Emotional Tears as Biological Signals

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Abstract: Emotional tears have been shown to enhance the interpretation of sadness that is inferred from facial expressions. The current paper puts emotional tears in an evolutionary context. By using biological signaling theory, it first looks at the distinction between cues and signals, both of which provide information to recipients, except that signals have evolved for that purpose. The conclusion is that a signaling function has yet to be shown. Nevertheless, as emotional tears are likely to function as signals, an analysis of certain inevitable effects of tears on the individual hint at more than a single signaling function, depending on the context in which tears are produced. Emotional tears decrease the perception of gaze direction or of changes in pupil size, and may function as attenuators of intentions. Emotional tears are more likely, however, to function as handicaps. By blurring vision, they handicap aggressive or defensive actions, and may function as reliable signals of appeasement, need or attachment.

Keywords: Emotions, tears, signaling, handicap, intentions.

Introduction

Human emotional tears are a riddle. We all feel we learn something about a person in tears, but the nature of this information has been poorly studied. For this reason, studies such as Provine, Krosnowski and Brocato (2009) (PKB), that isolate the effect of tears on spectators from that of sad or crying facial expressions, are important[1]. PKB describes an experiment in which observers were asked to identify emotions in sad or crying faces seen with and without (digitally removed) tears. The conclusion is that tears added information to spectators: sadness was rated higher when tears were shown. However, given that PKB claims to have shown a signaling function to emotional tearing, a lack of a reference to biological signaling is unfortunate. The mere fact that tears, just like drops of rain, give

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[1] At the time of publication, PKB were unaware of a similar study (Cornelius et al., 2000), presented in a conference with no peer-reviewed publication (Robert R. Provine, personal communication).

information, is not sufficient to conclude that tears are signals. Drops of rain, at least, are not. PKB has the potential to stimulate further research in this rather neglected field. Biological signaling theory should give this research a better focus in terms of the questions asked and in empirical tests.

Biological signaling theory looks at signals at two different levels (Harper, 2006; Hasson, 1997; Maynard Smith and Harper, 2003). First, it defines a "signal," as a fundamental component of communication, using evolutionary currencies. Second, it defines different types of signals based on their evolutionary mechanisms, considering costs, benefits, modes of their perception, modes of reliability (or deception) and the nature of their information. These describe the signals' evolutionary trajectories and modes of stability. The purpose of the current paper is to put emotional tearing in an evolutionary context. It uses biological signaling theory for asking relevant questions and gives a first array of possible answers.

Cues or Signals?

When defining "signals," as evolved characters, it is vital to separate them from "cues," such as running speed or the sound of rain, both of which provide information but have evolved (if biological) or exist for other reasons (Bradbury and Vehrencamp, 1998; Hasson, 1994; Maynard Smith and Harper, 1995, 2003). A definition of signals recognizes that each evolved trait is a result of some tradeoffs between costs and benefits. However, signals are defined as being distinct from cues (which also give information) and from other traits (which do not) in that their specific benefit, which leads to their evolution despite their cost, is given by changing the behavior of others, via a change in their information (Bradbury and Vehrencamp, 1998; Hasson, 1994, 2000; Maynard Smith and Harper, 1995). Therefore, two elements are needed for showing a signaling function to emotional tearing: (i) to show that they provide information to other individuals, (ii) to show a significant signaling effect, i.e. that their main benefit stems from changing the behavior of others as a result of this information. To show this, one should also rule out the possibility that tears are cues, i.e. that they do not directly benefit the person in tears (or that any such effect is minor relative to their signaling effect), nor are they a byproduct of the evolution of other traits.

PKB shows that tears provide information by enhancing the interpretation of sadness and its intensity. Are tears cues or signals? Chewing movements provide information about eating, and certain ways of mouth movements during chewing activities may give away information about jaw injuries or neurological diseases. However, as they have evolved (chewing) or exist (injury and diseases) for reasons other than providing information, these must be categorized as non-signaling characteristics, namely cues. Hence, although PKB shows that information is transmitted, it does not make an attempt to show a signaling effect.

Nevertheless, as shown below, there are many indications that emotional tears have a signaling function. Among mammals, emotional tears are unique to humans (reviewed in PKB). Therefore, an argument that excessive tearing in emotional contexts has benefits other than a signaling function, requires one of the following two doubtful options: either (i) human emotions induce a physiological stress that does not exist in other mammals and requires tears to cope with it, or (ii) the human eye's physiology is somehow different from

eyes of other mammals, such that it requires an excessive production of tears at circumstances other than physical or physiological stress. At least some support for the latter is the possibility that emotional tears are a byproduct of the unique evolution, in *Homo sapiens*, of a substantial cranial reduction in subnasal prognathism, and increased encephalization. Hypothetically, these developments may have constrained and sensitized the human tear ducts and sinuses when certain emotions are high. A signaling role, therefore, should not be taken for granted.

