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This paper is based on Karlijn Massar's dissertation, 'Unconscious Rivals: The automatic evaluation of rivals in jealousy-evoking situations', which was written at the University of Groningen under supervision of Abraham P. Buunk.

An evolutionary perspective on human (social) behaviour assumes that the human mind has evolved to be responsive to contextual stimuli that are relevant to fundamental motives such as survival or reproduction. In the current paper, we argue that the presence of a rival is one such contextual stimulus. We hypothesise that given the fact that the pair bond is essential to human reproductive success, rival evaluation over the course of human evolution has evolved into an automatic process, and that subliminal exposure to a rival should suffice to evoke jealousy. We describe three studies using subliminal priming that confirm this hypothesis, and which show that sex-specific jealousy was evoked by rival characteristics to which participants were exposed outside their conscious awareness – whether these were in the form of words, photographs, or line drawings.

Introduction

Entering 'jealousy' as a search term in Google generates 29,200,000 hits within 0.08 seconds, and the same search term generates over 2060 results from all areas of psychology in PsychINFO. Clearly, jealousy fascinates scores of people, both the layperson and the professional, and in all cultures. Most work focuses on the negative side of jealousy, which is justified, since jealousy is often implicated in spousal assault, stalking behaviour, and homicide (Daly, Wilson, & Weghorst, 1982). Despite this negativity, in the current paper we take the view that jealousy is a functional emotion, in the sense that it helps to solve an adaptive problem, in this case to warn that a rival is threatening the relationship. Acting on this emotion would help to prevent a partner's infidelity. Indeed, we posit that since protecting one's relationship is crucial for one's reproductive success, the ability to evaluate the threat of a rival has evolved into an automatic process, taking place outside one's awareness.

An evolutionary (social) psychological view of human behaviour assumes that human cognitive and motivational functioning is directed by specific functional mental mechanisms which have evolved to solve adaptive problems that in human evolutionary history were crucial for survival and reproduction. Considering the existence of sex differences in, for example, parental investment, these adaptive problems likely differed to an extent for the sexes (Miller, 2000; Buss, 1994; Trivers, 1972). Moreover, an evolutionary perspective assumes there is an interaction between variables within the person (such as motives, strategies, and capacities) and variables within the situation (i.e., contextual stimuli connoting threats or opportunities). More specifically, the human mind is

hypothesised to have evolved to be responsive to contextual stimuli that are relevant to fundamental motives such as survival or reproduction, in a flexible way (e.g., Neuberg, Kenrick, & Schaller, 2010; Maner, Gailliot, Rouby, & Miller, 2007).

Whenever such contextual stimuli are detected, motivational systems are temporarily activated and content-specific adaptive mechanisms are triggered – emotions, attitudes, or behaviour. For example, Schaller, Park & Mueller (2003) showed that people in a dark room – a situation that heuristically would suggest a vulnerability to harm and thus activates a self-protective motive – are more likely to perceive ethnic outgroup members in a stereotypic manner, e.g. as hostile and threatening. Similarly, since mating is a fundamental human goal, contextual cues are able to trigger cognitive mechanisms that are associated with reproductive success. Several studies have shown that especially physically attractive women capture the eye of men as well as women (Maner, Kenrick, Becker, Delton, Hofer, Wilbur, & Neuberg, 2003; Buss, 1989). For example, Maner et al. (2003) showed that both male and female participants overestimated the frequency of attractive faces in an array of pictures of women when they were given insufficient time to process all the faces thoroughly. Moreover, in a recognition memory task, participants showed biased recognition memory for attractive women as opposed to unattractive women. In this case, then, physical attractiveness triggered mating-related motives. Similarly, in an experiment by Roney (2003), young men who were visually exposed to young women reported more favourable attitudes to material wealth, reported greater feelings of ambition and aggressiveness, and described themselves as more extraverted than men exposed to other men or men exposed to older women. That is, exposure to potential mates seemed to activate a courtship motive, making the participants 'conform' to women's preferences for socially dominant and high-status males.

