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The Effect of Listening to Recordings of One's Voice on Attentional Bias and Auditory Verbal Learning

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Abstract

Previous studies have shown that exposure to recording of one's own voice can cause a negative reaction. This reaction may affect one's attentional system and auditory verbal learning rate. The aim of this study was to assess the effect of listening to recordings of one's own voice on attentional bias in one experiment and to assess the effect on auditory verbal learning in a second experiment. The present study was an experimental study that was designed and conducted as two separate experiments. Fifty-five subjects participated in the first experiment to investigate the effect of listening to recordings of one's own voice on attentional bias. The auditory Stroop test was performed on a computer with two different voices, i.e., 1) the recorded voice of another person and 2) a recording of the participant's own voice. The average reaction time of the participants was compared for the two recordings. Sixty-one subjects participated in the second experiment to assess the effect of listening to a recording of one's own voice on auditory verbal learning. The 61 subjects were divided randomly into two groups, i.e., an experimental group (31 participants) and a control group (30 participants). The Rey auditory verbal learning test (RAVLT, Persian version) was used with two different recordings, i.e., recordings of the participants' own voices for the experimental group and recordings of another person's voice for the control group. The mean scores of the two groups were compared for each trial.The comparison of the participants' mean of reaction time, which was measured twice in the experimental group, showed a significant difference. The comparison of participants' mean scores between the two groups in the second experiment, showed a significant difference only in the first trial (word span), and no significant difference was found in the other trials. The findings of the study showed that listening a recording of one's own voice caused attentional bias. Also, listening to a recording of one's own voice resulted in less auditory verbal learning in word span than listening to the recorded voice of another person.

Keywords: attentional bias, auditory verbal learning, RAVLT, Stroop test

1. Introduction

1.1 Background

Today, with the advancement of technology and the convenience afforded by electronic devices, such as personal audio and video devices, people are communicating increasingly using their voices and pictures. Studies that have examined this issue have concentrated more on the topic of self-recognition, especially recognizing one's own face. (Uddin et al., 2005). Several studies have shown that self-voice recognition is more difficult than self-face recognition (Ellis, Jones, & Mosdell, 1997; Hanley, Smith, & Hadfield, 1998; Joassin, Maurage, Bruyer, Crommelinck, & Campanella, 2004; Joassin, Maurage, & Campanella, 2008). However, few studies have been conducted in the field of self-voice recognition (e.g., Holzman, Rousey, & Snyder, 1966; Nakamura et al., 2001; Olivos, 1967; Rosa, Lassonde, Pinard, Keenan, & Belin, 2008; Rousey & Holzman, 1967). Despite the practical importance of recorded self-voice, few studies have conducted on how people perceive recorded self-voice, especially its impact on auditory verbal learning (Gaviria, 1966; Yeager, 1966).

1.2 Statement of the Problem

Holzman and Rousey (1966) conducted a study in which the participants' reactions to their own recorded voices were assessed, and they observed negative affective reactions. However, the participants did not have such a reaction when they listened to the recorded voices of other people. The researchers mentioned the difference between the perception of the voice that participants expected to hear and the voice they actually heard. Participants also focused more on grammar, syntax, and personality and psychological characteristics when they were listening to others' recorded voices, but they focused on the quality and tone of recordings of their own voices. Also, Holzman, Berger, and Rousey (1967) conducted a study of bilinguals that showed that listening to their recorded self-voices in their native languages created a more negative affective reaction than when they listened to their recorded self-voices in a second language. Another study that was conducted with people who had a speech defect showed that their negative affective reactions were significantly greater than those who did not have a speech defect when the two groups listened to their recorded self-voices. The results showed that, irrespective of speech defects, female subjects had greater negative affective reactions (Weston & Rousey, 1970).

The perceptions of the recorded self-voice and the recorded voice of other people differ in nature. When we speak naturally, the sound waves reach our ears in two ways, i.e., via air conduction and bone conduction. But when we hear our recorded voice (or the recorded voices of other people talking normally), the sound waves reach our ears only by air conduction. When the sound of our voices is received by both bone conduction and air conduction, the lower frequencies are strengthened, and, as a result, we hear a somewhat distorted version of our own voices (Holzman et al., 1967; Maurer & Landis, 1990; Tonndorf, 1972). Due to this phenomenon, Yeager (1966) conducted a study in which she examined the effect of recorded self-voice on learning with two different presentations (air and bone conduction). The results of her study showed that there was no significant difference between them in the rate of learning in two different presentations.

