

# Testosterone, Aggression and Status in Early Northern Literature

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THE subject of the dynamics of aggressive behaviour in Old Norse and Old English literature has received some scholarly attention, although perhaps not in proportion to its importance. Most relevant studies (for instance, Miller 1990) examine the complex relationship between social, political and cultural structures, as well as environmental and external factors in determining aggression. In cultural terms, there are concepts such as the honour system, the heroic society and feud to explain why men in particular act aggressively, resist or defer aggression. Structural approaches are also available: Jesse Byock for example, breaks the phenomenon of feud into particular narrative elements and describes a syntax for the action of feud in saga literature (Byock 1982).

These approaches can often give very convincing explanations of how individual characters respond in particular social settings, in particular where they are under social pressure to protect or gain reputation and honour through aggressive behaviour. When opponents or victims of aggression belong to the same social system they also need to respond to the challenge posed by a domineering individual with rising status. Such a situation leads to negative reciprocity or feud (cf. Miller 1990: 181), where individuals and their kin respond in turn to each other's challenges. The conflicts presented in the present study are more asymmetrical than in conventional feuds: certain individuals are able to dramatically increase their status in relation to others in the society by responding aggressively to a series of challenges. This article presents a refinement of the honour society model in order to describe such asymmetrical conflicts.

For characters who are described as aggressive and dominant, the motivation to seek to increase status through aggression is self-evident to

the audience. They are usually represented as successful to a certain extent, increasing their resources and status, although many ultimately fail after having created too many enemies or taking on challenges beyond their abilities. Some characters begin their roles as apparently unpromising, weak and unaggressive, but nevertheless go on to be involved in aggressive and often violent action, showing surprising prowess, and increasing wealth and status. Many also suffer the same negative outcome as the more obviously aggressive ones.

This article will attempt to describe these patterns of behaviour among the male characters of medieval Germanic literature according to a model from the behavioural sciences. It uses information about the hormone testosterone and its effects on human behaviour as a reference point to bring together social and individual factors that may explain a male character's aggressive behaviour as represented in some Old English and Old Norse literature. I am concerned in particular with representations of extraordinary successes and increases in status of individuals, rather than the more common reciprocal aggression of feuds, which is well described in the studies mentioned above and many others.

This study will focus on a limited number of texts of early Germanic literature, namely the Old English poem *Beowulf* and two Old Norse-Icelandic sagas of early Iceland, *Eyrbyggja saga* and *Njáls saga*. The dating of *Beowulf* is somewhat controversial but cannot be later than the mid-eleventh century and is probably earlier. *Eyrbyggja saga* and *Njáls saga* belong to the 'classical' period of saga writing in the second half of the thirteenth century. These are chosen because of their high status within literary studies, but the approach of this study can potentially be applied to a range of literary works, both more minor and from other genres and periods.

The following analysis of these texts is based on behavioural studies which use quantitative methods to analyse the relationship between an individual's testosterone levels and various external conditions. The conclusions of these studies are not deterministic but based on mathematical probabilities. Any given subject may not therefore display the general tendency, and others may show more marked tendencies. Literary studies tend to focus on certain works which are considered canonical or representative, whereas a quantitative analysis will ideally use a random sample. Quantitative analysis of behaviour in literature is possible, where random characters and sequences of action are categorised and statistical analysis then applied to the sample. The present study, however, aims to develop a framework for further research.

Men and women both produce and respond to testosterone, but there has been considerably less research into testosterone in women than in men

and male animals. For this reason the present study will be restricted to male characters.

There are certain features of medieval Germanic literature, particularly the Old Norse-Icelandic sagas, which lend themselves to a behavioural analysis. Such literature is very much concerned with the relationship between individual action and social context (Ólason 1998: 65), particularly as realised in face-to-face interaction. This relationship is the very essence of behaviour as the subject of social scientific study. The concern with outward action (behaviour) is also shown by how characters are described in this literature. In particular, characterisation in sagas is developed through external indicators, such as action and dialogue (Ólason 1998: 111–13), rather than the revelation of internal thought or emotion.

The style of saga writing is largely realistic and the behaviour of characters therefore has to be within the bounds of what is likely within a given social context (Miller 1990: 46). The behaviour of characters as represented in these texts does not have a strict historical reality; that is, this study does not treat these texts as documents of actual behaviour. However, their authors are likely to have based depictions of characters' behaviour on their own observations and/or traditional knowledge of how people behaved in such a society (Miller 1990: 47). The society depicted in these texts, likewise, is likely to be a reflection of the historical society known to the author (Miller 1990: 46).

