Rethinking Functional Reference

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The theoretical construct of functional reference is the main tool used by animal communication researchers to explore how animals refer to the world in the absence of a language. Functionally referential signals are commonly defined as signals elicited by a specific class of stimuli and capable of causing behaviors adaptive to such stimuli in the absence of contextual cues. I will argue that this definition is conceptually flawed and propose an alternative definition according to which signals can functionally refer to things that rarely cause them while relying on the essential contribution of contextual cues.

1. Introduction. The theoretical construct of functional reference is the main tool used by animal communication researchers to explore how animals refer to the world in the absence of a language. Functionally referential signals are commonly defined as signals elicited by a specific class of stimuli and capable of causing behaviors adaptive to such stimuli in the absence of contextual cues (Macedonia and Evans 1993).

Besides grounding much research in animal communication, the construct of functional reference is also important in the study of language evolution. Both philosophers and animal communication theorists have suggested that the ability to refer functionally is an evolutionary precursor of the ability to refer linguistically (e.g., Allen and Seidel 1998; Zuberbühler 2005; Bar-On and Greene 2011).

In recent times, however, the notion of functional reference has come under attack (e.g., Rendall, Owren, and Ryan 2009; Clay, Smith, and Blumstein 2012; Wheeler and Fischer 2012). The most significant criticism leveled against it is that few if any signals satisfy the current definition of functional reference. As a result, some have openly suggested that we should give up on

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†I want to thank the audience of my talk at the PSA 2012 meeting in San Diego this past November for helpful questions. I also want to thank the participants to the Proto-Language Workshop organized by Mitch Green and Dorit Bar-On at the University of Virginia in March 2012 for useful feedback on a different version of this article.

Philosophy of Science, 80 (December 2013) pp. 1006–1018. 0031-8248/2013/8005-0024$10.00
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https://doi.org/10.1086/673900 Published online by Cambridge University Press

functional reference. As Wheeler and Fischer (2012, 195) put it, "the concept of functional reference, while historically important for the field, has outlived its usefulness."

The purpose of this article is to argue that the current definition of functional reference is indeed conceptually flawed but to resist calls for getting rid of the theoretical construct altogether. What we need is simply a better definition. The new definition I propose avoids the conceptual traps into which the original definition fell, and it restores the centrality of functional reference in the study of animal communication.

2. Motivation and Reference in Animal Signaling. The study of animal communication finds its theoretical foundations in Charles Darwin's book *The Expression of the Emotions in Man and Animals* (1872). Darwin's core proposal was that a great many emotional expressions emerge according to the principle of serviceable associated habits.[1]

Consider the signal constituted by the baring of the teeth, produced by various species when in anger. For Darwin, this expression is an involuntary vestige of a voluntary action that used to be serviceable in the ancestral past of the species (biting) and kept being associated to the state of mind that brought it about by force of habit or by reflex. As a result of this origin, emotional expressions reliably correspond to the emotional states of their producers.

Darwin's account led to a century of dominance for the *motivational view* of animal signaling. According to it, animal signals are external readouts of internal motivational states (fear, hunger, etc.) and have a structure independent of the characteristics of external stimuli. The distress calls of precocial birds are a good example of signals of this sort. They reliably correspond to distress and are independent of external stimuli occurring in the environment. A corollary of this view is that linguistic and nonlinguistic creatures differ on a key dimension. Whereas linguistic creatures can refer to the external world by using language, nonlinguistic creatures lack this ability entirely.

Over the past 30 years or so, the motivational view has been called into question by a body of evidence suggesting that nonlinguistic creatures are capable of primitive forms of reference. This research program can be traced back to Struhsaker's (1967) studies on vervet monkeys in the Amboseli park in Kenya. These studies indicated that vervets produce three acoustically distinct alarm calls for three types of predators: snakes, leopards, and eagles.

1. Once some signals have been established through the principle of "serviceable associated habits," Darwin claimed, other signals can be generated through the subsidiary principle of "antithesis," according to which expressions are established in morphological contrast to existing ones. Finally, some expressions result from the "direct action of the nervous system," namely, from nervous excitation.