With respect to jealousy, an evolutionary psychological view holds that experiencing this emotion helps to prevent a mate's infidelity, and thereby maintains the pair bond, which is essential to reproductive success because it increases both one's own and one's offspring's survival chances. Jealousy can be conceptualised as part of a coordinated system of cognitive, affective, physiological, and behavioural responses aimed at guarding one's mate from potential intrasexual competitors which, ultimately, is of importance to reproductive success (Maner & Shackelford, 2007; Buunk, Massar, & Dijkstra, 2007; Buss, 1994; Daly, et al.,1982). In general, no sex differences in the intensity of jealousy have been found – when confronted with a jealousy evoking situation, men and women report equal amounts of jealousy (Bringle & Buunk, 1985; Pines & Friedman, 1998). However, when contextual factors are taken into account, sex differences in jealousy do emerge. One such factor is the presence of a rival: Research (e.g. Dijkstra & Buunk 1998, 2002; Buunk & Dijkstra, 2001; Buss, Shackelford, Choe, Buunk, & Dijkstra, 2000) has shown that the amount of jealousy evoked by rival is dependent on his or her characteristics. More specifically, women report most jealousy when they are confronted with a physically attractive rival, whereas a socially dominant rival evoked most jealousy in male participants (for an overview, see Buunk, et al., 2007).

As was mentioned above, contextual stimuli are able to trigger content-specific adaptive motives that are relevant to human reproduction (Maner et al., 2003, 2007a, 2007b; [Kenrick, Neuberg, Griskevicius, Becker, & Schaller, 2010) – most likely, on an unconscious level. This implies that people are often not aware of the influence of these stimuli on their behaviour, and it also means that even though they are aware of the stimuli themselves, they might not be aware of their ultimate

significance. Indeed, in most men the fact that physically attractive female faces capture their attention does not necessarily activate a conscious desire to spread their genes. Given the importance of preventing rivals from interfering with one's relationship it seems plausible that during the course of human evolution, humans have evolved to be especially sensitive to the presence of rivals, especially those with desirable mating characteristics. Indeed, since this capacity is so fundamental, it is reasonable to assume that rivals may be detected outside conscious awareness – and subsequently influence jealousy responses. This assumption was the basis of our research into the unconscious processes in rival evaluation (Massar, Buunk, & Dechesne, 2009; Massar & Buunk, 2009, 2010). The main focus of these studies was to determine whether men and women are able to detect a rival's characteristics without being consciously aware of having been exposed to him or her, and whether this unconscious exposure would evoke to the same extent the sex-specific jealousy reported in earlier studies (e.g. Dijkstra & Buunk, 1998, 2002). To test these hypotheses, we used a technique that is often used in social cognitive research but is new to jealousy research, i.e., subliminal priming (e.g., Bargh, 1989).

There is a large body of research that shows that it is possible to prime people with stimuli they report not having seen, but which nonetheless may influence their performance on subsequent tasks, their judgments, or their emotions (for an overview see Merikle, 2007). Bargh and Pietromonaco (1982) were the first to use this paradigm in a study on person perception. In their study, participants were exposed for 100 ms to words relating to hostility. Immediately after the word was flashed it was masked by a string of Xs. Next, participants were asked to read the description of a man named Donald behaving in a rather hostile way, but his behaviour could either be interpreted as stemming from the situation, or as stemming from his personality. When asked to evaluate Donald's behaviour, the results showed that participants who had previously been primed with hostility words evaluated Donald's personality more negatively than participants who had not been exposed to hostility words. These last participants were more inclined to ascribe Donald's ambiguous behaviour to situational factors (Bargh & Pietromonaco, 1982). Thus, without their awareness or control, these participants' evaluation of Donald was influenced by the subliminal priming. After this first study, over the years a number of studies on automatic evaluations and category accessibility have repeatedly established that unobtrusively presenting participants with input cues may nonconsciously prime attitudes and emotions, and may influence participants' person judgments or object evaluations (e.g., Ferguson, Bargh, & Nayak, 2005; Dijksterhuis, 2004; Wegner & Bargh, 1998; Devine, 1989; Fazio, Sanbonmatsu, Powell, & Kardes, 1986).

