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Cognition, endorphins and the literary response to tragedy

I

‘Aristotle asked the question, most famously. Dante did by inference. It was reiterated by Neo-Aristotelians throughout the renaissance. It busied Corneille. Freud made a characteristic stab at it’. Thus George Steiner, reviewing responses to the paradoxical question which provides the title of A.D. Nuttall’s 1996 book, *Why Does Tragedy Give Pleasure?*¹ As a concept, the interaction of pain and pleasure is simultaneously aesthetic, somatic, and emotional. Hume, writing in the eighteenth century, foregrounded the link between these three concepts in his observation that ‘spectators of a well-written tragedy’ are ‘pleased in proportion that they are appalled’.² The etymology of his verb ‘appal’ (from Latin *pallere* into Old French *apalir*: to make pale) acknowledges tragedy’s claim on the body. This is a claim understood by Renaissance dramatists. Hamlet addresses the onstage audience who ‘look pale and tremble at this chance [these accidents] (5.2.334)’.³ In *A Lover’s Complaint* the lover can ‘turn white and sound [=swoon] at tragic shows’ (307–08). In John Ford’s Caroline tragedy, *Love’s Sacrifice* the Duke instructs: ‘let each letter in that tragic sound/Beget a sigh and every sigh a tear’ (5.3.108-09).⁴ All these lines implicitly define tragedy not by its formal properties (Hume’s ‘well-written tragedy’) but by the somatic responses it generates: its power to cause paleness, tremors, tears. In this essay we want to explore spectators’ responses to tragedy by looking at the role played by endorphins, chemicals released by the body to fight pain.

The unexpected coupling of ‘tragedy’ with ‘chemicals’ in the previous sentence reflects the interdisciplinary composition of the seven-person team that co-authored this essay. Com-

prising three psychologists, two classicists and two English literature specialists, we are interested (from a humanities point of view) in what cognitive science can tell us about ancient Greek and early modern tragedy and (from a psychology point of view) in how literary texts can offer a new body of material as case studies for analysis. The link between our disparate interests is practical: laboratory experiments. The humanities researchers are interested in whether certain literary terms and responses can be tested or quantified ('ambiguity', for instance, was the subject of a pilot experiment⁵) and the psychologists are interested in the ecological validity (that is, the real-world applicability) that audience response to drama provides.

In the experiment that provides the material for this essay, we tested the extent to which spectators were pleased/appalled by an emotionally-wrenching film. Although our entry point was science and our method empirical, this is not an article that advocates a scientific approach as the solution to humanities questions. Rather, endorphins for us are a way into thinking about different aspects of audience response that are more and less obviously embodied, and we are as interested in what endorphins do not tell us as in what they do.

We are not the first to investigate the pain-killing effects of tragedy experimentally, although earlier researchers found the very notion that such effects could exist surprising. Experiments conducted in the 1990s to test the clinical potential of comedy films in the fight against chronic pain used tragedy as a control stimulus. Watching comedy provided the expected improvements in pain tolerance; but tragedy also yielded similar improvements, an effect that was as unexpected as it was strong.⁶

Literary scholars have long struggled with the question 'why do we enjoy tragedy?'⁷ The pleasures of comedy are clear, but why we undergo the pain of tragedy remains a conundrum. The reason we hoped endorphins might illuminate this conundrum lies in their two-way relationship with pain. Pain stimulates endorphin release; in turn, endorphins suppress pain sen-

sations and induce a sense of feeling good.⁸ Note that endorphins are triggered not only by pain but also by a range of cultural and social activities such as stroking, dancing, singing, and laughing (most, but not all of which, involve stresses on the body musculature). However, audiences do not typically engage in any of these other endorphin-triggering behaviours whilst watching tragedy, whereas they do typically experience considerable emotional pain. It is well-established that psychological pain and physical pain are two sides of the same coin, even activating the same regions of the brain;⁹ we wanted to test the hypothesis that the mental pain inflicted by watching a tragic film would stimulate the endorphin system in the way physical pain is known to do. If this hypothesis were shown to be true, endorphins could be thought to play a role in the counterintuitive ‘pleasure’ of tragedy.

In November 2014, we showed the made-for-TV film *Stuart: A Life Backwards* (2007) to audiences of students and non-students (169 in total), at Magdalen College, Oxford.¹⁰ Using a physical task (described below) and questionnaires, we measured our subjects’ endorphin activation, their sense of social cohesion, and various dimensions of their affective and intellectual response to the film. We divided our participants into audiences of different sizes to account for the possible effects of group size, both on their sense of bonding and on other aspects of their response.¹¹

Stuart dramatises — backwards — the true story of Stuart Shorter (Tom Hardy), who died in his early thirties living homeless in Cambridge. It is narrated by charity worker and would-be writer Alexander Masters (Benedict Cumberbatch), who becomes Stuart’s biographer and friend, and whose stable life and level personality contrast with the turmoil and extreme suffering which destroy Stuart as a mentally-ill violent criminal, an alcoholic, and a survivor of child abuse. We chose the film for its emotional intensity and its decidedly downward arc: the film’s opening moments strongly imply that Stuart is dead, and that is indeed where the film ends.

But this is equally the story of Alexander, and his journey to be a writer — a journey in which Stuart is crucial. Although Alexander's study, in which he first interviews Stuart, has the visual clichés of a writer's habitat, including scattered papers and pretentiously-titled books (Stuart queries the merit of a book titled *Mauve*: 'How the fuck do they get away with that?'¹²) he has yet to succeed as a writer. Alexander explicitly tells us he has to supplement his income with shifts at a homeless shelter. This is the modern, middle-class variant on the Victorian struggling artist.

The plot in which a struggling or unfulfilled artist is enabled by the suffering and demise of a marginalised figure is a classic tragic trope. Conventionally the doomed muse is female; *Stuart*'s innovation is to make the muse-figure male, and the narrative non-erotic. Stuart is thus identified as tragic twice over, both as the victim of his own biography as an abused, disabled addict, and by his sacrificial function in Alexander's narrative of personal growth. Perhaps nothing encapsulates the tragic nature of the film more urgently than the question 'What murdered the little boy I was?', which Stuart asks of Alexander. Alexander's attempt to answer this biographical question forces us to adjudicate different modes of tragedy throughout the film, wondering if this is a tragedy of inevitability or a tragedy of preventable action (this evaluative interrogation cued the series of questions on attribution in our audience questionnaire, discussed below). Given that all studies of tragic structures attend to causes, the film's backward structure keeps us searching for the originary moment of Stuart's personal tragedy. When Alexander asks Stuart to pinpoint the 'one thing' that he would change if he could, he reinforces this critical impulse to identify a single cause, coincidentally giving his biography of Stuart a narrative neatness.