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In a seminal paper, Seyfarth, Cheney, and Marler (1980) demonstrated that these alarm calls also elicit behaviors adaptive to the relevant predators: recipients of leopard calls run into trees, receivers of eagle calls look up and run into dense bush, and receivers of snake calls stand up tall. How can we explain these adaptive responses? Three main hypotheses were considered. The first was that "each alarm call effectively represented, or signified, a different class of external danger" (802). The second was that the different responses were produced by direct predator sightings. The third was that the different responses were a function of the degree of arousal associated with the motivational states of signal producers.

To distinguish between the first and the second hypothesis, Seyfarth et al. (1980) recorded alarm calls from the three categories of predators and played them through hidden loudspeakers when the relevant predators were absent. If recipient responses were driven by direct sightings, antipredator responses would in such case cease. But they continued to occur unchanged, suggesting that alarm signals alone cause evasive responses.

To distinguish between the first and the third hypothesis, predator calls associated with different degrees of arousal (as manifested by differences in call length and amplitude) were played. Unlike acoustic differences associated with predator types, differences in arousal had no effect on recipient responses. Seyfarth et al. (1980, 803) concluded that vervet alarm calls are an example of "rudimentary semantic signals."

3. The Standard Definition of Functional Reference. Seyfarth et al.'s (1980) paper galvanized the field of animal communication. It provided preliminary support for what we may call the *referential view* of animal signaling, according to which at least some animal signals refer to the external world. Signals with this ability eventually came to be called "functionally referential."

Hauser (1996, 509) explained that the phrase was introduced "to make clear that nonhuman animal calls are not exactly like human words, but rather appear to function in the same way." They appear to function in the same way in the sense that they are both taken by their recipients to stand for features of the external world.

They are not exactly like human words, on the other hand, in two main respects. First, no assumption is made that reference is grounded for animal signals the same way it is grounded for linguistic signals. In particular, whereas an arbitrary convention seems to underlie the connection between words and what words are about, animal signals are not about the world by virtue of an arbitrary convention. What grounds their connection with external objects and events is what a theory of functional reference must establish.

Second, no assumption is made that the mental mechanisms of producers and recipients of animal signals resemble the mental mechanisms of pro-

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ducers and recipients of linguistic signals. In particular, whereas the communicative intentions of producers and recipients of linguistic signals are thought to play a central role in linguistic communication (Grice 1989), animal communication researchers do not assume that functional reference requires intentions to communicate (Seyfarth and Cheney 2003).

A crucial step in the empirical investigation of functional reference was the emergence of a definition that made clear the concept's criteria of application. The most careful analysis of such criteria can be found in Macedonia and Evans (1993). I reconstruct it as follows (my wording):[2]

> A token of type X functionally refers to a token of type Y just in case the following two criteria are jointly satisfied:[3]
>
> (i) *Production Criterion*: Xs are reliably caused by Ys and only/mostly by Ys.
> (ii) *Perception Criterion*: X's presentations reliably cause responses adaptive to Ys in the absence of Ys and of any other contextual cues.

Signals that "meet both the production criterion and the perception criterion," Macedonia and Evans (1993, 180) concluded, are "functionally referential." I interpret this as an *operational definition*, namely, a definition that simultaneously tells us what functional reference is and what counts as experimental evidence for it. Let us consider the two criteria in turn.

Macedonia and Evans (1993) argued that "referential signals should exhibit a degree of stimulus specificity" with respect to what they refer to, which is to say that "eliciting stimuli must belong to a common category . . . although the size of this category . . . could vary considerably" (179). The implicit assumption here is that when members of such "common category" are present, the signal is elicited. For instance, "if the putative referent of the call is 'aerial predator', then airborne raptors should evoke the . . . call" (179).

I capture this assumption by requiring that Xs are reliably caused by Ys. I label this "world-signal" reliability, instantiated when the signal is reliably tokened whenever the world is in a certain state.[4] Macedonia and Evans (1993) make clear that the production criterion also involves a second form of reliability, which will be the focus of my critical analysis. As they put it,

2. Other notable theoretical investigations of the concept of functional reference include Marler, Evans, and Hauser (1992) and Evans (1997).