Much of this literature is notably concerned with male conflict and the gaining, protection and loss of status through conflict. A large number of the sagas of Icelanders are concerned in particular with individual action in response to threats to honour and status (Clunies Ross 2010: 110). The societies described in these texts are small-scale. In addition to the usual status signs of the period (such as family connections and wealth) status is established through face-to-face interaction. These interactions are required to maintain status acquired through wealth and family (Miller 1990: 29). A way of understanding status in behavioural terms in such societies is through the interaction of individuals as mediated by the endocrinal (hormonal) system.

A model for understanding status in groups was developed by Mazur in 1985, based on primate societies, including humans, in societies where status can be determined through face-to-face interaction, particularly with the use of aggression or the threat of violence. In most human social environments status is determined in a cooperative manner, that is, the social group determines who is high-ranking collectively and most social situations reflect this. Seating arrangements, greetings, decision making and a range of verbal conventions reflect and reinforce the social hierarchy. Any breaking of the hierarchy, normally by a lower-ranking person assuming the behaviour of a

higher-ranking one, represents a challenge to the status of the higher-ranking person, with a winner or loser and consequent reinforcing or modifying the status hierarchy (cf. Miller 1990: 30). These competitive interactions are the exception rather than the rule, and the normal outcome is to put the challengers back in their place or initiate reciprocal challenges. Most societies tend to reward people who are cooperative and pro-social in their behaviour and punish those who are overly aggressive.

There are particular contemporary environments where competition is normally used to assign status, such as sporting events and in certain occupations such as financial trading. In some social settings the normal cooperative allocation of status may be more competitive, such as where resources are particularly scarce and vulnerable to theft, especially the resources needed to create and support a family. The societies represented in much of our literature appear to be ones where status is often negotiated competitively, and social interactions are characterised by frequent status challenges.

The types of societies that are characterised by competitive allocation of status are ones where young men in particular are not subject to traditional community agents of social control (cf. Mazur and Booth 1998: 360), a situation sometimes described as a culture of honour (Nisbett and Cohen 1996). The social settings of many medieval Germanic literary texts appear to have these characteristics. One feature is a dearth of women (cf. Gräslund 2001; Wicker 1998), increasing the proportion of men and increasing competition for potential wives and the resources to support a family.

Mazur's model applies in particular to competitive status allocation among males. It has been refined and confirmed by a great many studies since, some of which will be referenced in the following discussion. It functions roughly thus: (1) An individual (Ego) displays a range of constant and controllable signs and behaviours that indicate status (for example strength, support, reputation; aggression, fearlessness). (2) Ego goes into a dominance contest with another individual (Alter) displaying these status signs. Alter will do the same and either display dominant or deferent signs, such as withdrawing, fighting and so on. (3) If Ego wins, his status increases and (4) this in turn produces an increase in testosterone in Ego (and a decrease in Alter). (5) The increased testosterone then has effects on Ego's status signs, including increased dominant behaviour. (6) These dominant signs in turn increase the ability of Ego to win future encounters, which result in further increases in testosterone. The following section will discuss this model in detail and how it relates to the present study.

**1. Ego displays a range of constant and controllable signs that indicate status**

The constant status signs of the individual include, among other things, age, body shape, muscle mass, strength, height, facial features, voice depth and strength and so on. These indicate to others that Ego is dominant or otherwise. Many of the physical characteristics are determined at puberty (body shape, facial features, voice, facial and body hair), usually mediated by testosterone. Others, such as body size and strength can be altered in adulthood through engaging in certain types of activities, such as weight training, again mediated by testosterone. (Anabolic steroids used by athletes and body builders to build muscle are normally derivatives of testosterone.) Mazur's model treats the constant signs as independent of circulating testosterone, but many of them have been shown by subsequent studies to be mediated by testosterone and behaviour. Resistance training (resistance to the force of muscular contraction, for instance, through weight training or wrestling), for example, increases testosterone levels and builds muscle, whereas aerobic exercise (including endurance activities such as swimming or running) tends to decrease testosterone. Testosterone increases muscle mass and strength and bone density, as well as cardiovascular fitness.

The controllable status signs include a range of behaviours that indicate dominance or deference. Dominance can be shown by engaging in violent acts, initiating hostile legal proceedings, verbal aggression such as insults, and anti-social behaviour such as theft. Aggressive and dominant behaviour has been shown by a number of studies to be mediated by testosterone (see Mazur and Booth 1998 for a review). In medieval Germanic literature, we can add a range of indicators of status and dominance, such as clothing and weaponry, as well as aggressive uses of language (such as insult and verbal challenge). Deferential acts include a variety of means of backing down or out of a conflict, and may include financial payments, rendering of services, ignoring status threats or reluctance to pursue a legal case.