Although we are invited to identify a single tragic cause, the film offers the audience two distinct points of entry into its narrative world. One is that of the cerebral observer, Alexander, fastidious and emotionally repressed, experiencing the world vicariously and analytical-

ly, unable to cry until the final moments of the film. The other is that of Stuart, the hedonistic and physical animal, instinctive and self-destructive, lacking control or restraint, constantly prey to overwhelming emotions he can barely parse. The split between the two is that between ‘head’ and ‘gut’; this split, and the different ways in which audience members identified with Alexander and Stuart, was a major source of investigative interest to us.

Thus, we chose this film for its classical credentials in structure, a film that would pack the hedonic punch of tragedy to test our hypothesis of endorphins released by mental anguish; this would help us establish if the low brought on by witnessing Stuart’s suffering was compensated for by the high the endorphins offered in return. And we chose this film because its protagonists’ starkly different personalities and attitudes had the potential to cue audience identification in measurably divergent ways.¹³

Using the standard psychological questionnaire to measure positive and negative affect, we asked our audiences to rate their emotional states before and then again after watching the film.¹⁴ As expected, average positive affect scores went down and, by twice the margin, negative affect went up as a result of the experience; and comments audience members made as they walked out told much the same story. Evidently, *Stuart* delivered the punch we were hoping for.

Endorphins cannot be assessed by self-report. Direct testing (requiring PET scans or cerebrospinal fluid samples via lumbar punctures) is invasive, but the effects of endorphins on pain tolerance make change in pain thresholds a suitable proxy for endorphin activation. We adopted a wall-sit skiing exercise from a number of earlier studies.¹⁵ ‘Sitting’ against a wall without the support of a chair is initially easy, but leads to a painful burning sensation in the thighs sooner or later, depending on one’s levels of fitness. We asked our participants to hold the wall-sit position for as long as possible, both before and after watching the film, interpreting the change in time achieved as a proxy for the level of endorphin activation.¹⁶

We found that participants were indeed able to hold the position longer afterwards, by a statistically significant average difference of six seconds – a 13% increase.¹⁷ As we discuss more fully below, not all our subjects showed a positive change, with some indeed showing a negative change; for the 73 out of 123 participants (62 per cent) for whom the film did trigger endorphin release the average increase was 21 seconds – a 25% increase). We also conducted a control condition of this experiment using 90 minutes of natural history documentaries. The video content was chosen to encourage a hedonically neutral state in the viewer, to check whether merely watching content as a group automatically triggered endorphin activation or increased wall-sit time. It did not.¹⁸ Therefore, the pain-killing effects created by *Stuart* must have been triggered by the specific content of the film. This evidence, then, gives weight to our original hypothesis: the tragedy of *Stuart* does indeed seem to be providing an endorphin kick for its audience.

[FIGURE 1 HERE]

[FIGURE 1 CAPTION]

This sketch of the role of endorphins in our audiences' responses is nuanced by two other results. First is the sense of being part of a group. The aim of our experiment was not only to understand better why we enjoy tragedy, but also why we regularly do so *together*. The endorphin system is, crucially, not just about pain tolerance and a sense of feeling good: in primates and humans it is central to social bonding and plays a crucial mediating role in creating cohesive, affective relationships.¹⁹ Given these group-bonding effects related to endorphins, we wondered if the painful, endorphin-releasing experience of tragedy would, in a group setting, also give rise to an enhanced sense of bonding. If so, this could perhaps explain another aspect of tragedy's appeal to audiences. Incidentally, other recent research has explored the

related question of how engaging with fictional narratives promotes pro-social feelings such as empathy; however, such research tends to concern reading, a solitary activity, and so is not directly transferrable to audience study.²⁰

Again using a standard questionnaire, viewers were asked how connected they felt to those around them, first before and then after the film.²¹ Unsurprisingly, on average, their sense of belonging (social bonding) increased significantly as a result of the shared experience of watching a tragedy (but not for documentary). More strikingly, within the 62 per cent of our tragedy audience who showed endorphin activation, the amount of increase in social bonding was directly correlated to the increase in their pain tolerance. The more endorphin release they experienced, the more connected to the group they felt; or, the more connected to the group they felt, the more endorphin release they experienced. (Correlations are inherently direction-neutral, and do not tell us which element in a relationship is a cause and which is an effect. However, there is no previous evidence that social bonding, per se, can trigger endorphins, whereas there are some indications that endorphins may trigger social bonding, suggesting the latter causative explanation.)²² Such changes in social bonding operated, incidentally, wholly independently from the actual size of the group. Again, in contrast to our audiences for *Stuart*, participants who viewed emotionally-neutral content for a similar length of time reported no increase in social bonding, despite participants in both viewing conditions reporting similar initial levels of social bonding. Thus, we can be confident that our results reflect the specific content of *Stuart*.

The correlation between endorphin release and social bonding says something important about the psychology of spectating. There is a frequently-articulated intuition that shared watching lends an important group dimension to seeing a film or play. Our results underline that intuition with data, and suggest that the endorphin system is involved in this process.

Moreover, our results suggest that this group dimension is experienced more acutely by those who have a greater endorphin kick.

A second piece of data enables us to fine-tune what we mean when we say people derive ‘pleasure’ from tragedy. We asked our audiences several questions about their enjoyment of the film, but only one of these turned out to be significantly correlated with the wall-sit test (pain threshold) data: ‘Given the opportunity, I would watch this film again’ (rated, like most of our questions, on a seven-point scale, ranging from ‘strongly disagree’ to ‘strongly agree’). The link between people’s desire to repeat the experience of watching *Stuart* and their endorphin release arguably points to the feel-good factor with which endorphins ‘reward’ us. In the *Stuart* viewing, the feel-good factor experienced by the audience looks heavily tempered by the profound suffering the film depicts. This, we presume, is why we found no correlation between endorphin activation and a more direct enjoyment question, ‘I enjoyed the film very much’. This is empirically different from Hume’s conjecture of a direct correlation between spectators’ pain and pleasure: ‘they are pleased in proportion that they are appalled’. The endorphin experience is one our audiences felt worth repeating, but not one they would necessarily label ‘enjoyment’. Although watching Stuart’s suffering is not enjoyable *in the same way* as laughing or singing, and in fact creates pain for which the endorphins act as painkiller, the ‘reward’ of endorphins means that, like thrill-seekers leaving a rollercoaster which has terrified us, we still want to ‘go round again’.