3. This definition presupposes that signal X has a "discrete" structure. Some add discreteness as a third criterion of functional reference, but I will leave it implicit.

4. The terminology and the discussion here and below are indebted to Godfrey-Smith (1991), who also distinguished between "world-head reliability" and "head-world reliability" in the context of an analysis of informational semantics.

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"one clear correlate of the 'production specificity' criterion is that referential signals should not occur at appreciable rates in inappropriate contexts. We therefore would not expect them to be produced in the absence of the putative referent" (179). I capture this idea by requiring that Xs are reliably caused only/mostly by members of the common category Y. This is what we may call "signal-world" reliability, instantiated when the world is reliably in a certain state whenever the signal is tokened.

The two kinds of signal reliability can in principle come apart. For instance, a signal X could have high world-signal reliability because it is always tokened when the world is in a certain state Y, but low signal-world reliability because it is often tokened also when the world is in some other state Z. Macedonia and Evans's (1993) definition requires functionally referential signals to instantiate both forms of reliability. Note that if Xs are reliably caused by Ys and only/mostly by Ys, X and Y are strongly correlated, and the signal X can be used to predict which state of affairs Y occurs in the world (conversely, Y can be used to predict which signal X is elicited).

Let us now turn to the perception criterion. According to it, "referential signals should be sufficient, in the absence of the eliciting stimulus and of other normally available cues, to allow receivers to select appropriate responses" (Macedonia and Evans 1993, 180). The absence of the eliciting stimulus is meant to ensure that the signal, rather than the stimulus, is causally responsible for the adaptive responses of recipients. The absence of other normally available cues such as the antipredator behaviors of the caller is meant to ensure that the signal is able to be solely causally responsible for the adaptive responses of recipients.

Macedonia and Evans (1993) acknowledge that contextual cues do play an important role in standard cases, but they require that such cues are "not essential" (180), in the sense that the signal reliably elicits adaptive behaviors in a context-independent fashion. The standard test for context independence is constituted by playback experiments, in which a recorded call X is played to recipients in the absence of the relevant predator Y and of any contextual cues. If recipients choose a response adaptive to Y, the signal is considered to have satisfied the perception criterion.

Since Seyfarth et al.'s (1980) article, evidence for functional reference has been collected with respect to different types of signals (mostly alarm signals and food signals), different sensory modalities (mostly acoustic and visual modalities), and different species, including nonhuman primates, birds, suricates, and honeybees (Seyfarth and Cheney 2003; Townsend and Manser 2013).

4. The Trouble with the Standard Definition of Functional Reference. In recent times, the concept of functional reference has come under siege. Some

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have called into question the appropriateness of using the notion of reference in a nonlinguistic context. Rendall et al. (2009), for instance, have described the notion of functional reference as an "oxymoron" because it suggests that animal signals refer but also that they do not refer the way words do. They take this to represent a "conceptual retreat in acknowledging that animal signals may never meet the semantic sine qua non of human language" (236). I have argued elsewhere that this is exactly the conceptual retreat we need (Scarantino 2010). The exploration of the semantic aspects of animal signaling should resist the identification of nonlinguistic signals with words, but it should also account for the fact that words and signals 'stand for' external objects in their own, distinctive ways. The label 'functional reference' usefully hints at the existence of both analogies and differences between linguistic and nonlinguistic reference.

A more threatening critique comes from those who have argued that the empirical evidence does not support the view that animal signals functionally refer. This charge can take one of two forms. The more radical one is that functional reference does not exist in the animal world. The less radical form, advocated by most critics, is that the phenomenon of functional reference is rarely instantiated and should consequently not have the centrality it currently enjoys in orienting empirical research in the field of animal communication.