**2. Ego goes into a dominance contest with another individual (Alter) displaying these status signs**

What constitutes a dominance contest is an encounter where status will change as a result of the outcome, which can usually be seen as winning or losing. Status itself is often described in abstract terms such as honour (*sæmð* in Old Norse), or it may be in financial terms such as monetary payments,

ownership or rights to land and resources, social recognition through, for example, seating arrangements or specific titles which give authority, such as an earldom or chieftaincy. In medieval Germanic literature contests that decide status may involve a range of encounters including simple fights, formal duels, battles and other violent encounters. Most violent encounters begin with a legal or verbal status challenge ('Who are you? What are you doing here?') before escalating into physical violence. Violence is not needed in itself, but can function as a threat, such as a verbal challenge by an armed man or group. In saga literature in particular, dominance contests include a range of legal proceedings including summoning, court cases and other formal legal procedures. These may result in loss of property, liberty or life. There are a range of formal and informal verbal encounters that involve status challenges, including insults and verbal challenges in court settings. A number of other encounters involve competition and potential status changes, including games such as horse fights and ball games. These all have the potential to escalate to direct violence.

There are a number of changes which occur in circulating testosterone levels in men in response to these status challenges and their outcomes. Before a competitive encounter, testosterone levels increase, and they increase further if the individual wins the encounter, and decrease with a loss (Booth *et al.* 1989; Campbell *et al.* 1988). Loss of status or dominance decreases testosterone (Mazur and Booth 1998, 358). These effects are known as the challenge hypothesis (Wingfield *et al.* 1990); increases in testosterone occur in response to challenges, particularly in situations which relate to reproduction. Since Wingfield's study, a large number of studies have shown that this effect applies to direct or indirect involvement in almost any competitive encounter which involves a change in status (reviewed in Mazur and Booth 1998). In humans, this effect is played out in a range of non-violent social situations, many of which are not directly relevant to reproduction but where status may be altered (cf. Mazur and Booth 1998: 358). For example, competitive situations such as sporting matches (Booth *et al.* 1989) or financial trading (Coates and Herbert 2008) show these tendencies: an initial increase in testosterone in preparation for competition, followed by further increases with a win or a decrease with a loss.

Similar effects are seen in a variety of social settings. The presence of a woman increases testosterone in aggressive dominant men (van der Meij 2008), and this is also seen in male animals when there is a reproductively available female present. This effect is presumably to prepare the male for competition for a mate. Men also behave in a more risk-taking manner when there is a female present (for example, see Ronay and von Hippel 2010). Men's

testosterone levels go down in a committed relationship, further in marriage, and still further with parenthood (Berg and Wynne-Edwards 2001), and also with falling in love (Marazziti and Canale 2004). These effects are presumably to signal changes in behaviour that promote nurturing and cooperation, necessary for typical human families to function. In contemporary Western populations, men's testosterone levels gradually decline with age, after peaking in the early twenties (Mitchell Harman *et al.* 2001; cf. Ellison *et al.* 2002, for comparisons with other groups). This, again, is probably related to the more stable status associated with aging in certain societies.

### 3. If Ego wins, his status increases

The change in status may be signalled in a variety of ways. In sagas, there is often explicit evaluation after the encounter (*ok hafði Gunnar ina mestu sæmð af málinu* 'and Gunnar got great honour from the case', *Njáls saga* ch. 24, p. 68).<sup>1</sup> Sometimes this may be expressed or reinforced by the quotation or recitation of verse, either from a saga character or a prominent poet. The authority of the evaluator is important: the more people recognise the change in status, and the higher rank they have, the greater the change in status.

The change in status may be identified by the gaining of resources or recognition. Formalised duels are designed to identify a winner, although they may be disrupted. In informal violent encounters the winning side will be the one that inflicts more injury, or injuries on higher-ranking members of the opposing side. A win may involve the opposing side or person backing down. In verbal situations, there are a number of deferent and dominant behaviours which signal winners and losers (cf. Mazur 1985: 389–93).

The change in status may involve the gaining of resources through a legal challenge or theft. Someone who gains chattels, land or natural resources (such as timber and driftage) from another (and gets away with it) gains status.

### 4. This in turn produces an increase in testosterone in Ego

Various studies have shown increases in testosterone following wins in a range of encounters, such as successful financial trading (Coates and Herbert 2008); winning in various sports (Booth *et al.* 1989); supporting a winning team in various sports merely as a spectator (Bernhardt *et al.* 1998); and voting for a

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1 References to *Njáls saga* are to chapter numbers in Einar Ólafur Sveinsson 1954.



successful candidate in an election (Stanton *et al.* 2009). This increase lasts for a few hours after competition (Booth *et al.* 1989; Campbell *et al.* 1988). Recent research suggests that there are longer-term effects of winning by increasing sensitivity to testosterone in neural pathways related to social aggression (Fuxjager *et al.* 2010). This means that the individual is likely to then show more aggressive responses to future increases in testosterone. Testosterone decreases with losing status and supporting a losing side. In general winning and a positive change in status produces increased testosterone levels, and loss results in decreased testosterone.