Neuroimaging studies in which people were examined as they were listening to their self-voices have reported that specific neurocognitive processes that are involved in the perception of one's own voice. The neurocognitive processes were different from the processes that occurred when the subjects were listening to the voices of other people (Allen et al., 2005; Kaplan, Aziz-Zadeh, Uddin, & Iacoboni, 2008; Nakamura et al., 2001). Also Graux et al. (2013) conducted an electrophysiological study that showed that different neural processes occur when discriminating the self-voice from the voices of others. Other studies that have examined the effect of recorded self-voice on psychophysiological responses also achieved significant results (Olivos, 1967; Holzman, Rousey, & Snyder, 1966). These studies showed that participants' psychophysiological responses when listening to their recorded self-voices were significantly greater than when they were listening to the recorded voices of others. These differences in psychophysiological responses occurred irrespective of whether the participants recognized their own voices. Gaviria (1966) examined the effect of recorded self-voice on learning. He conducted the study with the assumption that the increased psychophysiological responses while listening to recorded self-voice would enhance learning. The results of his study indicated that there were no significant differences between the rate of learning through listening to recorded self-voice and the rate of learning through listening to the recorded voices of others.

Studies have shown that words that subjects read aloud are remembered better than words that the same subjects read silently. This phenomenon is called the production effect (MacLeod, Gopie, Hourihan, Neary, & Ozubko, 2010). Also, MacLeod (2011) conducted a study in which, for comparative purposes, words were read aloud, words were read silently, words were read aloud by another person, and words were read aloud simultaneously by the subject and another person. The results indicated that words that are read aloud by the person being tested are more likely to be remembered. These studies were conducted with people using their actual voices, so the effect of recorded self-voice was not determined. In a study conducted by Aruffo and Shore (2012) on the McGurk effect, they reported implicit own voice processing. Since the McGurk effect is automatic, mandatory, and uninfluenced by attention, the results of their study showed that listening to recorded self-voice reduced the McGurk effect. Another study conducted recently by Candini et al. (2014) reported an implicit own voice processing. Their results showed that participants in the implicit self-voice recognition tasks had better and more accurate voice responses than they did in the explicit self-voice recognition tasks.

1.3 Objectives

A few studies were conducted about 50 years ago to examine the effects of recorded self-voice on learning, even though people at that time had few opportunities to hear their own voices. Currently, however, people have many occasions to encounter their recorded self-voices due to the ever-increasing technological advances. Given the importance of the perception of recorded self-voice, the aim of this study was to evaluate the impact of recorded self-voice on audio-verbal learning. Also with regard to the direct impact of the attentional system on learning, a separate experiment was conducted to assess the impact of recorded self-voice on attentional bias.

2. Materials and Methods

2.1 Research Design and Setting

This was an experimental study that was designed and conducted in two separate experiments. The first experiment was designed and conducted to examine the effect of recorded self-voice on attentional bias. A second experiment was designed and conducted to assess the effect of recorded self-voice on auditory verbal learning. Differences in the types and manners of conducting the tests to measure attentional bias and auditory verbal learning led to the design and implementation of two separate experiments. The study populations were students from Sistan University and Baluchistan University. The study ran for two years, i.e., from the beginning of 2013 until the end of 2014.

2.2 Sample Size and Sampling Method

In the first experiment, 55 subjects participated, i.e., 28 females and 27 males with the mean age of 22.02 ±1.7 years. In the second experiment, 61 subjects participated, which included a control group of 30 subjects and an experimental group of 31 subjects. In the control group, there were 14 females and 16 males with the mean age of 22.3±1.9, and, in the experimental group, there were 15 females and 16 males with the mean age of 21.4±1.8 years. The convenience sampling method was used in both experiments, and informed consent was obtained from all participants; the subjects had no problems with speech or hearing. They did not have any diseases or personal habits that affected these two abilities, such as hoarseness, colds, or smoking. While they were participating in the research, they did not use any drugs that could have influenced their abilities to pay attention and concentrate. Persian was the native language of all of the subjects.