The corollary of our experiment, therefore, is that the experience that Aristotle termed *catharsis* may have an identifiable physiological component (and it is a satisfying coincidence that one of the major strands of scholarship on the matter of what Aristotle may have meant when he spoke of ‘purgation/purification’ is itself somatic in emphasis).²³ The painful experience of watching tragedy stimulates the endorphin system, which then gives one a sense of

euphoria that mingles with the intense pain to create the paradoxical phenomenon that we think of as the pleasure of tragedy.

II

In our study, the endorphin rush did not appear to happen for everybody. This is what one would expect: individuals have different densities of endorphin receptors, and so respond to endorphin release differently.²⁴ Individuals also respond differently, of course, to dramatic works. But it is a reminder, if one were needed, that a focus on endorphins will only capture limited facets of the psychological effect of tragedy. The idea that a one-factor model, physiological or otherwise, might do justice to the complexity of literary response is extremely dubious. In this second part of the article we will therefore discuss some dimensions of our viewers' reactions that did not correlate to wall-sit test times, operating with apparent independence from the physiological effects we observed, before returning to endorphins in the third and final section to assess what this might mean.

Perhaps the most striking large-scale pattern in our data is this: while wall-sit test times correlate to the wish to see the film again, and (for those for whom they went up) to social bonding, they do not correlate to anything else in our data. This is despite the fact that many other types of response correlate to one another. Figure 2 represents the 'central engine' of our audiences' response — a range of affective and experiential factors which are, in our data, heavily interconnected.

[FIGURE 2 HERE]

[FIGURE 2 CAPTION.]

Our central engine appears to be built up from several interlocking sub-systems, as illustrated by the various ‘triangles’ in Figure 2 (for instance, transportation-negative affect-identification or transportation-positive affect-enjoyment).²⁵ The diagram is simply an overview, drawing out the relationships between cognitive phenomena that are operating while audience members are watching the drama, processes that may be complexly reliant upon each other. To look at these statistical relationships in more depth, we shall focus in turn on three areas: social bonding, identification with characters (including a discussion of audience members’ attribution styles), and finally, transportation.

Social bonding (and group size)

Our participants’ sense of being part of a group, as we saw in part I, went up as a result of watching the film, in step with endorphin release. What Figure 1 now shows is that the change in a viewer’s social bonding after watching the film is correlated to various other dimensions of their overall experience. The more our viewers felt connected to other viewers, the more positive they felt and the more they identified with both Alexander and Stuart -- all three factors rising in tandem with each other.²⁶

The importance of social bonding confirmed what we expected (though it is useful to see how this dimension is interwoven with the broader response to the film). What took us by surprise is that the same does not hold for group size. As mentioned above, we showed the film to audiences of different sizes, in the expectation that viewers in larger groups would have an enhanced experience. We found that only social bonding was multiply correlated, whereas group size was statistically inert: it made no difference to our participants whether they were almost alone in the auditorium, or part of a crowd. Our conclusion must be that the decisive factor was the *subjective* sense of connectedness rather than the *objective* numbers. We cannot draw far-reaching conclusions from this about the experience of cinema-going (let alone theatre-going), yet our data provide some indications that the communality of film

watching is something that can and must be generated in the audience's heads rather than something that is determined at the box office.²⁷

Identification and attribution

Using another well-established scale, we asked our participants to rate the way they related to Alexander and (separately) to Stuart through assessment of five statements, such as 'While viewing, I felt like Alexander felt'.²⁸ We thus arrived at a composite score for their emotional and cognitive perspective-taking, in short their 'identification' with each of the two characters. Like social bonding, identification is a node in the web of connected responses. The fairly strong correlations with (all) our enjoyment items says something important about the way we watch a film like *Stuart*: to paraphrase Hume, we enjoy the film in proportion that we identify with the characters. As mentioned, correlations cannot reveal the direction of the flow, but it seems plausible that the causal chain is from identification to enjoyment: the more appealing, believable and relevant we find the characters the more we enjoy the film.

The connection of identification to emotional state is slightly weaker statistically, but makes up for that with its interesting complexity. Identification with either character (Stuart or Alexander) is most strongly linked to negative emotion ('negative affect').²⁹ It might be tempting to interpret this as suggesting that negative affect is the 'hotline' to identification — that your sympathies are most conjured up, your perspective most tightly bonded to a character, when s/he is undergoing brutal emotional experiences. In a film in which characters continually suffer (Stuart's grandmother's defining line is the emphatic 'That boy has suffered'), strong identification will inescapably be a matter of feeling distressed, upset, scared, nervous and afraid (the negative half of the standard emotions questionnaire that we used) more than of feeling excited, enthusiastic, alert, inspired and determined (the positive half). Affect scores for a romantic comedy, for example, may well look very different, and a comparative study would help identify the key factors behind such differences. The powerful effect of

negative emotions certainly rings true for tragedy: the experience of having one's emotions pushed to the limits by the suffering on display is one with which every cinema- and theatre-goer is familiar, and it often comes with the sense of undergoing vicariously a character's sufferings.

So far so bleak, but it would be a mistake to ignore the (less strong) relationship between identification and positive affect.³⁰ Uplifting moments do occur in *Stuart*, based on the recurrent trope of the incongruous protégé who punctures Alexander's fastidiousness, or the genuine benefits each brings to the other's life, however temporarily. Stuart and Alexander share cooking, car journeys, political protests and a weekend away. Each visits the other's domestic space, and we see them make each other laugh. The link between spectators' positive affect and identification suggests that such moments in the film perform an important function by making the emotional onslaught bearable, creating breathing spaces, and ultimately pulling the audience in. Without such 'crumbs of comfort' the risk would be that viewers shut themselves off in a form of self-protection. The correlations show that viewers who are immune to these more positive moments enjoy the film less, are less 'transported' by it, and — our point here — identify less with the main characters.³¹

Irrespective of genre and irrespective of the balance between upbeat and downbeat elements in the film, the nature of the causal chain repays some thought. Arguably, the relationship between identification and affect constitutes a symbiosis rather than operating in just one direction. As we make a character's perspective our own, we allow ourselves to be affected by their emotions. Their fate is now ours. But equally, as our emotional state begins to mirror theirs more closely, we are likely to identify with them more strongly. Identification (we speculate) generates emotion generates identification generates emotion.