Social stimuli relevant to mating and mate-guarding may also be processed selectively and at a very early stage. In several experiments Maner, Gaillot, and DeWall (2007a) showed that when a mating motive had been induced, both male and female participants' attention 'stuck' to physically attractive women, but not to attractive men. This bias for attractiveness was more pronounced in sexually unrestricted men and in women who were insecure about their current relationship. Supposedly, this last group is inherently more attuned to rivals. More evidence for an early order, attention-grabbing component in jealousy comes from a study by Schützwohl (2008), in which participants who were currently involved in a romantic relationship and who were therefore hypothesised to be more vigilant to intrasexual competitors, had more difficulties disengaging their attention from cues signalling infidelity. These men and women recalled significantly less task-irrelevant target cues when they had been primed with cues relating to sexual and emotional

infidelity, respectively, than men and women not currently in a romantic relationship (Schützwohl, 2008).

In all of the studies described here, participants were unaware of the purpose of the study, or of the influence of the primes on their performance on subsequent tasks, suggesting that the jealousy mechanism is a highly vigilant monitoring device that operates at very early stages of information processing. Applying these findings from research in both social cognition and evolutionary psychology to rival evaluation in a jealousy context, in our series of experiments (Massar et al., 2009; Massar & Buunk, 2009, 2010) we assumed that subliminal exposure to rival characteristics should suffice to activate feelings of jealousy. We will now briefly describe these studies and their results.

Method & results

Study 1

For details on the statistical analyses and the results, see Massar, Buunk, & Dechesne (2009).

In this study, 35 men and 40 women (mean age = 22.8, SD = 1.94) were randomly assigned to either the social dominance or the attractiveness condition. Before starting with the subliminal priming task, they completed two questionnaires. First they completed a questionnaire that measured their mate value (Landolt, Lalumière, & Quinsey, 1995) Participants indicated on a five-point scale (1 = not at all, 5 = very much) how applicable certain statements were to them. Examples are: 'I receive many compliments from members of the opposite sex' and 'I receive invitations for sex from members of the opposite sex.' (M = 3.31, SD = 0.52). Next, participants who were in a relationship at the time of the experiment completed the relationship interaction satisfaction scale (Buunk, 1990). This scale measures the frequency with which the interaction with the partner in an intimate relationship is experienced as rewarding and not as aversive. There are eight items in this scale, and examples are: 'I feel happy when I'm with my partner,' and 'We have quarrels'. On a five-point scale (1 = never, 5 = very often) participants indicated how often these statements applied to them (M = 4.16 (SD = 0.49).

Next, in a subliminal priming procedure adapted from Dijksterhuis (2004), which was presented as an association task to participants, they had to indicate as quickly as possible whether two neutral words presented on the screen were related to each other. The visible words in this task had no relation to rival characteristics, but were neutral words like 'house' and 'garden'. However, unbeknownst to the participants, in between these two neutral words they were subliminally exposed to rival characteristics. To ensure that participants would relate the rival characteristics to another individual, and not to themselves, each word was preceded by a personal pronoun – 'he' for the men and 'she' for the women. The rival characteristics were those words that in a preliminary study were most often mentioned when men and women were asked to generate words relating to attractiveness and social dominance (Dijkstra & Buunk, 2002). For the attractiveness condition, these were 'pretty,' 'beautiful,' 'slender,' and 'sexy' (these are imperfect translations of Dutch words that apply equally to men and women), and for the social dominance condition, 'tough,' 'money,' 'power,' and 'success.'

Each rival characteristic was presented five times, making a total of 20 trials. A trial would thus consist of a neutral word (presented for 1.5 s), a personal pronoun (17 ms), a rival characteristic (17 ms), and then another neutral word (1.5 s). After completing the association task, participants read a jealousy scenario. In this short vignette they were asked to imagine themselves and their partner at a party, where an unfamiliar man or woman started flirting with their partner. Next, they were asked how jealous they would be in such a situation, measured on a scale ranging from 0 (not jealous at all) to 100 (extremely jealous). To make sure the only information the participants received about the rival was the subliminal primes, the rival's appearance and personality characteristics were purposefully withheld in this vignette. Using a funnelled debriefing procedure, participants' awareness of the primes was assessed. Next, they were informed about the true nature of the study and thanked for their participation.