Critics have focused on both the production criterion and the perception criterion. With respect to the former, Clay et al. (2012, 2) have argued that "most alarm signals do not meet the strict definition for production specificity." This is because alarm signals are produced also "in other circumstances, including in response to nonpredatory disturbances [and] social disturbances." Wheeler and Fischer (2012, 200) mention the example of "lemurs, New World monkeys, and many forest-living Old World monkeys" who give acoustically distinct calls to aerial and terrestrial predators but also give such calls "in other contexts that are, like predator detections, likely to elicit a stress response." The same difficulty emerges with respect to food calls. As Clay et al. (2012, 2) note, "for a considerable number of species, calls produced during feeding are also produced in nonfood contexts" such as social recruitment.

The perception criterion has also been criticized. Wheeler and Fischer (2012) have emphasized that the responses of signal recipients to acoustically indistinguishable calls vary depending on which contextual cues are available. For example, they report that male baboons ignore female baboon distress screams unless two contextual conditions are satisfied: the signaler is a female with whom the recipient has mated and the signaler has an infant. In such case, the recipient responds by paying attention and approaching the signaling female, presumably to thwart the potential loss of a genetically

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related infant.[5] Similarly, a tamarin's terrestrial predator alarm call is responded to by antipredator behavior only in contexts in which a rival group is not present. As a result, both baboon screams and tamarin alarm calls violate the perception criterion: they do not cause responses adaptive to a certain state of the world independently of contextual cues.

The lesson opponents of functional reference glean from these cases is that functional reference is at best a marginal phenomenon in animal signaling. Wheeler and Fischer (2012, 203) conclude that functional reference has "become a red herring in the pursuit of the links between primate communication and human language" by overemphasizing strong correlations between signals and referents and by underemphasizing the importance of context.

While I agree that most animal signals do not satisfy the standard definition of functional reference, I reject the view that the way forward is to drop the notion of functional reference entirely. This is because the standard definition of functional reference is defective on principled grounds. As a result, its failure to be satisfied by animal signals is not evidence that the phenomenon of nonlinguistic reference is not instantiated. I will formulate a new definition of functional reference and use it to argue that the alleged evidence that most alarm signals and food signals are not functionally referential is actually evidence that a great many alarm signals and food signals are functionally referential only by courtesy of contextual cues and despite not correlating strongly with their referents.

5. A New Definition of Functional Reference.

5.1. Signals Can Refer to What Rarely Causes Them. According to the production criterion, in order for a token of X to functionally refer to a token of Y the following must hold:

(i) Xs are reliably caused by Ys and only/mostly by Ys.

As we have seen, this criterion requires world-signal reliability and signal-world reliability. This requirement is too strong. To understand why, we must clarify what sort of phenomenon a theory of functional reference is supposed to account for. I submit that it is the following: organisms behaviorally respond to some nonlinguistic signals in ways that are adaptive not to the signals themselves, but to what the signals are evidence for.

This is the phenomenon that led Seyfarth et al. (1980) to posit the existence of rudimentary semantic signals. They observed that recipients of acoustically distinct vervet alarm calls changed their behaviors in ways that

5. This response is further strengthened by the additional contextual cue of a threat call by another male.

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were adaptive not to the calls themselves but to the presence of distinct predators. The best explanation they could find is that alarm calls are taken by signal recipients to stand for different classes of predators. At its core, the fundamental phenomenon of nonlinguistic reference is then that of *mediated-taking-account-of*: recipients take external objects into account by means of signals that provide evidence for them.

The point is that if this is the fundamental phenomenon we are trying to account for, there is no reason to expect that it will only be instantiated when signals and referents are strongly correlated, contrary to the production criterion. Godfrey-Smith (1991) has put the finger on the central problem faced by theories of reference (or representation) that require signals and referents to be strongly correlated.

This requirement disregards the different desirability of two possible mistakes representation consumers can make: taking X to stand for Y in the absence of Y (false positive) and not taking X to stand for Y in the presence of Y (false negative). Signal recipients with an evolutionary interest in avoiding false negatives more than false positives have an incentive in taking X to stand for Y even when Xs and Ys are not strongly correlated. The force of this point becomes apparent when we focus on alarm signals. Whereas responding to alarm call X with behaviors adaptive to predator Y when Y is not present involves a minor energy cost (false positives are cheap), failing to respond to alarm call X with behaviors adaptive to predator Y when Y is present is potentially deadly (false negatives are massively expensive).

