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The Complexity of Jokes Is Limited by Cognitive Constraints on Mentalizing

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Abstract

Although laughter is probably of deep evolutionary origin, the telling of jokes, being language-based, is likely to be of more recent origin within the human lineage. In language-based communication, speaker and listener are engaged in a process of mutually understanding each other's intentions (mindstates), with a conversation minimally requiring three orders of intentionality. Mentalizing is cognitively more demanding than non-mentalizing cognition, and there is a well-attested limit at five orders in the levels of intentionality at which normal adult humans can work. Verbal jokes commonly involve commentary on the mindstates of third parties, and each such mindstate adds an additional level of intentionality and its corresponding cognitive load. We determined the number of mentalizing levels in a sample of jokes told by well-known professional comedians and show that most jokes involve either three or five orders of intentionality on the part of the comedian, depending on whether or not the joke involves other individuals' mindstates. Within this limit there is a positive correlation between increasing levels of intentionality and subjective ratings of how funny the jokes are. The quality of jokes appears to peak when they include five to six levels of intentionality, which suggest that audiences appreciate higher mentalizing complexity whilst working within their natural cognitive constraints.

Keywords

Mentalizing; Jokes; Intentionality; Cognitive demand

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Laughter and humor are ubiquitous aspects of human behavior (Gervais and Wilson 2005), and laughter at least has a very ancient origin that may even predate the origins of the hominin lineage (Davila Ross et al. 2009; Dunbar et al. 2012). Despite this, laughter itself has been the focus of only limited research (Provine 1996). Although humor has attracted much more attention, this has primarily been the province of philosophers, psychologists, and language scholars rather than evolutionarily oriented researchers. More recently, however, there has been growing interest in the ultimate functions of laughter and humor. Laughter and humor may play a number of different (not always mutually exclusive) roles in human communication, including expediting courtship, facilitating the flow of an interaction/conversation, synchronizing emotional states, and social bonding (Bachorowski and Owren 2001; Bressler et al. 2006; Cowan and Little 2012; Curry and Dunbar 2013; Dunbar et al. 2012; Flamson and Barrett 2008; Gervais and Wilson 2005; Grammer 1990; Grammer and Eibl-Eibesfeldt 1990; Hurley et al. 2011; Li et al. 2009; Mehu and Dunbar 2008; Owren and Bachorowski 2003). However, the underlying cognitive mechanisms that both enable these effects to work and determine the maximum complexity of jokes are much less well understood.

Humor and laughter are exceptionally important for the flow of natural human conversations (Provine 1996; Vlahovic et al. 2012), and given that laughter triggers an endorphin release (Dunbar et al. 2012), it might serve to facilitate social bonding amongst groups of people (cf. Machin and Dunbar 2011). In order to cause laughter, the best jokes are thought to build up a set of expectations in a listener and then use a punchline to update their knowledge in an unexpected way (Canestrari and Bianchi 2012; Forabosco 2008; Hurley et al. 2011; Ramachandran 1998; Suls 1972). Whenever these expectations involve the mindstates (i.e., any thoughts or intentions) of third parties (i.e., characters other than the joke-teller or their audience), the natural constraints on our ability to handle mindstates should inevitably play an important role in the complexity of jokes. Mentalizing (the ability to understand the intentional states of other individuals) forms a naturally recursive hierarchy (e.g., he thinks that she thinks that ...), known as the levels or orders of intentionality (Dennett 1988; Kinderman et al. 1998). Of these, formal “theory of mind” (second-order intentionality) is the most familiar and by far the most extensively investigated. Mentalizing, and in particular high-order mentalizing, seems to be especially cognitively demanding—the number of mindstate recursions we can manage is fewer than the number of non-mindstate recursions we can manage (Kinderman et al. 1998). Individuals’ mentalizing competences are correlated with (and seemingly determined by) the volume of core brain regions, notably in the prefrontal cortex (Powell et al. 2010) but more generally with the size of units in the distributed “theory of mind” network (Lewis et al. 2011; Rice and Redcay 2014).

Language requires considerable mentalizing competences on the part of both speaker and listener: the speaker has to *intend* that the listener *understands* that he/she *intends* to convey something, and the listener reciprocally has to *understand* that the speaker *intends* the listener to *understand* something (Dunbar 1998; Sperber and Wilson 1995). In effect, a conversational exchange minimally requires third-order mentalizing (i.e., the representation of three embedded mindstates) even before the speaker begins to discuss the actual mindstates of whoever is the subject of the conversation, and each step in this chain adds quantitatively to the neurophysiological demand imposed by the task.