The results showed that subliminal priming in this context clearly had the hypothesised effects, but that there were sex-specific moderating variables that influenced the relationship between rival characteristics and jealousy. For women, their self-reported mate value, but not their relationship satisfaction, influenced their jealousy. Women with a high mate value reported more jealousy ($M = 82.03$) after being primed with attractiveness words than social dominance words ($M = 48.51$; $p < .01$), whereas women with a low mate value reported equal amounts of jealousy after exposure to the attractive and the socially dominant rival ($M = 78.51$ and $M = 75.15$ respectively, ns). For men, their relationship satisfaction, but not their mate value, moderated jealousy scores. Men high in relationship satisfaction reported more jealousy after exposure to a socially dominant rival ($M = 90.42$) than men low in relationship satisfaction ($M = 34.75$; $p <.001$). However, men high and low in relationship satisfaction did not differ in their jealousy response after priming with attractiveness words: $M = 75.51$ and $M = 57.38$ (ns), respectively.

This study established for the first time that it is possible to induce jealousy in participants through subliminal exposure to rival characteristics, and that individual differences in mating-related variables such as mate value and relationship satisfaction moderate the influence a rival has on one's jealousy. Our next study focused on facial attractiveness. Within and across cultures, common standards of (female) facial attractiveness are shared by both men and women from different social classes (for a review see Langlois, Kalakanis, Rubenstein, Larson, Hallamm, & Smoot, 2000). This high consensus in attractiveness ratings would suggest that there are biologically based standards of beauty. Indeed, early on in human development, before cultural standards of beauty are likely to have developed, a preference for attractive faces over unattractive faces emerges (Slater, Quinn, Hayes, & Brown, 2000; Rubenstein, Kalakanis, & Langlois, 1999). Most relevant to the present paper, women with attractive faces have more long-term mating success and become sexually active earlier in life than women with unattractive faces (Rhodes, Simmons, & Peters, 2005). Since facial attractiveness contributes less to male mate value than to female mate value, in this study (Massar & Buunk, 2010) we decided to use only women as participants, and predicted that they would report more jealousy after subliminal exposure to a photograph of an attractive woman than after exposure to an unattractive woman.

Study 2

For full details on the statistical analysis and the results, see Massar & Buunk (2010).

In this experiment, 40 women (mean age =20.78, SD = 4.26) participated. After providing some demographic information, they started with the priming task which consisted of a parafoveal priming procedure. In this procedure the primes are presented in the visual periphery of the attended region (for details, see Chartrand & Bargh, 1996). A fixation point consisting of an asterisk (*) remained in the centre of the screen and participants were told to focus on this fixation point throughout the task because of the unpredictable location and timing of the stimuli on the screen. Two keys on the keyboard were labelled L and R, and participants were instructed to press the L key whenever they saw a flash on the left side of the screen, and the R key whenever they saw a flash on the right side of the computer screen. As priming stimuli, pre-rated photographs of an attractive and an unattractive female were used. These priming stimuli were flashed in 15 of the 60 experimental trials. In the practice trials and in the remainder of the 45 experimental trials participants were exposed to geometrical shapes (circles, triangles and squares), which were also presented for 60 ms. The geometrical shapes were of the same size as the priming stimuli and consisted of black line drawings on a white background. Both the geometrical shapes and the priming stimuli measured 4 x 5 cm (width x height), and were presented for 60 ms. Each picture was immediately followed by a 60 ms masking picture, of the same size as the stimulus picture. This mask consisted of a scrambled (unrecognisable) version of the stimulus pictures. The stimulus pictures and the mask appeared randomly at one of four parafoveal locations on the screen (for details, see Chartrand & Bargh, 1996; Stapel, Koomen, & Ruys, 2002). Intervals between the offset of the mask and the onset of the next picture varied randomly from 2 to 7 s. Both the random presentation in one of the four parafoveal regions and the random time intervals between stimulus presentations ensured that it was impossible for participants to learn or predict the next presentation of the stimuli.

To get familiar with the procedure, participants were given 15 practice trials, in which only geometrical shapes were flashed. After the practice trials, the participants completed 60 experimental trials. The priming stimuli were flashed in 15 of the 60 experimental trials. In the remainder of the 45 experimental trials participants were exposed to the geometrical shapes which were also presented for 60 ms. After the priming procedure, the jealousy evoking scenario described above was presented to the participants, and their jealousy (0-100) was measured. In addition to jealousy, we also asked about a number of other emotions: suspicious, betrayed, worried, distrustful, jealous, rejected, hurt, anxious, angry, threatened, and sad, rated on a scale from 1 [not at all] to 5 [very much] (see DeSteno & Salovey, 1996). After completing these questions, participants' awareness of the primes was assessed using a funnelled debriefing procedure. Finally, they were informed about the true nature of the study and thanked for their participation.