Our understanding of the viewers' attitude to the characters becomes more fine-grained as one goes beyond identification and takes into consideration what psychologists term 'attribu-

tion'. Attribution is concerned with how people explain actions and events: to what type of factor they 'attribute' what happened.³² The standard model, which we followed, distinguishes between dispositional explanations — that is, factors originating from within a person themselves, their personality, ability or beliefs — and external explanations; the latter in turn divide into external situational and external personal explanations.

We asked participants to rate their agreement with different ways of answering a fundamental question of the film, which Stuart himself asks of Alexander: what went wrong in Stuart's life?, or in Stuart's own language, 'What murdered the little boy I was?'. We offered three accounts of this central tragic question, each representing a different attributional model, and in essence a different 'kind' of tragedy.

(1) 'Stuart is responsible for his own situation and behaviour. His own actions, choices and personal weaknesses — for alcohol, drugs, violence and criminality — got him where he is'.

(2) 'No-one is directly responsible for Stuart's situation and behaviour. It was caused by factors — his muscular dystrophy, family breakdown, mental illness and homelessness — that were out of anyone's control'.

(3) 'Stuart's situation and behaviour were a direct result of him having been abused by other people — sexual abuse by his brother and in care, bullying by other kids, assault in prison, and repeatedly being on the receiving end of a brutalising system'.

Of these, Option 1 is a dispositional attribution. Fundamentally, it's Stuart's own fault. Options 2 and 3 by contrast are external explanations, situational and personal, respectively. They both look beyond Stuart for causes.

[FIGURE 3 HERE]

FIGURE 3 CAPTION]

A participant's response to these three options is an expression of his/her mode of attribution. What makes this exercise meaningful is that it turns out that attributional mode is not self-contained but relates to our participants' experience of the film more widely. As Figure 3 shows, two opposed tendencies stand out from the data. The more people blamed Stuart for his own misfortune (dispositional explanation), the *less* likely they were to identify with either Stuart or Alexander, to be transported, to experience positive emotion (or indeed indicate any kind of emotional affect), and to recommend the film to friends. By contrast, those respondents who were more inclined to blame others (external personal attribution) were also *more* likely to rate highly for identification with Alexander, for negative emotion, for transportation, and for willingness to recommend the movie to a friend. When respondents were asked whether Stuart's childhood experiences excuse his adult behaviour, a similar split between those with a dispositional attribution response or an external personal response came into play. In short, if you took Stuart's side, your experience of the film was thoroughly different.

At this point, the now familiar question of the causal direction rears its head. Is it that the film has failed for you on all these various dimensions, and you have therefore become more judgmental of Stuart? And that if it is working for you, you have ended up believing that he is an innocent victim? Or, vice versa, does everything start from your judgement of guilt and attribution, which in turn affects your enjoyment, your emotions and the way you identify with the characters? Such questions cannot be answered on our evidence, but what the clusters of correlated and mutually opposed responses point to is the role of individual differences. A viewer's personal make-up — instincts, experiences, preferences — comes through when judging an extreme situation and extreme character such as Stuart's.³³ Subjectivity is a commonplace of criticism. The significant contribution that an empirical approach can make is both to justify the commonplace and to show that moral judgment is by no means isolated

from other responses. Arguably, there is no genre for which this is more true than tragedy, which so obsessively pushes audiences (and critics) into responding to events that are morally complex at the same time as being all-consuming emotionally.

Transportation

Finally, we should unpack the term ‘transportation’, which we have used several times. This is one of a number of terms that employ movement to describe the experience of entering fictional worlds. Lay expressions such as ‘I felt like I was there’, ‘I was immersed’, ‘I lost myself in the story’ (and indeed ‘entering fictional worlds’) all reflect the natural instinct to use kinetic metaphors to conceptualise deep engagement with fiction. Even so, the challenge of finding one definitive term remains. Expressions referring to the same basic concept can contradict each other, as is demonstrated by ‘suspension of disbelief’ vs. ‘make-believe’.

Our choice of ‘transportation’ (rather than, for instance, ‘immersion’) was driven by the very considerable body of empirical work that has operated under this heading.³⁴ Even though the term originates in the humanities,³⁵ it was soon adopted by other disciplines, not least consumer research, as advertisers seized on transportation as one factor that drives the success of an ad (where success is defined as the viewer’s willingness to buy the product). In the process, a term that was rather broad and suggestive in the first place became even broader. The standard questionnaire used in transportation research, adopted by us and adapted for film, asks viewers to rate statements as diverse as ‘While viewing the film, I felt as though I was right there, in the action’, ‘The film affected me emotionally’, and ‘After the film finished, I found it easy to put it out of my mind’.

The broadness of the transportation measure goes some way towards explaining the pervasive role it plays in our data. Figure 2 presents only a subset of the many correlations with transportation that we found, correlations which were also strong and statistically significant.

If our audience members rated their experience highly on the transportation scale, they were also much more likely to enjoy the film, identify with the characters, experience emotions (both negative and positive), adopt certain attributional explanations over others (as we have seen), and so forth. There are few measures in our data, in fact, that are *not* correlated to transportation.

We share many of the concerns voiced in recent, critical studies of the existing literature on transportation.³⁶ The concept can seem vague and perhaps too broad, coming precariously close to a catch-all term for engagement with a narrative — of it simply ‘working’ for you. However, there are reasons not to reject the concept outright. Statistically, the transportation scale does (for all its connections) behave like an independent scale with internal consistency and outward discrimination.³⁷ The transportation scale gets at ‘something’, however poorly defined, fundamental to spectatorship and closely-related to many other aspects of that experience.

However, there is one prominent measure to which transportation is not related: change in pain tolerance. In that sense, the transportation measure is emblematic of the larger story of this section: of the many interconnections between our audiences’ responses, some were expected, others thought-provoking, but all of them throw the absence of endorphins from the discussion into relief.

III

Our discussion must return therefore to endorphins. The question before us in this final section is how to account for the fact that endorphins, despite their apparent importance for the effect of the film on our audience (Part I), do not form part of the otherwise closely interwoven texture of responses in Figure 1 (Part II). We offer two contrasting explanations, each of them plausible as well as productive. Further work will be needed to decide between them.