An ultimate (evolutionary) explanation of a signaling role requires, therefore, a proof of social benefits to emotional tearing, whereas a proximate explanation requires a discovery of a neurological circuit, unique to humans, which is triggered by high emotional states and sends a stimulus to the lacrimal glands. Eventually, both are required for showing that emotional tearing has a signaling role – the selective force that can lead to its evolution, and the mechanism that had actually evolved to make it work.

Interestingly, if there is anything in PKB's paper that suggests that emotional tears are indeed a signal rather than a cue, it is PKB's anecdote about a female graduate student who cannot produce emotional tears. If tearing functions as a cue and provides no signaling benefits, then she should have felt socially better when her emotions remain concealed. Instead, however, she feels in a constant need to expose her emotions and explain them verbally. This example hints upon both social benefits by exposing emotions, and a role for tearing in doing this more efficiently. PKB correctly suggest that such cases constitute a natural experiment, which can be very useful to studies of the signaling functions of emotional tears.

What type of a signal?

The second important use of biological signaling theory in the understanding of signals, such as emotional tears, is made by relating them to known signal types. As different signal types are classified by the different ways they associate information with reliability (Harper, 2006; Hasson, 1997; Maynard Smith and Harper, 2003), the following three questions can give us a lead:

1. What are the necessary consequences of the presence or the production of an excess of tears?
2. What information, therefore, is inevitably revealed by tears?
3. How is reliability (or deception, if this is the case) of tears, as signals, maintained?

By not addressing any of these questions, PKB does not ask why emotional tears are linked with sadness. Unwillingly, therefore, PKB appears to assume that emotional tears function as conventional "symbols," such as words in our language, which do not have such a link, are cheap to produce and prone to lies (Hasson, 1994, 1997; Maynard Smith and Harper, 1995). Such an interpretation has certain implications on the evolution of a signal, on its reliability and on its stability (Hasson, 1997; Maynard Smith and Harper, 2003), which should also be tested. However, before concluding that tears function as symbols, one should use first the three questions above, and look for links between constraints, information and reliability. This leads to the option that emotional tears function as other signal types, with simpler consequences on reliability and stability.

We begin with the first question (consequences of emotional tears), and ask: What is so special about tears? Why have tears been evolutionarily "chosen" (i.e. selected) by natural or by signal selection (Hasson, 1997), to be associated with high emotions? This is important, because if there are no constraints on the production of tears, or if tears make no other impact on the person who produces them, then information provided by tears may equally be reliable or deceptive. We therefore need to consider constraints and consequences of the production of emotional tears or of tears themselves.

Assuming that emotional tears have a signaling function, and assuming further that producing tears is relatively cheap (an assumption that may prove incorrect), there are nonetheless two unavoidable consequences of tears: tears diffuse light and blur vision of the tearing person on the one hand, and diminish the perception of gaze and pupil movements by other individuals, on the other hand. These two options lead to entirely two different signaling functions.

Handicapping aggressive actions: Appeasement, need and bonding.

The interruption of a clear vision of the person in tears may qualify excessive tearing as a handicap (Bradbury and Vehrencamp, 1998; Hasson, 1997; Maynard Smith and Harper, 2003; Zahavi, 1975; Zahavi and Zahavi, 1997). More specifically, if tears handicap the ability to see clearly, and hence also the ability to accurately and quickly respond to environmental events or interactions, they increase vulnerability to attacks, and reliably signal either submission or a social need for help. The first is aimed at attackers, the second is aimed at supporters such as parents or other social partners (where "aimed" is used as "benefits by changing the behavior of"). Appeasement signals (first interpretation) advertise peaceful intentions reliably only if they handicap attacks or defensive actions. By blurring vision, tears diminish efficiency of both attack and defense, and may, therefore, assume an appeasement function towards an aggressor. Appeasement signals are likely to be found when such information is relevant, i.e. in animals and contexts in which the purpose of fighting is mostly to establish, even temporarily, a hierarchy or a pecking order, rather than to kill.

Signals of need (second interpretation) require a stronger social cohesion with an interest of others to help. To be reliable, they must entail some general cost (Hasson, 1997; Kilner and Johnstone, 1997). This may lead to the evolution of emotional tears in a number of contexts of intensive social emotions, and explain their reliability in conditions of need. Considering that human beings are social animals with tight and needy social relationships, both interpretations may be correct. Crying with tears, for example, may be directed at an aggressor as an appeasement signal (first interpretation), or at social supporters when in need of either a general help or as help against the aggressor (second interpretation). In extreme cases, tears may even attract other aggressors to intervene and interact with the first aggressor. This possibility is a known function, for example, of an "alarm pheromone" (*Schreckstoff*), delivered unwillingly when wounded, by some fish (Chivers, Brown, and Smith, 1996). Indeed, studies of adult crying (which did not separate tears from crying), show that a crying face often communicates to others that one is vulnerable, suffering, and in need of help, and elicit attention, empathy and support (Cornelius, Nussbaum, Warner, and Moeller, 2000; Hendriks, Croon, and Vingerhoets, 2008; Hendriks and Vingerhoets 2006; Lane, 2006;).