The results confirmed our expectations: women who were subliminally exposed to the attractive woman reported significantly more jealousy ($M = 77.24$) than women exposed to the unattractive rival ($M = 64.50$; $p < .05$). Significant effects were also found on both the mean of the other emotions ($M = 3.09$ and $M = 2.53$ respectively, $p < .05$), and on several separate emotions. Women who were subliminally exposed to the rival with the attractive face reported they would feel more worried,

angry, hurt, and sad if the situation described in the scenario would happen to them than women exposed to the unattractive rival (p's < .05).

This study thus established that exposure to attractive faces evokes women's jealousy, even outside their conscious awareness. However, not only facial attractiveness, but also body shape is an important cue that contributes to one's physical attractiveness, particularly when individuals are observed from a distance (e.g., Alicke, Smith, & Klotz, 1986). A low waist-to-hip ratio (WHR) is one factor contributing to women's physical attractiveness. This ratio is considered an indicator of a woman's reproductive capability and health as it is the result of high levels of oestrogen that cause more fat to be deposited on the buttocks and hips than on the waist. A low ratio, between 0.67-0.80, results in a curvaceous, hour-glass shaped figure and is considered most attractive, and a WHR around 0.7 is considered an 'ideal' female body shape. Ratings of female attractiveness are significantly correlated with WHR (Singh, 1993; Streeter & McBurney, 2003), and WHR has been shown to be a reliable morphological indicator of the levels of sex hormones (Singh, 1993). Paper-and-pencil studies have shown that rivals with a relatively low WHR evoke more jealousy in women than in men, and that women pay more attention to the waist, hips, and legs in evaluating their rivals (Buunk & Dijkstra, 2001; Dijkstra & Buunk, 2005).

Male physical attractiveness is largely determined by body parts such as the chest and shoulders. Moreover, men whose torsos have an inverted triangle shape, that is, men who have broad shoulders and narrow hips, are considered most attractive (Fan, Dai, Liu, &Wu, 2005; Franzoi & Herzog, 1987). This body shape is indicative of larger physical strength and muscular development in the upper body. Men with a high SHR are also perceived as being higher in both social and physical dominance than men with a low SHR (Dijkstra & Buunk, 2001). A male's waist also plays a role in determining physical attractiveness: research has shown that a male WHR of 0.9 is considered the optimal ratio and that increasing WHRs decrease a male's attractiveness (Dijkstra & Buunk, 2005). Concerning jealousy, there is evidence from paper and pencil studies that rivals with a relatively high SHR evoke more jealousy in men than in women, and that men say that they pay more attention to their rivals' shoulders, chest, and belly (Buunk & Dijkstra, 2001; Dijkstra & Buunk, 2001). In our next study, we focused on WHR and SHR, and used Singh's (1993) line drawings as subliminal primes.

Study 3

For full details on the procedure, the statistical analyses and the results, see Massar & Buunk (2009).

Thirty-four men (mean age = 22, SD = 3.0) and 54 women (mean age = 21.6, SD = 3.0) took part in this experiment, and after providing some demographic information, they started with the parafoveal priming procedure. The primes (taken from Singh, 1993, and Dijkstra & Buunk, 2001) were for male participants: a figure with either a high shoulder-to-hip ratio (e.g., an attractive body shape), or a low shoulder-to-hip ratio (an unattractive body shape), and for female participants: a figure with either a low WHR (an attractive body shape), or a high WHR (unattractive body shape). The priming procedure was identical to the one described above. After this priming task, participants read the jealousy-evoking scenario again, and indicated their jealousy. After completing the dependent variables, participants' awareness of the primes was assessed using a funnelled debriefing procedure. Finally, they were informed about the true nature of the study and thanked for their participation.

