experience and empirical evidence, and has also constructive implications for social interaction with pain sufferers. Indeed, the operant conditioning model of pain has led to persistent and popular misunderstandings (Eccleston et al. 1997), particularly the pernicious and erroneous idea that pain behaviour is a deliberate strategy that occurs whenever the benefits outweigh the costs. Pain behaviour, including facial display, is contingent upon a more complex set of interactive influences, rather than a conscious decision to exaggerate behaviour. We are only now beginning to understand the extent and rigidity of biases in observer judgements of pain, commonly considered as inaccuracies in judgement (Chambers et al. 1998).

Williams suggests that parents and caregivers may tend toward conservatism [of judgement] to avoid exploitation. We suggest taking this hypothesis a step further. Parents and caregivers are often characterised as powerful and capable of providing care. However, two features of everyday analgesic behaviour are frequently overlooked. First, in comparison with the number of expressions of pain and explicit or implicit requests for analgesia that occur on a daily basis (e.g., Fearon et al. 1996), the number of successful caregiver analgesic behaviours must be spectacularly low. Analgesia, with the possible exception of anaesthesia, is difficult to achieve and when successful is slow in most cases. In short, most pain complaints are delivered and received by observers incapable of delivering the desired response. Second, it should be remembered that when successful analgesia is achieved, its effects are commonly distal to the pain behaviour. It is difficult to imagine exactly how this type of pain relief is a reinforcer of pain behaviour. Instead, we suggest that an evolutionary perspective of the facial display of pain as a signal of trouble and as a request for help only makes sense in the context of the immediate effects it elicits in the potential caregiver.

In line with this idea is the finding that viewing persons in pain affects observers primarily by eliciting distress (Batson et al. 1987; Vaughn & Lanzetta 1981). Similar findings have been found in studies of primates in which monkeys become distressed by observing other monkeys in distress (Mineka & Cook 1993). It is possible that the mismatch between observer and patient on a judgement of pain is at least partially a function of the observer's distress and the failure to help. Underestimation in the context of chronic or procedural pain could be viewed simply as a defence, or as a method of reducing distress in the caregiver. Similarly, attempts to suppress pain expression can be understood as a function of the relationship between patient and caregiver. The desire to limit distress in others may be more adaptive than the expression of pain. It is therefore no surprise that 72% of patients suffering from chronic pain find talking about their health-related emotions to others unhelpful (Herbette 2002). This percentage is in sharp contrast with the general belief in nonclinical samples that the disclosure of emotions is beneficial (Rimé et al., 1998). Taking further the idea that facial expression of pain in the presence of potential caregivers is a release of the suppression of pain expression, we therefore hypothesise that such a release may be not only a function of the perception that potential caregivers are agents of analgesia, but also a function of the perception that they will be robust in response to the display of suffering, and will not avoid, flee, or attack.

We are grateful to Williams for provoking debate into the neglected field of the communication of pain and distress. Analgesic behaviour, or its absence, is a rare topic of investigation. If we are to understand the expression of pain and the complaint of suffering, we must study it within its relational context.

Psychophysical studies of expressions of pain

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Abstract: What differentiates expressions of pain from other facial expressions? Which facial features convey the most information in an expression of pain? To answer such questions we can explore the expertise of human observers using psychophysical experiments. Techniques such as change detection and visual search can advance our understanding of facial expressions of pain and of evolved mechanisms for detecting these expressions.

In the last section of her target article, Williams notes that "Empirical and observational studies are needed both on the production of facial expression and on its detection and interpretation, and a major purpose of this paper is to stimulate empirical work as well as theoretical debate" (sect. 8). This is the focus of our commentary. We discuss the visual detection and interpretation of facial expression, and the existing empirical evidence for evolved propensities based on recent psychophysical studies such as visual search, eye movements, and change blindness. We discuss implications of these studies and suggest new directions for research that will constrain future theoretical accounts of evolved capacities for the detection and interpretation of pain.

