory conditions?' and these results show that some effect is measurable. However, while conducting the study under laboratory conditions allows a more controlled examination of the social mediation effect, the findings cannot be generalised to all social situations, and must be replicated in different situations to understand the possible applications of this effect.

Further work could include measures of personality and attachment in order to statistically control for individual differences in forming relationships. It would also be interesting to compare this study which used unacquainted dyads to one which uses people who already know each other.

6 CONCLUSIONS AND FURTHER WORK

The present study was designed to investigate the social mediation effect of Paro under controlled conditions. This research adds to the limited evidence which shows that robotic technologies can support social interaction between people. Our results suggest that when people interact together with Paro it helps provide a context in which to form a good first impression of their partner, and have a positive experience with them.

The findings of this study demonstrate that robotic technologies can support human-human interactions by encouraging social interaction and assist in the formation of relationships. More research is needed to fully understand this potential role for the further development of robot companions.

As the quantitative data in this study comes from self-report measures in the questionnaire, we expect the observed behavioural data from the covert video recording might highlight differences between interactions in robot conditions more clearly. The next stage of this study will be to examine the content of the interactions with the video data. Further research is needed to examine the social mediation effect of the Paro with its target users; older-aged adults, including those who are healthy and those with dementia. One application of the social mediation effect of Paro which has not been evaluated to date is its use in visits to care homes from family and friends. It would be valuable to investigate the role of Paro during these visits, and whether it leads to an increase in quality of the visitation time.

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