Factual conversations (exchanges of factual information) involve only third-order intentionality, irrespective of the number of facts and their causal embedding, because they do not require the individual to model other individuals' mental states. However, more than two-thirds of natural conversations are concerned with others' social behavior and typically involve the mindstates of other individuals (Dunbar et al. 1997). This suggests that most natural conversations are cognitively demanding because they require those involved to work at levels well above the three orders of intentionality used in exchanges of strictly factual information.

The cognitive cost of mentalizing is reflected in the fact that the typical adult can manage only about five levels of intentionality (Kinderman et al. 1998; Powell et al. 2010; Stiller and Dunbar 2007). This predicts a limit on the complexity of stories that individuals can tell, at least in terms of the number of mindstates that are involved. Some evidence to support this comes from the fact that the number of speaking parts in a scene in Shakespeare's plays (Stiller et al. 2004) and at least two genres of modern film (Krems and Dunbar 2013) is identical to the number of individuals who can engage in natural conversations (Dezecache and Dunbar 2012; Dunbar et al. 1997).

In the case of verbal humor, a major component involves manipulating the expectations of the listener, or equivalently manipulating the mindstates of one or more characters in the story, in order to allow the listener to recognize and resolve incongruity (Canestrari and Bianchi 2012; Forabosco 2008; Suls 1972). We may thus expect stringent limits on the number of mindstates (and hence characters) that can be included in a joke without overtaxing the listener. At their evolutionary origins, precursors of humor (without language) would have been limited in complexity and functionally acted as forms of chorusing, with emphasis placed on basic manipulations of factual information or on essentially visual forms of situational humor ("slapstick"). The development of language and recursive mentalizing skills would have allowed humans to develop jokes with greater relevance to the social world as well as increased complexity, which would become increasingly appealing since they allow a more interesting "twist" at the punchline. The appeal of verbal jokes would, nonetheless, inevitably be limited by the cognitive processing demands of the joke: verbal jokes that exceed the listener's processing capacity will simply be incomprehensible. If mentalizing is one of these constraints, jokes should not exceed the mentalizing competences of the audience. Since the aim of a comedian should be to most efficiently trigger laughter in the audience, jokes should be tailored quite explicitly to push the audience's cognitive limits in mentalizing competences without exceeding them.

A comedy performance is a two-way interaction between the comic and individual audience members, much as in a casual conversation. As with natural conversations, the comedian has to *intend* that the audience *understands* that the comedian *intends* [to tell a joke about somebody else's mindstate]. In some cases, the joke involves the comic's own mindstate on some previous occasion or a manipulation of the audience's mindstate, but in many cases it may involve the mindstate of some other (often anonymous) character about whom the joke is being told. Either way, from the comic's perspective, three mindstates are committed before he/she even begins to tell the story. With a natural upper limit on mentalizing competences of five orders of intentionality, the commitment of three orders to creating a

“conversation” would imply that jokes cannot involve the mindstates of more than two characters if they are to remain within the audience’s ability to process them.

Since mentalizing ability places a constraint on the appreciation of verbal humor, we can make two predictions about levels of intentionality in jokes. One is that jokes are funnier when there are more mindstates involved because they include greater levels of incongruity to resolve. The second is that there should be an upper limit on the complexity of jokes, at least in terms of their mentalizing demands, because unusually complicated jokes will make the joke too difficult to process and therefore less funny. Comics who wish to trigger laughter must thus limit the complexity of their jokes within the typical cognitive limits of the audience.

We test these two predictions by analyzing the mentalizing levels implicit in an independently selected sample of jokes from well-known professional stand-up comics. We assume that, because these jokes were used by some of the historically most successful professional comedians, they have been carefully honed to appeal to the typical audience member, bearing in mind the cognitive limits on mentalizing. We took advantage of the fact that the jokes have “ratings” and used them to determine whether there is a relationship between mentalizing level and perceived joke quality, and then obtained independent ratings of the quality of a sample of these jokes to more carefully replicate this result.