2.3 Auditory Stroop Task and Rey Auditory Verbal Learning Task

A computerized auditory Stroop test with two conditions was used in Experiment 1. One condition involved participants hearing their own voice naming colors and the other a gender matched saying color names. Our measurement tool was a modified version of Roelofs (2005) test. We used SuperLab Pro 4.0.7 SKD software to modify the test, and, in doing so, we considered the way that Ghawami, Raghibi, and Daryadar (2013) modified and used the test in their study. Experiment 1 used a Stroop task and one condition assessed response times to color names for another's voice and the other condition the participants' own voice. In the second test, we used the Persian version of Rey's auditory verbal learning test (Rezvanfard et al., 2011). This test has five main trials, including a list of 15 words that are read for participants in each trial. When the words were read, the rate of recalling was recorded. The numbers of words recalled in the first trial (word span), the fifth trial (final acquisition level), and the total of the first through the fifth trials (total acquisition) were examined in this study. A recording of the list of words for the control group was played with an unfamiliar voice of their own gender, whereas the recorded self-voice was played for the experimental group.

2.4 Data Collection

This study consisted of two experiments. Samples for each test were collected separately and at different times. Each experiment consisted of two sessions. The objective of the first session was to record the test content with the voice of the subject, and the objective of the second session was to conduct the test. In the first experiment, after the first session (recording subjects' voices), the auditory Stroop test with recorded self-voice was conducted separately for each subject. A few days later, at the second session, the subjects' reaction times were measured by conducting duplicate Stroop tests of their recorded voices. The first measurement was done using an unfamiliar recorded voice of the subjects' own gender, and the second measurement was done using the subjects' recorded self-voices.

In the second experiment, after the first session in which the voices of the 61 subjects were recorded, the 61 subjects were randomly divided into experimental and control groups. Then, the audio files of reading the test words were provided with recorded voices of the subjects of the experimental group. Two audio files of different genders were made for the control group. Six months after the first session, the second session was conducted separately for each subject. In the second session, the auditory verbal learning test for the experimental group was conducted using the recorded self-voices, and the test was conducted for the control group using an unfamiliar recorded voice of each subject's own gender. In the second experiment, we assessed the recall accuracy of subjects.

2.4.1 Experiment 1

2.4.1.1 First Session

After confirming the students' interest in participating and cooperating in the first experiment to investigate the effect of recorded self-voice on attentional bias, a briefing session was held and coordination was made with 57 participants for implementing the first session. After obtaining demographic data and written informed consent, the subjects were asked to record their voices, and the dialogue between the examiner and each subject (related to issues of the students' lives and their future careers) was recorded by a Sony PCM-D50 digital recorder at the highest quality. In the middle of the conversation, the participants were asked to read loudly and clearly a list of 10 words, including the name of colors. The target colors (red, blue, and green) were inserted among the words. Then, the second session was planned based on the students' schedules and availability.

2.4.1.2 Making Tests

The file containing the recorded voices of the participants was given to a sound specialist to analyze and compile. He examined the various qualitative and quantitative aspects of the sounds using Adobe Audition Cs 5.5 v4.0 software and chose the appropriate files for use in the test. Among the extracted files, two participants' ways of reading did not meet the necessary criteria and were excluded. The voices of the other 55 subjects naming colors (red, blue, and green) were found to be suitable for conducting the auditory Stroop test. Then, the software SuperLab Pro 4.0.7 SKD conducted an auditory Stroop test for each participant separately from her or his own recorded voice. The two other auditory Stroop tests of recorded voices with the unfamiliar sound of different genders also were designed and produced, and the auditory Stroop test of the recorded voice of one's own gender was used in the first measurement. After designing the tests, the participants were invited to participate individually in the second session.

2.4.1.3 Second Session

The tool used in the second session consisted of a personal computer with a standard 15-inch monitor that was about 40 cm from the participant. The computer had a standard keyboard on which three keys that were covered with white labels were used by the subjects to respond to stimuli. Creative Inspire T3030 speakers were used, and the speakers were placed at the left and right sides of the participants. In the second session, first the computerized auditory Stroop test with recorded unfamiliar voice of their own sex was played, and the reaction time of the participant was recorded. A short time later, the computerized auditory Stroop test with recorded self-voice was played, and the reaction time of the participant was recorded. The mean of each participant's reaction time was calculated and collected for analysis. At the end of the test, the participants were asked questions to determine whether they recognized their recorded self-voices.