Several studies suggest that negative expressions receive more attention than positive. Studies of attention, for example, reveal that faces displaying negative emotions interfere more with cognitive tasks than faces displaying positive emotions (White 1996). Moreover, in visual search tasks, observers detect negative facial expressions more quickly than positive (Eastwood 2001). Future experiments using a "flanker" task can investigate the interference associated specifically with expressions of pain, and from this infer the degree to which this expression attracts visual attention. In this task observers make judgments about a central face (e.g., about its gender) while ignoring two flanker faces, one on either side of the central face. The two flanker faces differ from the central face, but are identical to each other in identity and expression. By changing the expression of the flankers from trial to trial we can measure, via reaction times and error rates, how much interference each expression generates and therefore how much attention each expression attracts. Pain may attract more attention than other negative expressions such as anger. On an evolutionary level, pain can carry mixed messages: a warning of danger or a cry for help. Since our response to an individual expressing pain may depend on our relationship to that individual, the data might show that attention to pain expressions varies based on kinship or familiarity.

Several facial action units (AUs) are correlated with pain. These include lowered brows, raised cheeks, tightened eyelids, a raised upper lip or opened mouth, and closed eyes (Craig et al. 1991; Prkachin 1992b; Prkachin & Mercer 1989). However, it is not known which core AUs are most crucial, or most successful, in conveying pain. This can be studied with a forced-choice task in which two face images are presented side-by-side, and observers are asked to decide which face expresses the most pain. The faces display neutral expressions except for one or more superimposed element corresponding to a pain AU. By comparing which AUs, and which of their combinations, results in the highest pain rating, one can determine which AUs contribute most to an effective pain expression.

The human evolutionary response to the expression of pain can also be investigated. Subjects undergo the same procedure just described, but are asked to decide to which of the two faces they would more likely offer assistance. By comparing results from these subjects with results from the first, we can determine if faces that are most successful in expressing pain are also most likely to receive aid. Perhaps higher ratings of pain correlate with higher ratings of help. Even if they do not, the results can be analyzed to determine which pain AUs recruit the most human assistance. This might give insight to possible differences between perception of chronic and acute pain, since some AUs may be correlated more highly with one type of pain than another.

Previous studies of eye-movements indicate that we employ different patterns of fixation for different facial expressions. For example, when human observers view smiling faces they more often fixate on the corners of the eyes (Williams et al. 2001). Apparently we subconsciously check for evidence of a "duchenne," or genuine, smile which causes crinkling of the folds around the eye. A merely social smile lacks these crinkles. As with the smiling face, we may also have evolved to subconsciously fixate on certain key features when viewing a face in pain. Results from eye-movement studies can reveal which features we fixate on initially and which most frequently, when viewing expressions of pain.

Although studies of eye movements reveal much about patterns of looking, they are not an infallible guide to the distribution of attention (Ballard et al. 1995; Hayhoe et al. 1998; Zelinsky 1997). A complementary approach is the flicker task from the field of change blindness (Rensink et al. 1995; 1997; Simons & Levin 1997). Although change blindness is traditionally used to investigate attention to scenes, recent studies show the flicker technique can be used to study attention to faces, and that faces engage specific endogenous, that is, meaning-driven, mechanisms of attention (Davies & Hoffman 2002). The flicker technique involves a brief presentation of one image (about 100–1,000 milliseconds), a blank screen (about 100 milliseconds), and then the same image again with one small change to the image. This sequence cycles until the observer detects the change, and surprisingly, it often takes a long time. One reason is that the blank screen prevents motion from directing attention to the change. As a result, observers must build descriptions of items in the scene one by one, store these in visual short term memory, and then compare these descriptions with descriptions built from the second image (Rensink 2000a; 2000b; 2000c). Items whose changes are better detected are items that are likely to have received more attention. In comparing change blindness results for pain and other expressions we may find differential patterns of attention, which may indicate different evolved mechanisms for processing, and ultimately perceiving, specific expressions.