##### **5. The increased testosterone then has effects on Ego's status signs, including increased dominant behaviour**

Effects of testosterone on status signs include a number of behavioural as well as physiological changes. The physiological changes associated with circulating testosterone are discussed above.

In both human and non-human studies, testosterone is associated with dominance, that is, behaviour designed to increase an individual's status in relation to others. Some studies have shown this association to apply particularly to periods of social instability (for example, see Sapolsky 1991). There are a number of specific behaviours associated with elevated testosterone which will tend to increase a male's tendency to display dominant status signs and help to win future contests, including: search persistence (such as seeking rival males or prey or defending a large territory; cf. Andrew and Rogers 1972); appetite for risk (including a willingness to attack and take risks generally; cf. Booth *et al.* 1989); fearlessness in the face of novelty (for example, the ability to respond to new challenges; cf. Boissy and Bouissou 1984; Hermans *et al.* 2006). These behaviours are unrelated to intrinsic fighting ability (Oyegbile and Marler 2005). Other effects include decreased parenting responsibilities and caring behaviour (Fleming *et al.* 2002). Attention to status threats coincides with elevated testosterone levels (van Honk *et al.* 1999), meaning that individuals with elevated testosterone levels are more likely to respond to challenges rather than ignore them.

The behaviours associated with elevated testosterone levels are represented in literature in various ways. Search persistence may involve characters seeking fights further afield, travelling in search of adventure, a greater perception of potential threats and willingness to respond to them. Appetite for risk can be seen in any willingness to take risks, in terms of physical aggression and also in social arenas, including financial and legal



risks. Fearlessness in the face of novelty can be seen in the ability to respond when faced with unusual combatants, weapons, monsters, and so on.

**6. These dominant signs in turn increase the ability of Ego to win future encounters, which result in further increases in testosterone**

The model is complex and involves a positive feedback mechanism where social situations and outcomes produce hormonal changes in the individual which in turn produce behavioural changes that influence social situations and outcomes. Although the model has been developed by the measurement of testosterone levels in experimental subjects, it is confirmed also by studies which demonstrate a number of its features independently of direct observations of testosterone levels. For example, the observation that winning an encounter increases the chances of winning future encounters has been shown in a range of human and animal environments and is termed the 'Winner Effect' (Dugatkin 1997). Importantly, this effect is not related to intrinsic fighting ability (Oyegbile and Marler 2005), and can help the winner to overcome an advantage of size in an opponent (Whitehouse 1997). The Winner Effect has been shown in dozens of species without reference to hormonal levels, but a number of recent studies have shown that the Winner Effect is closely linked to reciprocal effects of winning and circulating testosterone: winning causes an increase in testosterone and increased testosterone boosts the chances of winning (see Mazur and Booth 1998, for a review). Oyegbile and Marler (2005) refer to the system as the 'Winner-challenge Effect'. In human societies which show honour sub-cultures, this produces a positive feedback mechanism that means that young men are particularly sensitive to status challenges: 'feedback between challenge and [testosterone] may create a vicious circle, sometimes with lethal effects' (Mazur and Booth 1998: 360).

Outward status signs, such as facial masculinity and other indicators of high levels of testosterone during development, correlate with increased aggressive behaviour (Apicella *et al.* 2008; Pound *et al.* 2009). These are indirect indicators of testosterone but can be observed without measuring the hormone itself.

All the externally-observable features of Mazur's model are represented in medieval Germanic literature: the physiological and behavioural status signs, the competitive encounters in various forms, the allocation of changes in status, and, importantly, the corresponding changes in behaviour and fighting ability that result indirectly from increased status.

The relationship between what we now understand as the hormone testosterone and medieval representations of behaviour requires us to

assume that the effects of the hormone were observable to medieval writers though not understood in a modern scientific sense. For this literary study testosterone functions as a more abstract concept to trace how a character reacts to status challenges in literature. This approach is the equivalent of identifying a biological or neurological condition in one of our characters: one cannot directly diagnose Egill's possible Paget's Disease (cf. Byock 1995), for example, but a reading of his saga in these terms explains a range of physiological and behavioural characteristics consistent with the biological condition. Testosterone, like the endocrine system generally, functions as an internal communication signal in the individual, responding to social situations that affect status and in turn signalling to other systems (behaviour and physiology) changes that may reflect and affect status.