2.4.2 Experiment 2

2.4.2.1 First Session

In the second experiment, the effect of listening to the recorded self-voice on auditory verbal learning was discussed. After confirming the students' interest in participating and cooperating in the second experiment, a briefing session was held and coordination was made with 87 participants for implementing the first session. In the first session, after obtaining demographic data and written informed consent, the subjects were asked to record their voices, and the dialogue between the examiner and each subject (related to issues of the students' lives, their future careers, and the importance of co-participants by the end of the study) was recorded by a Sony PCM-D50 digital recorder at the highest quality. During the conversation, the participants were asked to read loudly and clearly a list of 90 words, including word lists Rey, Lezak, Shapiro, and Harrison's version of the AVLT test (Rezvanfard et al., 2011). The 15 target words of Rey's test were inserted in the middle of the list. Then, the second session was planned based on the students' schedules and availability.

2.4.2.2 Making Tests

The files that contained the recorded voices of the participants were given to a sound specialist to analyze and compile. He examined the various qualitative and quantitative aspects of the sounds using Adobe Audition Cs 5.5 v4.0 software and chose the appropriate files for use in the test. After designing the tests, the participants were invited to participate individually in the second session. Among the extracted files, 26 participants' ways of reading did not meet the necessary criteria, and they were excluded. The voices of the other 61 subjects were found to be suitable, and they were divided randomly into an experimental group (31 subjects) and a control group (30 subjects). An audio file that contained a list of 15 words was prepared with the recorded self-voice. For the control group, two audio files were prepared with people of different genders reading the list of 15 words.

2.4.2.3 Second Session

Six months after the first session, the participants were invited to return for the second session. In the second session, a personal computer and two speakers of a standard Creative Inspire T3030 model were placed to the left and right of the participants to play the sound. The test was conducted according to the procedures used in the AVLT test in Rezvanfard et al.'s (2011) study. The only difference was that we used recorded voices rather than actual voices. The recorded voices we used were those of the participants in the experimental group and the unfamiliar recorded voice of each gender for the control group. In each trial, the recorded voices were played, and the researcher immediately recorded the rates at which the subjects recalled the voices. The test was conducted five times, and the participants' scores were recorded each time. At the end of the test, the scores of the two groups were collected for analysis. After the participants in the experimental group completed the test, they were asked questions related to their recognition of their recorded voices.

2.5 Ethical Consideration

This study was approved by the Research Ethics Committee of the School of Psychology at the University of Sistan and Baluchestan (No. 91.3.5883). Before conducting the experiment, written consent was obtained from each participant. Also, the students' interest in participating was enhanced by offering them a token for buying books, free use of the University's facilities. After each experiment, a psychologist had a conversation with each subject about the issue of hearing the recorded self-voice to ensure that there was no resentment about being exposed to the recorded self-voices that could have distorted the findings. Two special sessions were held to share the results of the study with the participants from each experiment.

2.6 Statistical Analyses

SPSS version 21 software was used to analyze the data. A paired samples t-test was used to compare the mean reaction times in the two conditions of the Stroop test in Experiment 1. In the second experiment, an independent groups t-test was used to compare the mean number of recalled words in the experimental and control groups.

3. Results

3.1 Experiment 1

In the first experiment, two runs of the computerized auditory Stroop test were conducted with a group of 55 people. The mean of the subjects' reaction times in providing correct responses by naming the colors was calculated, and then the mean of the groups' reaction time was obtained. The mean of the participants' reaction times in the first run, i.e., an unfamiliar voice of their own gender, was approximately 709 ms. This mean had a standard deviation (SD) of approximately 117 ms.

Responses to voices of the same gender as the participant were significantly shorter (M=709 ms, SD=117) compared to when the voice was that of the participant's own voice (M=748 ms, SD=151). Analyzing the data using the paired t-tests to compare the means indicated that the mean of the participants' reaction times in the second run (recorded self-voice), with the mean difference of 39 ms (SD 77), was significantly meaningful ($P<0.0001$, $t(54)=37.3$, $df=54$) and greater than the mean of the participants' reaction times in the first run (recorded unfamiliar voice of their own gender). From the 55 participants, 24 (43.6%) recognized their voices in the experiment.