By investigating human performance in the perception and detection of pain, we can learn more about subconscious processes that influence how we fixate on, react to, and interpret expressions of pain. By comparing these results to those for other facial expressions we can more clearly define the key attributes that make pain a unique facial expression for which we have evolved specific mechanisms of perception and action.

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Pain, evolution, and the placebo response

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Abstract: Williams argues that humans have evolved special purpose adaptations for eliciting medical attention from others, such as a specific facial expression of pain. She also recognises that such adaptations would almost certainly have coevolved with adaptations for providing and *responding* to medical care. The placebo response may be one such adaptation, and any evolutionary account of pain must also address this important phenomenon.

Williams argues that among the evolved human facial expressions there is a distinct facial expression of pain. The function of this state, she claims, is to elicit social assistance of a medical kind. The plausibility of this claim depends on how long medical care has been in existence.

Unfortunately, we are extremely ignorant about the exact age of medicine. It must have originated after the human lineage had already diverged from that of the chimpanzees, because chimpanzees do not practise medicine, if by medicine we mean the provision of special care to a sick individual *by others.* Primatologists have observed many cases in which chimpanzees take care of *themselves* when ill or injured, sometimes in quite elaborate ways, such as consuming plants with medicinal properties or dabbing leaves on bloody wounds, but they have never seen one chimp provide this sort of medical assistance to another. Chimpanzees do spend long hours picking the ticks off each other's backs, which could, perhaps, be regarded as a kind of preventive medicine, but *therapeutic* medicine seems to lie outside their behavioural repertoire.

Archaeological evidence of ancient medical practices does not appear until relatively late. Ancient texts from Mesopotamia and Egypt provide written evidence that sophisticated medical practices were well established by 1,700 BC (Porter 1997), but evidence of the existence of medicine prior to the advent of writing is much harder to come by. One rare example is the existence of skulls with small holes surrounded by calluses that indicate that trepanning was being performed in places as far apart as France and the Pacific by 5,000 BC. This is an operation which involves cutting a small hole in the skull and scraping away portions of the cranium. If such a complex operation was being performed 7,000 years ago, it is a fair bet that more primitive forms of medicine were being practised earlier, but how much earlier is hard to say.

We know, then, that medicine – the provision of special care to the sick by others – must have originated some time between five million years ago and 10,000 years ago. Of course, that is a very large time window. It is so large, in fact, as to leave us ignorant on the vital question of whether or not there has been enough time for natural selection to shape specific adaptations for medical care. If medicine originated towards the beginning of this window, shortly after the hominid lineage branched off from that of the chimpanzees, then there would certainly have been time for the human brain to have developed special purpose mechanisms for eliciting, providing, and responding to medical help. If, however, medicine only started towards the end of this time window, when our ancestors were already fully human, then there would not have been time for any such special-purpose medical adaptations to have evolved.

Still, even if we are ignorant on this point, we can still explore each of the alternatives. The first possibility is that medicine is a few million years old, and that humans have evolved special psychological and physiological mechanisms that are for eliciting, providing, and responding to the provision of medical attention. Williams concentrates on adaptations for eliciting medical care, in particular, on the facial expression of pain, but she also points out that such adaptations would almost certainly have coevolved with adaptations for providing and *responding* to medical care.

Williams draws on the work of the late Patrick Wall, particularly on his claim that pain is a "need state," like hunger and thirst (Wall 1999b). Need states are terminated by specific consummatory acts; hunger by eating, thirst by drinking, and so on. Pain, presumably, is no different. Withdrawing one's hand rapidly from a hot stove is a consummatory act that terminates one sort of pain; keeping a sprained ankle still is a consummatory act that terminates another. Crucial to Wall's argument, however, is that pain can sometimes be terminated simply by care and attention from others. It is this addition of a purely social event to the list of various consummatory acts relevant to pain that makes human pain such an evolutionary novelty.

Wall's claim about the relevance of social support to pain relief is supported by studies that have investigated the anti-inflammatory effects of fake ultrasound (Hashish et al. 1986; 1988). One of these studies found that the placebo response was only triggered when