Materials and Methods

We used an online compilation of 101 jokes selected as the “funniest of all time” (Steinberg 1999), most of which were culled from the archives of well-known stand-up comics. Some of them are short and would count as “one-liners” (a single sentence with a punchline), but others are longer and more complex. After agreeing on the basic principles for rating, RD and JL rated the number of mindstates involved in each joke separately and then compared findings and arrived at an agreed-upon value. Overall, raters agreed on 98% of the jokes—just 2 of 101 jokes differed by one intentionality level (disagreements revolved around whether or not additional characters in the story counted as additional mindstates even if they weren’t explicitly ascribed a mental state), and these cases were resolved by discussion. In order to measure the quality of jokes, we first obtained “ratings” of all the jokes as provided in the online compilation (Steinberg 1999, accessed 21/04/2015). These ratings appear to be the cumulative number of people who clicked a link to say that they liked the joke, but given that they are provided with no explanation or details about participants,¹ we had a sample of the jokes independently rated by an additional panel. For this procedure, jokes that were deemed potentially offensive or too culturally obscure to the UK participant pool were removed; the remaining 65 jokes were rated on a scale of 1 (Not at all funny) to 4 (Very Funny) by 55 (34 female; age $M = 20.8$, $SD = 1.75$) undergraduates at the London School of Economics, who gave written informed consent to take part in this study.

¹We contacted the website authors for more information about these ratings but received no reply.

Results

The distribution of the number of intentional states involved in the jokes, including the minimum obligatory three mindstates for the comic and audience, is plotted in Fig. 1. The distribution is bimodal, with clear peaks at three and five levels of intentionality. A k -clusters analysis yields an optimal division into two clusters ($F_{1,99} = 420.5$, $p < 0.0001$). The peak at three levels of intentionality involves cases where the only mindstate in the joke itself was the comic's (usually reflecting on some misapprehension to which he/she had fallen prey or an observation being made on the world at large (e.g., "I bought a box of animal crackers and it said on it, 'Do not eat if seal is broken.' So I opened the box, and sure enough ..."). Only 8.9% of all jokes involved more than three mindstates in the joke itself (i.e., six or seven levels of intentionality in total), and only one was rated as involving seven mindstates (i.e., four characters in the joke). Leaving aside the mainly factual three-level jokes, 86.6% of the remaining jokes involved just four or five levels of intentionality in total (one or two mindstates in the joke).

Online ratings of the jokes ranged from 140 to 3225 "clicks" and correlate significantly with those from the ratings panel (Spearman $\rho = 0.569$, $n=65$, $p < 0.0001$). They were weakly but significantly correlated with the levels of intentionality ($\rho = 0.20$, $p = 0.04$), suggesting that higher levels of intentionality are associated with better-quality jokes (Fig. 2). This correlation is marginally more significant after excluding the outlying point at level 7 ($\rho = 0.21$, $p = 0.03$). The 65 jokes rated by undergraduate participants ranged in average rating across participants from 1.36 to 2.87, and, as with the online sample, participant ratings for each joke correlated positively with the coded levels of intentionality ($\rho = 0.29$, $p = 0.02$) (Fig. 3). The funniness ratings in both samples appear to be asymptotic with respect to level of intentionality, with a flattening from level 5. The larger sample suggests a sharp decrease in ratings at level 7, although this is only based on the rating of one joke and should be interpreted with caution.

The length of the jokes (number of words) correlates with their intentionality level ($\rho = 0.53$, $p < 0.0001$), and it might be something about the length of a joke rather than its mentalizing structure that determines its funniness. We tested this by examining the relationship between funniness rating, word count, and intentionality level. For these purposes, we used the online ratings because they include a wider range of jokes on both scales. Since word count is considerably more variable than intentionality level (range 5–221 vs. 3–7), we calculated standardized normal deviates for each of the two variables so as to be able to compare their impact on humor rating directly and fitted quadratic equations to each (Fig. 4 and Table 1). Note that the two equations are of opposite sign: humor rating increases exponentially with word length but has a hump-shaped distribution with respect to intentionality level, with a maximum at about one standard deviation above the mean (i.e., at an intentionality level of 5.5). This suggests that we can dissociate the two variables despite the fact that they are correlated, and that it is intentionality level and not word length that places a limit on joke funniness, with that limit occurring at around fifth-order intentionality.

Discussion

Our analysis suggests that verbal jokes are constrained by the cognitive limits imposed by the mentalizing competences of the comedian and the audience. In the present sample, about a third of all jokes are “factual” jokes—observations on idiosyncrasies of the world that do not involve third-party mindstates—that are relatively undemanding. Two-thirds involve the mindstates of third parties. However, very few of them involve the mindstates of more than two characters within the joke, making for a total of five intentionality levels (including the obligatory reflexive mindstates of the comedian and the audience). Increasing the mentalizing complexity of the joke improves the perceived quality of the joke, but only up to this limit.

We do not interpret this finding as suggesting that humor is *defined* by the mentalizing structure of a joke, but rather that mentalizing competences set an upper limit on the complexity that jokes can achieve. This seems to suggest that professional comics cannot afford to tell jokes of such complexity that they leave the audience baffled. Their task is to elicit laughs as directly and as fast as possible, and they do that most easily by ensuring that they keep within the mentalizing competences of the typical audience member. If they exceed these limits, the perceived quality of the joke decreases. Our results suggest that, on the whole, professional comics in fact do this very effectively.