The first, most obvious hypothesis is that there are two separate systems. In this hypothesis, endorphins have a crucial role to play, but this role, clearly, is circumscribed. They are linked to, and may indeed create (in many, though not all, viewers) a sense of togetherness, and crucially they give an uplift that makes viewers want to repeat the experience despite having been put through the wringer. And then there is a separate system of interconnected responses — the more ‘literary’ ones — in which endorphins appear to play no role. It is important to realise that this is not a matter of viewers using only one or the other system. The two systems operate in concert rather than in alternation, as individuals can have both an endorphin rush and, for example, identify strongly with the characters — many of them do. It is just that there appears to be no systematic or causal connection between the two.³⁸

This hypothesis both fits the data and permits one to speak with some precision about the role of endorphins. Moreover, one can speculatively make sense of the specific effects that we found for endorphins in terms of what is known about their effects in general. Since endorphins help determine our experience of pain, well-being, and togetherness, but do not seem to directly govern more narrowly cognitive functions, it makes sense that we do not find them to have an impact on responses to individual characters or transportation.³⁹ To overstate the case, endorphins have a lot to do with how we feel as we sit in the auditorium, but little to do with how we relate to the story on the screen. The strain from watching a distressing film activates the endorphin system, but beyond that endorphins regulate our sense of well-being in the real world (and, hence, the relationships we have with those with whom we share the experience), not the nature of the individual’s engagement with the fictional world.

In an alternative (but not mutually exclusive) hypothesis, there may indeed be connections between cognitive response and endorphin effects, albeit too modest to be picked up properly in our study. We certainly found some indications that the two-systems model may be too stark. When one reintroduces the split (as in part I) of our participants into those (62

per cent) whose wall-sit times increased and those (38 per cent) whose times decreased, and compares the correlations one finds within each of the two sub-groups, something intriguing emerges with respect to identification. For the group who had no endorphin increase, identification with Alexander was much more heavily correlated to other, especially experience-related, factors than for the group who did experience endorphin increase. By contrast, for audience members who had an increase in wall-sit test time, identification with Stuart was correlated more widely than for those who didn't.⁴⁰ In roundabout terms, this suggests that Stuart was more strongly keyed into the viewing experience of those who showed endorphin effects, while Alexander 'mattered' more for those who didn't. Since Stuart is the more impulsive and volatile character of the two, it is tempting to posit an endorphin-related distinction in our volunteers between 'head' and 'gut' people — between the cerebral, disembodied Alexanders of the world, and the instinctive, visceral Stuarts — and this might credibly be related to their endorphin response. There isn't enough here to tie endorphins conclusively to our viewers' broader literary response, but there is too much to dismiss it as mere noise.

The possibility that endorphins play a larger role than our data suggest is supported by consideration of the broad proxy measure we employed to measure endorphin levels. Like previous studies, we have treated the wall-sit test as determined solely by a physiological factor — endorphins. However, there may also be cognitive and emotional factors at play. Holding a painful position is a matter not just of physiology but also of willpower, and it is perfectly possible that *Stuart* affected people's ability or determination to push themselves to the limit in a physical exercise. This can go in two directions: a net increase in pain tolerance because of overall endorphin release, or a net decrease in pain tolerance because of film-induced negative mood, and consequent sapping of motivation.⁴¹ In fact, any increase would suggest that the film had a stronger endorphin effect than the wall-sit times at first suggest, because the overall endorphin effect was still present even after this putative lowering of

willpower. It is possible therefore that *all* participants experienced an endorphin effect, but that for a subset it was masked by the negative willpower effect. Although the wall-sit test is obviously noisy (i.e. imprecise), this does not invalidate it: the statistical tests compensate for this to the best of science's ability.

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The situatedness we have discussed encompasses different levels of embodiment. Simply put, the first is a base system of endorphin reaction. The second is complexly cognitive, encompassing items as diverse as factual recall and emotional identification with characters. The third is social, both within the auditorium (social bonding) and in the attributional decisions the viewer makes about the social world of the film.

The traditional approach to tragedy, for very good reasons, looks at the formal properties of the text. Byron's canonical, if now clichéd, observation that 'All tragedies are finished by a death' (*Don Juan* III, 9, 1) is one of the simplest (and, from the viewpoint of Greek tragedy, hugely over-simplified) approaches to tragic structure. But the frequency with which recent criticism poses the question 'Can tragedy still be written?' indicates that much more than dramaturgy is at stake.⁴² We are not the first to look instead at audiences of tragedy: Raymond Williams argued as early as 1966 that tragedy should be defined by its identifiable effect on people.⁴³ Our central engine attempts to map those effects. The obvious question is whether this central engine is generalizable beyond *Stuart*. It may be that the map documents how viewers experience and interpret *this* specific tragedy and its operations, but we suspect that some of the engine's affective and interpretative elements are indeed applicable elsewhere. Endorphins, as we have argued, are certainly not the only ingredient in audience response to tragedy. But, as mentioned in Part I, studies of how comedy releases endorphins

also indicated — unexpectedly — tragedy’s similar effect: by extending that work, we have provided here a case study for endorphins in tragedy.

The traditional approach to tragedy, again for very good reasons, also tends to talk about spectators collectively: the ‘audience’. Our methodology revealed, perhaps unsurprisingly, variations in audience somatic and affective response: the ‘audience’ is Hydra-headed. Earlier in this article we suggested that *Stuart* forces us to consider what kind of tragedy it is. Our audiences’ attributional responses indicated that that question was only answerable on an individual level. Taking Stuart’s side, for example, turned the film into a tragedy of circumstance, and had correlations with other key aspects of the individual viewer experience. As has been clear throughout, endorphins have one important function to play (delivering the compensatory opioid high for the pain of suffering) but are not related to other interpretative responses.

Unsurprisingly, endogenous morphine has not been part of the critical armoury from Aristotle onwards — endorphins were only discovered in 1974.⁴⁴ But the vocabulary of critics, ancient and modern, instinctively situates reaction to tragedy in the body as well as the mind, and the history of theatre audiences memorialises extreme bodily responses. An ancient biography of Aeschylus claims that children fainted and women suffered miscarriages when seeing the Furies in *Eumenides*; ‘trustworthy reports’ offer a surprising parallel in Hamburg in 1776, detailing how audience members swooned and women miscarried at a performance of *Othello* (the play was subsequently rewritten to provide a happy ending).⁴⁵ Writing a commendatory poem in the Beaumont and Fletcher First Folio, ‘T. Palmer’ recalls how theatre spectators were so involved in the dramatic fiction that they intervened in the action: ‘how often did I know / When the spectators ran to save the blow’.⁴⁶ These are not just headline-grabbing anomalies — they are the somatic continuum on which all spectators of tragedy exist.