This asymmetry leads us to expect that a great many alarm systems will be designed to produce signals that occur at appreciable rates in the absence of their referents, because this is an efficient strategy to minimize false negatives. For instance, if an eagle alarm call were produced whenever something even remotely resembling an eagle appears (e.g., owls, shadows overhead, airplanes, etc.), there would be a great many instances of the signal in the absence of its referent (many false positives), but the chance that an eagle shows up in the absence of an eagle alarm call would be minimized (few false negatives).

As reported in section 4, critics of functional reference have unveiled many cases in which alarm signals and food calls lack "signal-world" reliability. What has not been sufficiently emphasized is that this sort of reliability is absent even in cases that allegedly satisfy the standard definition of functional reference. Take vervet monkey alarm calls, which still constitute the best example of functional reference in the animal world.

Whereas it is true that eagle/leopard/snake alarm calls are reliably caused by eagles/leopards/snakes, it is false that they do not occur at appreciable rates in the absence of eagles/leopards/snakes. As Searcy and Nowicki (2005, 62) have noted, "incorrect calls were quite common, especially for juveniles." The data are especially striking with respect to eagle calls. Only 56%

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of adult eagle calls (31 of 55) and only 22% (!) of juvenile eagle calls (17 of 77) were given in the presence of the sort of eagle that predates on vervet monkeys (Seyfarth and Cheney 1986). The rest of the eagle alarm calls were given mostly to nondangerous raptors (e.g., owls) and, especially in juveniles, to nondangerous nonraptors (e.g., storks). Yet, both adult and juvenile calls elicited the appropriate adaptive responses.

I propose that we replace the production criterion with the following information criterion:

(i*) *Information Criterion*: Xs are correlated with Ys (weakly or strongly).

I call this the information criterion because I assume that X carries information about Y just in case Xs and Ys are correlated (Scarantino 2013). On this view, smoke carries information about fire because smoke events and fire events are correlated. The information criterion differs from the production criterion in two main respects. First, the information criterion does not demand that Xs are caused by Ys but simply that they are correlated with Ys. This is to include cases in which the signal and what the signal refers to are correlated, but the signal is not caused by what it correlates with. An example would be signals that functionally refer to the future behaviors of the signaler. For example, aggressive signals may functionally refer to future aggressive behaviors, but they are not caused by future aggressive behaviors (aggressive signals and aggressive behaviors share a common cause: anger).[6]

Second, the information criterion does not demand that there is a strong correlation between Xs and Ys, but simply that the correlation is different from zero. A full defense of this condition would require more space than I have here (see Millikan [2004] and Shea [2007] for a more extended treatment). The basic intuition should be easy to convey. The intuition is that the signal and the referent must correlate enough to make responding to the signal in ways that are adaptive to the referent evolutionarily advantageous.

What counts as enough correlation will depend on the payoffs of being right and being wrong when the recipient takes the signal to stand for the referent. What we know from the observation of existing signaling systems in which recipients take signals to stand for external objects is that relative to some payoff structures enough correlation amounts to strong correlation, whereas relative to other payoff structures enough correlation amounts to weak correlation. Both types of correlations are therefore compatible with tokens of X functionally referring to tokens of Y.

6. Although I have mostly referred to external events as referents, the definition I have provided is in principle compatible with signals functionally referring to internal states. I will disregard this aspect in what follows.

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5.2. Signals Can Refer in a Context-Dependent Way. According to the perception criterion, in order for a token of X to functionally refer to a token of Y the following must hold:

(ii) X's presentations reliably cause responses adaptive to Ys in the absence of Ys and of any other contextual cues.

As we have seen, this criterion requires that the responses of signal recipients are invariant to changes in contextual cues. This requirement is also too strong. Consider the following scenario. A signaler in three clearly distinguishable contexts C, C′, and C″, emits acoustically indistinguishable calls of type X. Signal recipients respond to X in context C with behaviors adaptive to Y, they respond to X in context C′ with behaviors adaptive to Z, and they respond to X in context C″ with behaviors adaptive to W. When X is presented in the absence of any contextual cues (e.g., in a playback experiment), X does not reliably elicit any recipient responses.