Having established the model, I will now apply it to analysing particular examples from medieval Germanic literature. The Old English poem *Beowulf* provides a specific setting of a challenge to the status and territorial integrity of the Danish court, and a setting where an individual can gain status within the context of that threat. Having built a massive and impressive hall in Denmark, the Danes and their king, Hrothgar, face a series of attacks by a monster, Grendel. They lose good warriors and control over their territory, and abandon the hall (lines 145b–146a).<sup>2</sup> The society of *Beowulf*, like that of the sagas, is a culture of honour where status can be negotiated competitively in face-to-face interactions.

Beowulf, a young warrior from Geatland, arrives in Denmark relatively untested. We are told later in the poem that he was unpromising and lazy in his youth (lines 2183–9). His main known previous exploit is an aerobic challenge, a swimming contest, to which I will return. Various incidents presented in the narrative correspond to Mazur's model and similar situations. In analogous human studies, Beowulf's testosterone levels would rise in response to various situations before the fight with Grendel.

Beowulf's arrival in Denmark involves three challenges that have social and territorial dimensions, and the potential for a violent encounter. The first challenge (lines 217–300) occurs when Beowulf enters the territory of the Danes: the coastguard presents a verbal challenge but with the threat of violence (*þrymmum cwehte / mægenwudu mundum, meþelwordum frægn*, 'he powerfully brandished the mighty shaft in his hands, questioned them in formal words', lines 235b–236). Beowulf's response is successful, with the coastguard backing down, letting Beowulf and his men through. The guard shows deference, offering the service of guiding the troop and guarding their ship (lines 291b–294a). The second challenge (lines 332–55) occurs at the royal

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2 References are to line numbers in R. D. Fulk *et al.* 2008.

hall, Heorot, where Beowulf is challenged by Wulfgar, who guards the hall. Wulfgar already shows deference by recognising the Geats' apparent bravery (lines 336b–337), and Beowulf responds boldly, identifying himself but not stating his errand until he has seen the king (lines 344–5). The outcome is that the men are allowed into the hall and the king Hroðgar responds positively. The third challenge comes from the councillor Unferð (lines 499–606). Although there is no threat of violence, this involves a significant verbal and social challenge to Beowulf's status. Unferð here uses Beowulf's swimming contest with Breca as an example of Beowulf's lack of success. The swimming competition referred to is a testosterone-reducing activity (aerobic exercise), and the challenge itself is a threat to Beowulf's status. In responding to the challenge, Beowulf changes the emphasis to his successful fights with sea-creatures, in addition to the aerobic aspect of the contest (the swimming). Beowulf responds to the challenge from Unferð by issuing a counter-challenge. In Mazur's model, failure to terminate a topic or to respond when given the opportunity is a deferent act in a verbal setting (Mazur 1985: 393). Beowulf thus wins this third verbal challenge.

Other features of the lead-up to the fight with Grendel correspond to testosterone-increasing situations in behavioural studies: the proximity of a reproductively-active female can be seen in Wealhþeow, who serves drink to Beowulf (lines 624ff), addresses him and responds positively to his words (lines 640ff). That she is sexually active is shown by her going to bed with Hroðgar (lines 664–5). Anticipation and preparation for the encounter are also seen (lines 665ff). Although Beowulf prepares himself by disarming, this action still represents a manifestation of the challenge hypothesis, as it represents preparation for an aggressive encounter.

These encounters and features of the setting should increase Beowulf's testosterone levels in preparation for the encounter with Grendel, which he wins (lines 823–4). Unlike the swimming contest with Breca, the fight with Grendel, in which the two struggle with each other (lines 748ff), is resistance exercise, which would further boost testosterone levels in the hero. The change in status is indicated by general recognition that he is the greatest warrior in the world, and worthy of kingship (lines 856–61), the composition of poetry about the hero (lines 871–4) and recognition from Hroðgar, as well as feasting and lavish gifts.

The fight with Grendel and the lead-up to it represent a literary manifestation of situations that cause an increase in testosterone in analogous experimental conditions. The effect of the resulting elevated testosterone levels is seen in the subsequent fight with Grendel's mother. Beowulf at this point starts to show the behavioural effects of the new hormonal levels.

Search persistence, for example, can be seen in Beowulf's willingness to go into very much unknown territory to seek out his opponent, whereas the fight with Grendel occurs on 'home' or at least familiar territory – that of the hall. Hroðgar emphasizes the danger and remoteness of the territory he is to seek out (lines 1357–76), and the risk involved (1379b: *sec gif þu dyrre!* 'seek if you dare!'). There is no clear indication from the poem that Grendel's mother will continue to be a threat to the Danes in the way that Grendel was, only that she sought revenge for her son's death (line 1278). The risk involved is therefore far greater in relation to the benefits than in the case of Grendel, and in general the unknown territory and opponent represent a much bigger risk for Beowulf than the previous encounter. In the encounter itself, we see fearlessness in the face of novelty on the part of Beowulf: his earlier grab-and-rip technique fails, as does the powerful sword Unferð lends him, but in the end Beowulf manages to deal with the monster and wins yet again.