3.2 Experiment 2

In the second experiment, the auditory verbal learning test was performed on the experimental group and the control group. The sum of the first through the fifth trials also was calculated as total acquisition. Table 1 shows the mean of the two groups for each trial and the total performance across the 5 trials.

Table 1. Mean of the numbers of words recalled by members of the experimental group and members of the control group in each trial (Experimental group n=31, Control group n=30)

Condition	Group	Mean	Standard Deviation
Trial 1 (word span)	Control	8.33	1.605
	Experimental	7.10	1.599
Trial 2	Control	10.97	1.790
	Experimental	10.77	1.857

Trial 3	Control	12.70	1.535
	Experimental	12.29	1.883
Trial 4	Control	13.43	1.194
	Experimental	13.19	1.851
Trial 5 (Final acquisition)	Control	13.90	1.029
	Experimental	13.81	1.078
∑ 1-5 (Total acquisition)	Control	59.33	5.492
	Experimental	57.16	6.929

The mean of word recalling number in the two groups in each trial was analyzed by the test of comparing the mean of the independent t-tests. The results showed that the difference was significantly meaningful only in the first trial (word span). The mean of word recalling number in the control group in the first trial (word span) was greater than that of the experimental group ($P>0.004$, $t(59)=3.014$, $df=1.24$). There was no significant difference in the other trials, including the fifth trial (final acquisition level) and the total acquisition (sum of the first through the fifth trials). Table 2 shows the results of the independent t-tests comparing the means for the experimental group and the control groups in each trial. At the end of the second experiment, among the 31 subjects in the experimental group who listened to their recorded self-voices, 15 subjects (48.4%) recognized their voices, and 16 subjects (51.6%) did not.

Table 2. Comparison of the means of the two groups' in each trial by the independent t-test

Condition	t	df*	Sig. (2-tailed)
Trial 1 (Word span)	3.014	59	0.004
Trial 2	0.412	59	0.682
Trial 3	0.930	59	0.356
Trial 4	0.599	59	0.552
Trial 5 (Final acquisition)	0.347	59	0.730
∑ 1-5 (Total acquisition)	1.354	59	0.181

Note. * Degrees of freedom

4. Discussion

4.1 Experiment 1

In the first experiment, we examined the effect of the recorded self-voice on attentional bias with two different runs of the auditory Stroop test (recorded self-voice and unfamiliar recorded voice of their own gender). The results showed that the means of the participants' reaction times in the Stroop task were greater when they listened to their recorded self-voices than when they listened to unfamiliar recorded voices of their own gender. Hence, listening to one's own voice leads to attentional bias. One of the reasons that can be cited to explain this phenomenon is a negative affective reaction that the participants showed when listening to the recorded self-voice (Holzman & Rousey, 1966). This negative affective reaction may engage the attentional system when responding to the test content in the second run (recorded self-voice) and cause increases in the participants' reaction times. Increasing reaction time is a phenomenon that has been observed in studies using the emotional Stroop test (Williams, Mathews, & MacLeod, 1996). The negative affective reaction of the participants was due to the difference of the voices that the participants expected to hear and what they actually heard (Holzman & Rousey, 1966). This difference in their perception of their recorded self-voices and their perception of listening to self-voice while speaking naturally was created by the differences in the ways that sound can be transmitted. When a person hears her or his recorded voice, the sound is only received via air conduction. However, when we hear our natural voice as we are speaking, the sound is received through both the air and bone conduction, which enhances the lower frequencies (Holzman, Berger, & Rousey, 1967; Maurer & Landis, 1990; Tonndorf, 1972).