¹ George Steiner, 'Agony and the Ecstasy', *Times Higher Education Supplement*, 26 July 1996; c.f. also Eva Maria Emy Koopman, 'Empathic Reactions After Reading: The Role of Genre, Personal Factors and Affective Responses', *Poetics*, 50 (2015), pp. 62–79, and 'Why do we read sad books? Eudaimonic motives and meta-emotions', *Poetics*, 52 (2015), pp. 18–31.

² David Hume, *Essays, Moral, Political, and Literary*, ed. Eugene F. Miller (Indianapolis 1987 [1758]), p. 218.

³ All Shakespeare quotations are from *The Riverside Shakespeare*, gen. ed. G. Blakemore Evans (Boston 1974).

⁴ John Ford, *Love's Sacrifice* ed. A. T. Moore (Manchester 2002).

⁵ Felix Budelmann, Laurie Maguire and Ben Teasdale, 'Ambiguity and Audience Response', *Arion: A Journal of Humanities and the Classics*, 23: 3 (2016), pp. 89-114.

⁶ Dolf Zillmann, Steve Rockwell, Karla Schweitzer, and S. Shyam Sundar, 'Does Humor Facilitate Coping with Physical Discomfort?', *Motivation and Emotion*, 17 (1993), pp. 1–21:17. Other studies replicated the results, if sometimes inconclusively: e.g. James Weaver and Dolf Zillman, 'Effect of Humor and Tragedy on Discomfort Tolerance', *Perceptual and Motor Skills*, 78 (1994), pp. 632–4; Minet de Wied, Dolf Zillmann, and Virginia Ordman, 'The Role of Empathic Distress in the Enjoyment of Cinematic Tragedy', *Poetics*, 23 (1995), pp. 91–106; Dolf Zillmann, Minet de Wied, Cynthia King-Jablonski, and Stefan Jenzowsky 1996 'Drama-induced Affect and Pain Sensitivity', *Psychosomatic Medicine*, 58:4, Jul-Aug (1996), pp. 333-41; Matisyohu Weisenberg, Tal Raz and Tamar Hener, 'The Influence of Film-induced Mood on Pain Perception', *Pain*, 76 (1998), pp. 365–75.

⁷ For a sample, see A.D. Nuttall, *Why Does Tragedy Give Pleasure?* (Oxford 1996), Sarah Dewar-Watson *Tragedy* (Basingstoke 2014), pp. 96-110, Michael R. Trimble, *Why Humans*

Like to Cry: Tragedy, Evolution, and the Brain (Oxford 2012).

⁸ Endorphins belong to a family of neuropeptides that act as neurotransmitters in the brain.

As natural opioids closely related chemically to morphine and opium, they both act as an analgesic, suppressing pain sensations, and create a light opiate ‘high’. The name is an abbreviation of endo(genous mor)phin(e) – morphine produced from within the body.

⁹ A review of the literature can be found in Geoff MacDonald and Mark R. Leary, ‘Why Does Social Exclusion Hurt? The Relationship Between Social and Physical Pain’, *Psychological Bulletin*, 131 (2005), pp. 202–23; for neuroimaging experiment see, for example, Ethan Kross, Marc G. Berman, Walter Mischel, Edward E. Smith and Tor D. Wager, ‘Social Rejection Shares Somatosensory Representations with Physical Pain’, *Proceedings of the National Academy of Sciences of the United States of America*, 108 (2011), pp. 6270–5 and Esther L. Meerwijk, Judith M. Ford, and Sandra J. Weiss, ‘Brain Regions Associated with Psychological Pain: Implications for a Neural Network and its Relationship to Physical Pain’, *Brain Imaging and Behavior*, 7 (2013), pp.1–14.

¹⁰ 101 were female, 66 male; two respondents declined to specify their gender. Gender played a negligible role in our results. Very few of our respondents had seen the film or read the book on which it is based (Alexander Masters, *Stuart: A Life Backwards* (London 2005). The film was directed by David Attwood and produced by Neal Street Productions, Knifedge, BBC and HBO. Our thanks to Neal Street Productions for permission to use the film. The questionnaire we used is available at ORA [####](#). For more detailed exploration of the experiment’s conclusions about endorphins, see Robin I. M. Dunbar, Ben Teasdale, Jackie Thompson, Felix Budelmann, Sophie Duncan, Evert van Emde Boas and Laurie Maguire, ‘Emotional Arousal when Watching Drama Increases Pain Threshold and Social Bonding’, *Royal Soci-*

¹¹ There were groups of three sizes: small (2-5), medium (9-18) and large (43-49). The variation within the groups was due to irregular attendance by volunteers who had signed up.

¹² *Mauve* is a biography of William Perkin, the scientist who ‘invented’ the colour (Simon Garfield, *Mauve: How One Man Invented a Color That Changed the World* (New York 2001)).

¹³ For the purpose of this study we were, then, less interested in specifically ‘cinematic’ aspects of the film (e.g. cinematography, shot length, sound effects, music). We are well aware that a study by professional film scholars might have been very different. Within film studies, promising work in the area of (situated) cognition has been done under the aegis of the *Society for the Cognitive Study of the Moving Image* (<http://scsmi-online.org>).

¹⁴ We used a short form of the Positive and Negative Affect Scale (PANAS; see David Watson, Lee Anna Clark and Auke Tellegen, ‘Development and Validation of Brief Measures of Positive and Negative Affect: the PANAS scales’, *Journal of Personality and Social Psychology*, 54 (1988), pp. 1063–70; short-form: Andrew MacKinnon, Anthony F. Jorm, Helen Christensen, Ailsa E. Korten, Patricia A. Jacomb and Bryan Rodgers, ‘A Short Form of the Positive and Negative Affect Schedule: Evaluation of Factorial Validity and Invariance Across Demographic Variables in a Community Sample’, *Personality and Individual Differences*, 27 (1999), pp. 405–16. Subjects answer a series of questions about their current feelings on 7-point scales, and these are summed to yield separate composite scores for positive and negative affect. Psychology considers positive and negative emotions to be best modeled as two independent dimensions that can vary on their own, rather than being two extreme ends of a single scale.