The Winner Effect is seen in the series of territorial and verbal wins followed by the defeat of Grendel and then of Grendel's mother. This sequence of wins dramatically increases Beowulf's status. What happens in the subsequent narrative in some ways represents the destructive extension of Mazur's model. Beowulf does not engage in the behaviours that would normally lower testosterone levels: he does not marry nor father any children, and can thus be read as maintaining youthful – and consequently elevated – testosterone levels into old age. When the dragon attacks in the second part of the poem, Beowulf displays the typical elevated testosterone response: search persistence, appetite for risk, and fearlessness in the face of novelty. There is no pressing need to fight the dragon except for the treasures and for revenge: as with Grendel's mother, there is no indication that the threat from the monster will recur. Beowulf neglects his caring responsibilities towards his people by risking his life for this goal. The result is that he defends too great a territory and takes too big a risk, leading ultimately to his death.

In the sagas of Icelanders, we have a similar setting of a society where status or honour can be gained through competition (cf. Andersson and Miller 1989: 55). An example of Mazur's model as applied to medieval Germanic literature can be seen in the Mávahlíð episode in *Eyrbyggja saga*. This episode is interesting for a range of reasons: the coal-biter trope, the skilful verses recited with the episode, and its general sympathy with opponents of Snorri goði, which goes against the general tendency of the saga. The episode again provides an example of an untested male, Þórarinn svarti, who is explicitly criticised for his unwillingness to engage in aggression and consequent low status. The dispute centres on some missing horses which Þorbjörn digri Ormsson blames on his neighbour Þórarinn. When Þorbjörn first arrives

at Þórarinn's house (chapter 18), he wants to search the premises and then assembles a 'door-court'.<sup>3</sup> There is an obvious territorial threat here, and initially Þórarinn backs down and goes inside. Þórarinn's mother, Geirríðr, incites him to action and he goes out and kills one of the servants in Þorbjörn's party, whereupon Þorbjörn's party leave. This constitutes Þórarinn's first 'win': the killing of the slave and Þorbjörn's withdrawal. After finding out that his wife, Auðr, has lost her hand in the encounter, Þórarinn seeks out Þorbjörn's party. This action manifests search persistence and appetite for risk, both greatly increased since Þórarinn's initial reactions to retreat into the home and avoid conflict. Þórarinn kills Þorbjörn and two of his farmhands, and maims another. Þórarinn returns home and recites a series of verses describing his exploits. By this stage Þórarinn is a changed man, although later in the saga things calm down and he becomes less aggressive again.

Þórarinn's change in behaviour and his success are analogous to Mazur's model. Initially, his intrinsic fighting ability is suspect and his status is low. A territorial challenge (to his farm) and a reproductive threat (the injury to his wife) cause him to become more aggressive, engaging in a competition with his opponent. An initial win and increase in status reinforces what corresponds to increased testosterone in a contemporary environment. This sets him on a path to further aggressive and risk-taking behaviour, and success in subsequent fights, ultimately increasing his status and dominance.

*Njáls saga* is a particularly useful source for finding patterns of behaviour related to these effects, given its interest in masculine behaviour (cf. Ármann Jakobsson 2007), and the balance between aggression and risk. Kári Sölmundarson's vengeance provides an excellent example of Mazur's model. Following the burning of Njáll, Kári's decision to pursue the case against the burners is determined by the social demands of kinship and the death of his young son, Þórðr. The way in which he fulfils the duty of kinship can be described in biosocial terms. Although a successful warrior, Kári initially achieves little in pursuing Flosi, who led the burning. His sleep is disrupted (chapter 132) and he dwells in verse on the harm done to him (chapters 132, 135), behaviours that are consistent with high cortisol levels and correspondingly low testosterone. Things start to turn around when he challenges Mörðr Valgarðsson into giving him support by threatening to remove his wife. Mörðr backs down and offers his support. Later at the Alþingi, matters are fairly balanced with a series of alternate successes and failures in prosecuting the case. When the court case breaks down (chapter 145), battle begins and here Kári starts to accumulate some wins: he kills three, maims another, injures a fifth, causes others to flee; and his supporters force Flosi to turn away and retreat.

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3 References are to chapter numbers in Einar Ólafur Sveinsson 1935.