The results were in line with our expectations: Males reported significantly more jealousy after subliminal exposure to the figure with the attractive body shape (high SHR; $M = 77.43$) than after exposure to the figure with the unattractive body shape (low SHR; $M = 61.03$, $p < .05$). The results for women also confirmed the hypotheses, i.e. the attractive body shape evoked most jealousy ($M = 74.18$ versus $M = 65.86$, $p = .05$), but only after the stimulus pictures were modified by removing possibly distracting features like the face and the arms.

Discussion

Using methods commonly used in social cognition, we have tested hypotheses derived from an evolutionary psychological approach to human behaviour. Our experiments show that participants are able to evaluate a rival's threat outside their conscious awareness, and that sex-specific jealousy is aroused by adaptively relevant rival characteristics, i.e. facial and physical attractiveness for women, and social and physical dominance for men. The research reported here is largely in line with Kenrick et al. (2010)'s model of top-down, fundamental motives being activated by bottom-up processes such as visual processing. This model presumes that functionally relevant stimuli in the environment are quickly and automatically attended to, especially when a fundamental motive is activated, whereas less relevant features are more likely to be ignored. For example, activation of a mate retention goal will increase attention to goal-relevant stimuli – such as physical attractiveness and social status in same-sex others – and in this way bias how these stimuli are interpreted and remembered. The results from our experiments suggest that having been exposed to stimuli before a functionally relevant goal is activated produces the same effects as exposing participants to stimuli after a goal is activated (see Maner et al., 2003). That is, the interpretation of stimuli which would on their own not necessarily have been very informative to participants was retrospectively affected by activating a mate retention goal.

One can assume that highly adaptive responses have evolved to become automatic, since automaticity frees up cognitive resources. This in turn helps the individual respond easily and adaptively to a wide range of physical and social challenges, thereby enhancing reproductive success. Bargh (1989) identified four core components of automaticity: Intention, awareness, efficiency, and control. More specifically, a process – or behaviour, emotion, attitude, etc. – is deemed to be automatic when there is little intention involved (i.e. it is spontaneous), when it takes place without one being aware of it, when it is highly efficient (i.e. it requires little cognitive capacity), and finally, when it is outside one's control (i.e. it is unconscious). However, not all four features need to co-occur before one can say mental processes are automated (Bargh, 1989). The studies above can be said to have at least three of the hallmarks of automaticity. First of all, the evaluation of the rival was spontaneous: without the presence of explicit prompts to evaluate the subliminal prime, it had an effect on subsequent emotions, most notably jealousy. Second, participants were not aware of the priming, and thus of the presence of the rival. Finally, the information was presented to participants outside their conscious awareness. Moreover, due to the nature of the subliminal priming task, we can assume the rival evaluation was highly efficient – i.e. requiring few cognitive resources – as well. Thus, in the present studies it seems that rival evaluation shaped subsequent responses even though participants were not explicitly directed to do so.

In our research, evaluating a rival automatically produced overall the same results as evaluating a rival consciously (e.g., Dijkstra & Buunk, 1998). Is implicit evaluation of rivals indeed similar to explicit evaluation? Evidence for a correspondence between explicit and implicit evaluations comes from Gardner, Bargh, Shellman, and Bessenoff (2002). In this study, brain activation patterns of participants making conscious evaluations of stimuli and participants who were merely told to listen to stimuli names – the implicit evaluation condition – were compared. The participants in the latter group did not know they were evaluating, and did not intend to evaluate the stimuli. However, the results showed that in both groups of participants the same area of the brain unique to the evaluative response reacted to the stimuli, suggesting that unintended, unconscious evaluations evoke the same brain activation as explicit evaluations. Thus, we feel it is reasonable to assume that in the experiments presented in this paper, the process of unconscious rival evaluation was comparable to the explicit rival evaluation reported by Dijkstra and Buunk (1998, 2002).

To conclude, using paradigms from social cognitive psychology to test evolutionary psychological hypotheses, our research program has helped to unravel how the male and female minds are made up to pay attention in different ways to specific rival characteristics. We argue that using implicit manipulations or measures to test hypotheses derived from an evolutionary perspective on human behaviour provides opportunities to test whether processes that are assumed to have evolved into automatic tendencies indeed influence and guide our behaviour, attitudes and emotions outside our awareness.

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