¹⁵ Elainie A. Madsen, Richard J. Tunney, George Fieldman, Henry C. Plotkin, Robin I.M.

Dunbar, Jean-Marie Richardson, and David McFarland, 'Kinship and altruism: a cross-cultural experimental study', *British Journal of Psychology*, 98 (2007), pp. 339-59,

Freya Harrison, 'Strength of Social Tie Predicts Cooperative Investment in a Human Social Network', *PLoS ONE*, 6.3 (2011), e18338. The 'sitting' posture is also that of the downhill skier, hence the test's two names: wall-sit test or ski-test.

¹⁶ 123 viewers at the various showings of *Stuart* (72.8 per cent of the total) performed the physical task. All participants in small and medium groups were tested. Because administering the wall-sit test is time-consuming, we sampled only half our participants (chosen at random) from large groups, rather than cause unnecessary delays for everyone. The second trial was administered ca. ten minutes after the film ended (upon completion of the questionnaire).

¹⁷ Mean before watching: 1 minute, 17 seconds; mean after watching: 1 minute, 23 seconds.

¹⁸ Times overall decreased by 2 seconds (a non-significant difference) from 1 minute 23 seconds to 1 minute 21 seconds. There were 67 participants, in 4 groups of between 13 and 20 viewers. Similar control conditions were used in Zillmann et al, 'Does Humor Facilitate Coping', Zillmann et al, 'Drama-induced Affect', Weaver and Zillman, 'Effect of Humor', Weisenberg et al. 'The Influence of Film-induced Mood', and Robin I. M. Dunbar, Rebecca Baron, Anna Frangou, Eiluned Pearce, Edwin J.C. van Leeuwen, Julie Stow, Giselle Partridge, Ian MacDonald, Vincent Barra and Mark van Vugt, 'Social Laughter is Correlated with an Elevated Pain Threshold', *Proceedings of the Royal Society B: Biological Sciences*, 279 (2012), pp. 1161–7.

¹⁹ Cf. Anna J. Machin and Robin I. M. Dunbar, 'The Brain Opioid Theory of Social Attachment: A Review of the Evidence', *Behaviour*, 148 (2011), pp. 985–1025 and Lauri Nummenmaa, Sandra Manninen, Lauri Tuominen, Jussi Hirvonen, Kari K. Kalliokoski, Pirjo Nuutila, Iiro P. Jääskeläinen, Riitta Hari, Robin I. M. Dunbar and Mikko Sams, 'Adult

Attachment Style is Associated with Cerebral μ -Opioid Receptor Availability in Humans', *Human Brain Mapping*, 36 (2015), pp. 3621–8. Endorphins have, accordingly, been shown to be elicited by a number of social activities, such as singing, making music, dancing, and laughing: cf. e.g. Dunbar et al, 'Social Laughter', Robin I.M. Dunbar, Ian MacDonald, Kostas Kaskatis, and Vincent Barra, 'Performance of Music Elevates Pain Threshold and Positive Affect: Implications for the Evolutionary Function of Music', *Evolutionary Psychology*, 10.4 (2012), pp. 688–702, Eiluned Pearce, Jacques Launay, and Robin I. M. Dunbar, 'The Ice-Breaker Effect: Singing Mediates Fast Social Bonding', *Royal Society Open Science*, 28 (October 2015), DOI: 10.1098/rsos.150221, Daniel Weinstein, Jacques Launay, Eiluned Pearce, Robin I. M. Dunbar, and Lauren Stewart, 'Music, Endorphins, and Social Connections: The Effect of Singing in Small and Large Groups', *Evolution and Human Behavior*, 37: 2 (2016), pp. 152–158.

²⁰ For a review of the literature on readers of fiction, see Eva Maria Emy Koopman and Frank Hakemulder, 'Effects of Literature on Empathy and Self-Reflection: A Theoretical-Empirical Framework', *Journal of Literary Theory*, 9.1 (2015), pp. 79-111.

²¹ The Inclusion-of-Other-in-Self scale (IOS, Arthur Aron, 'Inclusion of Other in the Self Scale and the Structure of Interpersonal Closeness', *Journal of Personality and Social Psychology*, 63 (1992), pp. 596–612). This scale invites the subject to rate their sense of inclusion, or submersion, in another individual or group, by selecting one from seven pairs of circles that become progressively overlapped.

²² See Dunbar et al, 'Emotional Arousal', p. 8.

²³ For an overview of interpretations of the term, cf. Stephen J. Halliwell, *Aristotle's Poetics*, 2nd ed. (Chicago 1998), appendix 5 (with p. xi).

²⁴ Nummenmaa et al.

²⁵ For the statistically-minded, the arrows are significant ($p < .05$ two-tailed) Pearson's r correlations, with the thinnest arrows showing $r < .3$, the medium arrows r between $.3$ and $.5$, and the thickest arrow $r > .5$.

²⁶ These correlations become greater in number when the variable considered is not *change* in social bonding but social bonding *after watching* (which is necessarily dependent not only on the effects of the viewing experience but also on the level of social bonding with which our audience members came into the experiment): in this case social bonding is not only significantly correlated with positive affect and identification, but also with transportation.

²⁷ Many other factors will be involved in determining how 'communal' a cinematic experience feels: dispersal of the audience (ours was forced to sit together), familiarity with other audience members (few of our respondents knew others), venue capacity, light, sound, film content, etc. For further discussion of the factors involved in 'collective spectatorship', see e.g. Julian Hanich, 'Watching a Film with Others: Towards a Theory of Collective Spectatorship', *Screen*, 55 (2014), pp. 338–59.

²⁸ We used the scale developed in Jonathan Cohen, 'Defining Identification: A Theoretical Look at the Identification of Audiences With Media Characters', *Mass Communication and Society*, 4 (2001), pp. 245–64.. For discussion of how this measure relates to those of transportation and enjoyment, see Nurit Tal-Or and Jonathan Cohen, 'Understanding audience involvement: Conceptualizing and manipulating identification and transportation', *Poetics*, 38 (2010), pp. 402–18.

²⁹ Work on how negative emotional valence heightens theory of mind responses has been done by Ulrike Altmann, Isabel C. Bohrn, Oliver Lubrich, Winfried Menninghaus and Arthur

M. Jacobs, 'The Power of Emotional Valence: From Cognitive to Affective Processes in Reading', *Frontiers in Human Neuroscience*, 6 (2012), art. 192.