The following day at the Law Rock he is challenged by Skapti Þóroddsson for fleeing from Njáll at the burning, to which he responds with verses boasting of his successes and mocking Skapti. A verse by Snorri goði reinforces his win in this verbal contest. A complicated settlement ensues. After the assembly, Kári now seeks vengeance further afield (chapter 146), attacking the Sigfússons' party of fifteen with Þorgeirr. Kári kills two, Þorgeirr kills three and they force the survivors to flee. The increased status of Kári is explicitly mentioned: *Pótti monnum Þorgeirr mjök hafa framit sik í þessu ok báðir þeir Kári*, 'People thought that Þorgeirr had greatly increased in status from this, and Kári too' (chapter 146). Kári leaves Þorgeirr, who accepts settlement with the burners, and seeks refuge with Björn hvíti, a man known for his bragging, although his wife is generally unimpressed with him. Björn meets the Sigfússons and says that Kári is afraid of them, increasing their appetite for risk (chapter 149). Björn continues to be criticised by his wife and is unclear about his willingness to fight. They go to find a party of the burners and attack. Kári kills five and wounds another and Björn wounds three, but does not risk himself. Later they are ambushed just after Kári has been sleeping. He kills one and spares Ketill í Mörk. Kári's increased status is articulated by Flosi (chapter 151) and Björn has also increased standing (chapter 152). Kári then leaves Iceland (chapter 154). By this stage Kári's search persistence, appetite for risk and fearlessness in the face of novel situations has increased to such an extent that he goes to Orkney, enters the earl's hall and, alone and surrounded by potential enemies, cuts off Gunnarr Lambason's head (chapter 155). He goes further afield to Wales, where he also decapitates the slanderous burner, Kolr (chapter 158). Finally, he seeks Flosi himself back in Iceland. When Kári enters Flosi's house, Flosi does not behave in the dominant way of the other burners, all of whom attack Kári and his former companions verbally or physically before being attacked themselves by Kári. Instead, Flosi displays deference, by immediately rising to greet Kári and seating him in the high seat. The two are reconciled. Kári marries Flosi's niece and has further children, thus breaking the cycle: marriage and parenthood encourage more cooperative behaviour, and with it comes an end to the risk-taking, travel and aggressive behaviour.

While Kári's intrinsic fighting ability is never in question (except among his enemies), the initial failures at the burning and Alþingi seem likely to disrupt his success. Mazur's model is consistent with his initial failures, his subsequent success and aggressive, risk-taking behaviour, and finally his return to normal life.

Gunnarr Hámundarson shows a more typical trajectory of the saga hero who ends up outlawed or killed: after initial successes in various social, legal and aggressive encounters, especially abroad, the hero returns to Iceland with



elevated status and has trouble settling down to marriage and fatherhood, instead focusing on protecting territory and maintaining status and dominance; the hero responds aggressively to real and perceived threats; he takes on more than he can handle, creating too many enemies and ends up being unable to protect his family and is ultimately killed. Gunnarr is presented as being unaggressive and inclined to seek settlement before violence, but he is sensitive to perceived status threats (cf. van Honk *et al.* 1999) and responds to almost all of them. Gunnarr has a reputation for being slow to respond but strong when he does (*‘Þat mun opt á finnask,’ segir Hildigunnr, ‘at Gunnarr er seinþreyttr til vandræða, en harðdræggr, ef hann má eigi undan komask.’*, “It often turns out,” said Hildigunn, ‘that Gunnar is slow to be drawn into quarrels but hard to tame if he can’t get out of them.’ [chapter 58]). Such behaviour is consistent with studies that show that attack latency, that is, slowness to respond to a threat, is related to increased overall aggressiveness (Oyegbile and Marler 2005: 265), although this may seem counter-intuitive. This overall aggressiveness of Gunnarr’s is seen in the number of deaths and injuries he eventually causes. Gunnarr’s increased status is not sustained and his excessive aggression, effectively predicted by Njáll as killing more than once in the same family and not honouring a settlement (chapter 55), leads to his death. His aggression is in stark contrast to his friend, Njáll Þorgeirsson, who is unwilling to respond aggressively even to explicit status threats.

The actions of Beowulf, Þórarinn, Kári and Gunnar are a consequence of the honour society and can also be described in terms of previous studies of medieval Germanic society: men need to respond to status threats and challenges to protect their reputation and gain honour (although there are plenty of counter-examples, such as Njáll). Their opponents have the same social pressures<sup>4</sup> and respond to the challenges in order to gain or maintain their status. These particular conflicts are asymmetrical in the sense that Beowulf, Þórarinn, Kári and Gunnar greatly increase their status in relation to others through a series of challenges and wins. Mazur’s model provides a nuanced description of these asymmetrical feuds which is consistent with the honour society model.