According to the perception criterion, X would in such case not be functionally referential. But this is clearly the wrong verdict, because the central phenomenon that motivated Seyfarth et al. (1980) to posit functional reference in the first place is staring us in the face. Signal recipients are behaviorally responding to some nonlinguistic signals "in a context" in ways that are adaptive not to the signals themselves but to what such signals "in a context" are evidence for.

The original definition of functional reference mistakenly assimilates nonlinguistic with linguistic reference. As the word "snake" appears to stand for snakes in a context-independent fashion, the implicit assumption was that in order for a snake call to stand for snakes it must also do so in a context-independent fashion. But there is no good theoretical reason to expect that the way words stand for their referents will be replicated by the way animal signals stand for their referents. Furthermore, there is a great deal of context sensitivity in language as well, not just with respect to pragmatics but also with respect to semantics. An example is given by indexical expressions such as "I" or "he," whose referents are always fixed by the context of utterance.

Now, there is a clear practical advantage in requiring context independence. This allows the study of functional reference to rely on simple playback experiments, in which recorded sounds are played by a loudspeaker in the absence of any contextual cues (and of the putative referent). The problem is that this practical advantage has been turned into a defining criterion of functional reference in the absence of any good theoretical reason for doing so.

Summing up, whether recipients take signals to stand for states of affairs in isolation or with the essential help of contextual cues cannot ground a distinction between functionally referential and functionally nonreferential

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signals, but at best a distinction between ways in which signals are functionally referential: context dependently and context independently.

My recommendation is that we replace the original perception criterion with a context-dependent version of it. Context dependence, furthermore, should be embedded in the information criterion as well, because the unit of reference now becomes the signal "in a context."

The new definition of functional reference I propose takes the following form:

> A token of type X in context C functionally refers to a token of type Y just in case the following two criteria are jointly satisfied:
>
> (i**) *Contextual Information Criterion*: Xs in context C are correlated with Ys (weakly or strongly).
> (ii**) *Contextual Perception Criterion*: X's presentations in context C reliably cause responses adaptive to Ys in the absence of Ys.

This definition potentially encompasses many of the alleged counterexamples to functional reference (a case-by-case analysis will be left to other papers). First, the absence of "signal-world" reliability is compatible with a signal being functionally referential. For example, the fact that a certain call produced by lemurs to aerial predators is also produced in nonpredatory circumstances does not prevent such call from functionally referring to aerial predators, as long as aerial calls and aerial predators are at least weakly correlated and recipients of aerial calls respond to them in ways that are adaptive to aerial predators.

Second, the presence of context dependence is compatible with a signal being functionally referential. For instance, female baboon screams can refer to the impending infanticide of an offspring when produced in a context that includes a mating history with the signal producer and a dependent infant, as long as female baboon screams in that context are at least weakly correlated with infanticides and signal recipients in that context respond in ways that are adaptive to the impending infanticide of an offspring.

The new definition of functional reference I have provided will require a systematic examination of the contextual cues that affect reference. I predict that these will include among others identity cues (who is issuing the signal and how the signaler it related to the recipient), behavioral cues (what are the signaler and other recipients doing), and environmental cues (what else is happening in the environment prior, during, and after the signaling).

The new definition will also require a change in the experimental paradigm used to investigate functional reference. Simple playback experiments will have to be enriched by contextual cues, and sensorily indistinguishable signals may end up having multiple referents. Finally, the new definition will

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allow the exploration of the mental mechanisms involved in the integration of signals with contextual cues, which may or may not differ from the mental mechanisms involved in responding to context-independent signals.

6. Conclusion. I have argued that the standard account of functional reference is conceptually flawed. In particular, I have rejected the assumptions that functionally referential signals must be strongly correlated to what they refer to and must be context independent. The alternative definition of functional reference I have provided fixes these problems and brings functional reference back to center stage in the exploration of animal communication and of the evolutionary origins of language.

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