³⁰ Identification is significantly correlated with levels of positive affect *after* the film, rather than with *change* in positive affect — i.e. it partly depends on your emotional state before you started watching the film. This is why there is no line in the diagram to *change* in positive affect.

³¹ Work on transportation and empathy has been done by Matthijs P. Bal and Martijn Veltkamp, 'How Does Fiction Reading Influence Empathy? An Experimental Investigation on the Role of Emotional Transportation', *PloS One*, 8.1 (2014), e55341.

³² For attribution theory, cf. e.g., Glenn D. Reeder, 'Attribution as a Gateway to Social Cognition', in Donal Carlston, ed. *The Oxford Handbook of Social Cognition* (Oxford 2013), DOI: 10.1093/oxfordhb/9780199730018.013.0006

³³ For work on how personality traits influence empathic engagement with a narrative, see Koopman et al, 'Effects', and David Michelson, 'Personality and the Varieties of Fictional Experience', *The Journal of Aesthetic Education*, 48.2 (2014), pp. 64–85.

³⁴ A 2014 meta-analysis counted 279 publications on the subject (Tom van Laer, Ko de Ruyter, Luca M. Visconti and Martin Wetzels, 'The Extended Transportation-Imagery Model: A Meta-Analysis of the Antecedents and Consequences of Consumers' Narrative Transportation', *Journal of Consumer Research*, 40 (2014), pp. 797–817.

³⁵ Richard J. Gerrig, *Experiencing Narrative Worlds: On the Psychological Activities of Reading* (Boston 2013). Cf. Richard J. Gerrig and David N. Rapp, 'Psychological Processes Underlying Literary Impact', *Poetics Today*, 25 (2004), pp. 265–81. The standard scale used in transportation research derives from Melanie C. Green and Timothy C. Brock, 'The Role of Transportation in the Persuasiveness of Public Narratives', *Journal of Personality and*

Social Psychology, 79 (2000), pp. 701–21.

³⁶ E.g. Rick Busselle and Helena Bilandzic, ‘Measuring Narrative Engagement’, *Media Psychology*, 12: 4 (2009), pp. 321–47, Richard J Gerrig, and Matthew A. Bezdek, ‘The Role of Participation in Aesthetic Illusion’ in *Immersion and Distance: Aesthetic Illusion in Literature and Other Media*, ed. Wolf Werner, Bernhart Walter, and Mahler Andreas (Amsterdam 2013), pp. 89–112, Marisa Bortolussi and Peter Dixon, ‘Transport: Challenges to the Metaphor’, in Lisa Zunshine ed. *The Oxford Handbook of Cognitive Literary Studies* (Oxford 2015), pp. 525–40

³⁷ This is not to say that our results were entirely free of statistical wobbles: one of the scale’s items (‘I found myself thinking of ways the story could have turned out differently’) did not go up and down in parallel with the other items on the scale.

³⁸ Nor is it a matter of an embodied versus an unembodied response. Identification, transportation and attribution too will have a bodily dimension; it is just that we have not looked at that dimension in this study.

³⁹ Admittedly, the lack of a correlation with both positive and negative affect is harder to explain. Our best guess is that the terms employed by the affect scale (listed above, p. ###) — which can be broadly seen as measures of arousal, both positive and negative — do not capture the kind of sensations that trigger, or are triggered by, endorphins.

⁴⁰ Positive correlations with identification-with-*Alexander* found only among those with *no* increase in wall-sit test time: negative affect (after watching), identification with Stuart, approval of Stuart, transportation, enjoyment (all three scales), dispositional explanation of ‘What murdered the boy I was?’ Positive correlations with identification-with-*Stuart* found only among those *with* increase in wall-sit test time: negative affect (after watching and change), enjoyment (watch again, recommend, overall), Stuart’s childhood excuses his adult behaviour. Several of these correlations are remarkably strong.

⁴¹ The effect of mood on pain tolerance has been established experimentally: cf. e.g. Nicole K.Y Tang, Paul M. Salkovskis, Amy Hodges, Kelly J. Wright, Magdi Hanna and Joan Hester, 'Effects of Mood on Pain Responses and Pain Tolerance: An Experimental Study in Chronic Back Pain Patients', *Pain*, 138 (2008), pp. 92-401.

⁴² See Clifford Leech, *Tragedy* (London 1969) and Dewar-Watson, *Tragedy*. Edward Albee's play *The Goat* (2003) is an attempt to answer the question (Albee, *The Goat, Or, Who Is Sylvia?: Notes Toward a Definition of Tragedy* (Woodstock 2003). A character in Stoppard's *Tango* asks 'Don't you see that nowadays tragedy isn't possible any more? Reality is stronger than any convention, even tragedy' (Sławomir Mrożek, *Tango* trans. Nicholas Bethell, adapted by Tom Stoppard (London 1968)). The history of film since 1968 disproves the premise behind this question.

⁴³ Raymond Williams, *Modern Tragedy*, cited by Jennifer Wallace, *The Cambridge Introduction to Tragedy* (Cambridge 2007), p. 3.

⁴⁴ J. Hughes, T. W. Smith, H. W. Kosterlitz, Linda A. Fothergill, B. A. Morgan and H. R. Morris, 'Identification of Two Related Pentapeptides from the Brain with Potent Opiate Agonist Activity', *Nature*, 258 (1975), pp. 577-9; Rabi Simantov and Solomon H. Snyder, 'Morphine-Like Peptides in Mammalian Brain: Isolation, Structure Elucidation, and Interactions with the Opiate Receptor', *Proceedings of the National Academy of Sciences of the United States of America*, 73 (1976), pp. 2515-9.

⁴⁵ William M. Calder, 'Vita Aeschlyi 9: Miscarriages in the Theatre of Dionysos', *The Classical Quarterly*, 38: 2 (1988), pp. 554-555. The anecdote is almost certainly un-

historical (Calder Vita, p. 555). Julie Hankey offers further examples of spectators' physical responses to *Othello* (ed. William Shakespeare: *Othello* (Cambridge 2005), pp. 4-5, 17).

⁴⁶ Francis Beaumont and John Fletcher, *The Works of Beaumont and Fletcher in Fourteen Volumes*, ed Henry Weber (Edinburgh 1812), p. 251.