The interactions of testosterone-related behaviours constitute a detailed means of understanding the hormonal basis of chains of action in these works. The complexity of the relationships, the ability to observe reciprocal cause and effect, and the consistency of incidental details show that it is quite likely that there is not only a parallel here but that the sagas are depicting patterns

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4 The exceptions are the monsters that Beowulf fights, who are outside human society. However, even in these cases, the responses of Grendel’s mother (line 1278b) as well as the dragon (line 2305) are expressed in terms of vengeance for the death of kin or theft.



of behaviour which are consistent with the complex interactions between behaviour, social environment and hormone production, albeit realised in fictional or semi-fictional situations. Although no external reference points exist in the form of measurable hormone levels, the system is complex and internally consistent in terms of the social and behavioural causes and effects of testosterone production. Mazur's model is consistent with features which may in some ways appear unrealistic: the behavioural changes and success of characters with low status and poor initial fighting ability; the excessive risk-taking and fearlessness of characters who have experienced a series of wins; and the behavioural changes in characters that have lived violent lives and later settle down to marriage and parenthood.

Mazur's model can be seen in a number of other literary genres. Romance, in particular, involves a combination of reproductive and physical challenges for the hero: classically, the knight must defeat rivals and win the favour of his lady (for example, in Chrétien de Troyes' *Yvain*). These challenges result in a series of successes leading ultimately to increased status and dominance (for instance, Yvain becomes 'the best knight in the world', lines 2918–19 [Roques 1980: 89]). Marriage and fatherhood often break the cycle and introduce stability, and falling in love can cause a temporary disruption to dominant behaviour (cf. Andreas Capellanus's *De Amore* Book II; Marazziti and Canale 2004). The genre of romance, like that of medieval Germanic literature, constructs social environments that facilitate Mazur's model: a backdrop of territorial instability with the ability of male characters to gain or protect territory and achieve reproductive success in individual encounters. The environments often feature a combination of territorial uncertainty (newly-settled land, large-scale migration, raiding, invasion and so on), social instability (lack of centralized power, increased social mobility), lack of women (because of the population sex ratio or the isolation of a male group), and low productivity of the land, resulting in a highly competitive environment for reproduction. These features are well-documented for Viking-Age Iceland. It is, however, difficult to ascertain these features in *Beowulf*, although the low number of settlement names in contrast with the large number of ethnic and group names in the poem may point to territorial instability.<sup>5</sup> The Migration Age provides the appropriate setting for Mazur's model in other genres

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5 Apart from Heorot, I count only seven citations of settlement names in *Beowulf*: Freslond (lines 1126, 2357), Scedeland/Scedenig (lines 19, 1686), Sweorice (lines 2383, 2495) and Wedermearc (line 298). The other place-names in the poem do not denote settlement, including headlands (Earna Næs, line 3031; Hrones Næs, lines 2805, 3136), a forest (Hrefna Wudu, line 2925; Hrefnes Holt, line 2935), a hill (Hreosna Beorh, line 2477) and a mound (Biowulfes Biorh, line 2807). There are, however, well over a hundred references to ethnic groups in the poem.

such as Arthurian romance as well as the *fornaldarsögur* of medieval Iceland, and similar environments can be reproduced using other pseudo-historical settings such as the Trojan wars, the Viking Age or the American Old West.

There are some caveats at this stage of the research: this is by no means the only way of explaining the literary representation of certain patterns of behaviour, but it does provide a sound way of understanding aggressive behaviour leading to dramatic status increases.

As pointed out earlier, this study is qualitative and identifies particular episodes and sequences of action that fit well to the model and is therefore biased towards literature that supports the argument. In contrast, the experimental studies upon which this analysis is based are quantitative, applying statistical methods to behaviour observed in controlled environments and using random subjects. For this line of research to be pursued effectively with respect to literature, relevant behaviour in a broad sample of the literature will need to be studied using quantitative methods. This involves identifying particular situations where testosterone increases in a character (preparation for challenges, fights, winning or supporting winning in social or violent encounters, the presence of a woman, dream sleep, resistance exercise, among others) or decrease (losing social or violent encounters, status loss, sleep deprivation, falling in love, marrying, becoming a parent, aerobic exercise, among others). It should also examine the behavioural effects of elevated testosterone (including aggressive behaviour, attention to status threats, search persistence, fearlessness, appetite for risk, lack of parental responsibility or caring behaviour, and an increased chance of winning) and could also consider physiological signs of testosterone (such as physical appearance, changes in fitness and strength, balding, and penile problems). Moreover, it should also consider social factors that affect testosterone production and response (for example, stability of social hierarchy, reproductive pressures, availability of women, and territorial threats). Such a study is feasible because these factors are all represented in literature. Statistical methods can then be applied to determine correlations between the apparent causes and effects of testosterone. Such a study would not only enhance our understanding of patterns of behaviour and the relationship between behaviour and social environment in literature, but it may in turn inform our understanding of behavioural endocrinology.

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