In other emotional contexts (e.g. pride, empathy, joy, sadness etc.), excessive tears,

by reliably advertising peaceful intentions (aggressive actions are handicapped), may be used for showing social trust and a need for attachment, and thereby improve social cohesion and bonding. This may be particularly true when emotional tears are simultaneously produced by all bonding individuals, although different social roles expect to affect the intensity of individual involvements in a group display of emotional tears. This can create gender or age differences, for example, in the use of tears in emotional contexts, as well as in responses to them, which are known for adult crying (Hendriks et al., 2008; Rottenberg, Bylsma, Wolvin, and Vingerhoets, 2008; Shields, 2007). The above signaling functions are not mutually exclusive. By handicapping aggressive acts, emotional tears can reliably function, at different social contexts, as signals of need, as appeasement signals or for bonding. This creates the link, unexplained by PBK, between excessive tearing and sadness or other emotions.

Attenuating information about intentions.
The human eye is unique among primates, with its white sclera and elongated shape that amplify information about gaze direction (Emery, 2000; Kobayashi and Kohshima, 2001), and hence about intentions. These two features have probably evolved to provide information (i.e., have a signaling function). The reliability of information given by the eyes is maintained by design, and they are likely to function as amplifiers (see Gualla, Cermelli, and Castellano, 2008; Harper, 2006; Hasson, 1989, 1991; Stenseth and Sætre, 2004; for theoretical explanations; and Galvan and Sanz, 2008 for a particularly good empirical test). By creating a liquid screen that is often accompanied by redness in the sclera (decreasing further the contrast between the iris and the sclera), tearing prevents spectators from a good view of the gaze direction and possibly also of pupils' movements (Hess and Polt, 1960). Excessive tearing may thereby withhold information about intentions when a person is found in a stressful condition, and may therefore function as an attenuator (Hasson, Cohen, and Shmida, 1992; Hasson, 1997). Although an attenuating effect of emotional tears is unavoidable, attenuation may not be their main effect (i.e. which leads to their evolution). A primary attenuating function is expected when individuals benefit by deceiving others about intentions in various social interactions, including pure conflicts and combats. In certain social contexts, a primary or secondary attenuating function may even be a reasonable option. However, as excessive tearing seems to appear mostly during needy, amicable or supportive social contexts (PKB), a primary handicapping function is likely to be more common.

Emotions

Some caution is required when studying evolutionary consequences of emotions. PKB and others report that emotional tears are produced in a variety of emotional states such as crying, grief, despair, frustration, helplessness, powerlessness, pain, happiness, anger and empathy. We can add to this list also pride, longing and probably a few other emotions, although some of them, such as anger and frustration, or longing and sadness or love, may be related to each other. Considering this long list of emotions, PKB's results raise other interesting questions, such as: What perception do tears change when added or removed from faces of people smiling in joy? Do tears add a perception of sadness to people who feel pride or frustration? Or, is it possible to generalize from PKB's test on

sadness, and argue that tears improve precision of a perception of any high emotional state rather than just sadness? However, despite the interest we may have in such questions, without an evolutionary focus, they may send us on a wild goose chase.

Clearly, some emotions, such as aggression, are tear-free. Some, such as sadness or empathy, are commonly accompanied with tears, whereas others, such as joy or anger, sometimes lead to excessive tearing, but not at other times. These differences may simply arise, however, if the terminology of emotions does not precisely mirror pure emotional circuits in our brain. It would be surprising if this is not the case, at least partly, given the minute differences between, for example, "happiness" and "joy," their different meanings to different individuals, or the somewhat different interpretation or terminology of these and of other emotions in other languages. In such a case, a term for a certain emotion, such as love, empathy or joy, might actually describe a mixture of two, perhaps more emotional mechanisms, only one of which leads to excessive tearing. For example, anger involves tears when it is accompanied with frustration (or is it helplessness?), but perhaps not in other contexts. Hence, as the terminology of emotions is rather vague, it should be more useful to think about emotions and tears in functional terms that are fitness relevant, as is done here.

Conclusions

Whatever is or are the signaling functions of emotional tears, none of them preclude the apparent possibility that in many conditions excessive tearing is also a cue of a physical or physiological stress that is operating on the eye. Nevertheless, emotional tears seem to have a signaling function. They may attenuate intentions inferred by gaze or pupil movements, but they are more likely to have evolved because they reliably give information about submission, about needs or about social attachments, depending on the social context. An interpretation of excessive tearing as signals of appeasement, need or attachment explains the association between excessive tearing and certain emotions. Furthermore, if this is true, then it should be even possible to better define emotions, at least when they are intense, by their association with excessive tearing, or, for that matter, probably also by their association with other factors such as behavioral changes and voice tonality (Zahavi, 1982). When emotions are real, when one benefits by showing them, and when excessive tearing is a reliable signal of such emotions, then tears are expected to validate the perception of these emotions, as shown by PKB.

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