Neuroimaging studies examining the recognition of self-voice have reported the involvement of different brain areas when listening to the recorded self-voice. These areas are different from those that are involved when listening to recorded voices of other people (Kaplan et al., 2008; Allen et al., 2005; Nakamura et al., 2001). The results of an electrophysiological study conducted by Graux et al. (2013) also showed that the discrimination of one's own voice involves a different neural process than discrimination among unknown voices. In addition, studies have indicated that participants exhibit more psychophysiological responses when listening to recorded self-voices than when listening to the recorded voices of other people. These responses occur irrespective of whether the participants recognized their own self-voice (Olivos, 1967; Holzman, Rousey, & Snyder, 1966). This phenomenon reflects an implicit processing of self-voice hearing. A study by Aruffo and Shore (2012) examined the McGurk effect and reported the implicit processing of self-voice. Since the McGurk effect is mandatory, automatic, and uninfluenced by attention, the subjects showed weaker McGurk effect when they heard their self-voices. A recent study by Candini et al. (2014) found that subjects in implicit tasks can recognize the recorded self-voice better and more accurately than they can in explicit tasks. In our experiments, listening to recorded self-voice caused attentional bias, but only 43.6% of the subjects were able to recognize their self-voices at the end of the experiment, which suggested an implicit process of recorded self-voice.

4.2 Experiment 2

The second experiment examined the effect of recorded self-voice on auditory verbal learning by comparing the mean of the number of recalled words of RAVLT in each trial in the two experimental groups (listening recorded self-voice) and the control (listening recorded voice of their own gender). The results showed that there were significant differences only in the first trial (word span), and the rate of auditory verbal learning in word span when the subjects listened to their recorded self-voices (experimental group) was less than it was when they listened to unfamiliar voices (control group). Despite the lower ability to recall words in the word span (first trial), there was no significant difference between the groups in rate of recalling in final acquisition level (fifth trial) and total acquisition (sum of the first through the fifth trials).

The findings of Gaviria's study (1966) that examined the effect of self-voice on verbal learning showed that there is no difference between rates of learning whether listening to recorded self-voice or learning with the recorded voices of others. Also Yeager (1966) emphasized how sound is transmitted (air and bone conduction) and showed that there was no difference between learning with recorded self-voice and learning with the voices of other people. The results of the present study on the level of final acquisition (fifth trial) and total acquisition (sum of the first to the fifth trial) were compatible with these results. However, the reduction in the rate of recalling word span (first trial) while listening to recorded self-voice was different from the previous results. The first experiment showed that listening to recorded self-voice caused attentional bias. This attentional bias may cause a reduction in the rate of recalling word spam (first trial) by engaging the attentional system. Holzman and Rousey (1966) reported negative affective reaction of subjects while they were listening to recorded self-voices. This negative affective reaction may be an effective factor in recalling the word span at a lesser rate (first trial). In addition, more psychophysiological responses while listening to recorded self-voices also may be effective in reducing the rate at which words were recalled in the first trial. Studies that have reported increases of psychophysiological responses in listening to recorded self-voices also noted that this phenomenon also occurred when the subjects were not able to recognize their recorded self-voices (Olivos, 1967; Holzman, Rousey, & Snyder, 1966). In the experimental group of our experiment, only 48.4% of the subjects were able to recognize their recorded self-voices at the end of the experiment. In previous studies, the rate of recognition of recorded self-voce was about 50% (Holzman & Rousey, 1966; Rousey & Holzman, 1967). With the development of technology and people's increased exposure to recorded self-voices, such as voice messages, video cameras, and other devices, the rate of self-voice recognition has been increased significantly. For example, in the study of Hughes and Nicholson (2010), the rate of accurate recognition of recorded self-voice was 89-93%, and it was 94-96% in the study of Rosa et al. (2008). One reason for the low rate of self-voice recall in this study was that the participants were not informed that they would hear their self-voices, whereas, in some studies that examined the recognition of recorded self-voices, the participants knew that they would hear their self-voices. This recognition rate of recorded self-voice was compatible with studies that have reported implicit own-voice processing (Aruffo & Shore, 2012; Candini et al., 2014).

4.3 Limitations

The subjects in this study were students in a university in Iran, so there was an age limitation and a cultural limitation in that the students were from the Persian culture and spoke the Persian language. Therefore, the generalization of the results to other communities and languages is not feasible.

5. Conclusions

The findings of this study showed that listening to recorded self-voice caused attentional bias and reduced the auditory verbal recalling rate in word span (trial 1). The implication of these findings is for educational research and practice, where the effect of exposure to recorded self-voice in teaching and learning can be taken into account. Conducting other research on the effectiveness of recorded self-voice on the systems of attention and learning in other communities and languages with neurological approach may be an appropriate path for future research.

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