Our choice of jokes from some of the best-known professional comics was intended to guarantee the quality of the jokes: these individuals are likely to have the most experience with what makes audiences laugh and are thus most likely to know how to push audiences to their limits without overtaxing them cognitively. These jokes are thus likely to represent the most demanding ones. In this respect, jokes seem to differ from other forms of literature (e.g., drama) in which more characters are commonly involved. In drama, for example, Shakespeare commonly has four speaking parts in a scene (Stiller et al. 2004), and the same is true of both hyperlink films (an emergent film genre that seeks to push the boundaries of the medium in order to mirror contemporary life in the globalized community: examples include *Babel*, *Crash*, *Love Actually*, *Mammoth* and *Traffic*) and romantic interest films (Krems and Dunbar 2013). The difference between drama and jokes may lie in the fact that the playwright does not sit between the audience and the action on the stage, so the audience does not have to factor the playwright’s intentions (i.e., mindstate) into their understanding of the situation. The same is probably also true of written literature. In this respect, written literature and drama may give the narrator more flexibility than stand-up comedy, in which the comic stands between the audience and the action in the joke, thereby using up a mentalizing state that the narrator in a drama does not require.

Jokes are likely to achieve their aim by a punchline that rapidly changes or updates the knowledge state of the listener. The current results suggest that the optimal level for updating knowledge in a way that can be perceived as funny is just two mindstates within the story or joke itself. Ideally, we would wish to test this claim experimentally by asking subjects to rate jokes of increasing mentalizing complexity beyond the levels we have observed in our sample, in the expectation that there would be a dramatic downturn in subjects’ ratings once the joke contains three or more characters’ mindstates (i.e.,

intentionality level 6 and above). The very low rating of the one joke with seven levels (i.e., four mindstates) in our current sample suggests that, at this level, audiences can no longer engage with the joke and appreciation drops dramatically.

An experimental design that used jokes with more than six levels of intentionality would have been desirable, since this would have allowed us to test the hypothesis that jokes with more than five levels become progressively less funny. Although in principle it would be possible to have jokes with more than six levels, this would probably require the services of professional scriptwriters who have sufficiently high mentalizing competences to be able to work effectively at eighth- or even ninth-order intentionality. The distribution of mentalizing competences found by Kinderman et al. (1998) and Stiller and Dunbar (2007) indicates that only a small proportion of the population can cope with sixth- or seventh-order statements. Such an experiment would thus not be easy to engineer, and the results may inevitably be ambiguous since it might be difficult to distinguish between the cognitive limitations of the scriptwriter and those of the raters. Another extension of the current project would be to investigate whether individual differences in mentalizing competences (which are known to be quite considerable: Powell et al. 2010; Stiller and Dunbar 2007) determine individual differences in humor appreciation. It may be, for example, that someone who can accommodate six levels of intentionality will find jokes with four or five levels more amusing than someone who can only manage four levels of intentionality (cf. Carney et al. 2014).

It is likely that, in most everyday humor, people do not use as many levels of intentionality as in the current sample, and a sampling of casual jokes from natural conversations (as opposed to recitations of crafted jokes that the speaker heard from a professional comic) might provide further insights into how jokes are used in everyday life. At present, we have little idea how everyday conversational jokes differ from our sample of professional jokes, or whether some individuals who are natural humorists appear so because they can perform at the level of professional comics. Our concern has been with determining whether there are natural limits to the complexity of jokes, and for this we had to be sure that the quality of the jokes we used could be guaranteed. Our use of jokes from professional comics allowed us tighter experimental control in this respect. An important further study will be to examine jokes told in casual conversations.

Our data indicate that the word count of a joke is a significant predictor of its quality as a joke. This is all but inevitable: it is almost impossible to write any statement that involves many intentionality levels without using more words. However, it is difficult to envisage a compelling, principled reason why word count alone would determine how funny a joke is (and no data exist on this, so far as we know). In the present study, the greater variability in word length makes it inevitable that this would be a statistically significant predictor in a standard regression analysis, even if it was an artifact. However, the analysis in Fig. 4 allows us to conclude that word count does not act as a *constraint* on ratings of the jokes, whereas level of intentionality does. The fact that the two variables have diametrically opposite relationships with the ratings index (Table 1) suggests that we can differentiate between them, and that only intentionality imposes a constraint.

Laughter triggers an endorphin response (Dunbar et al. 2012; confirmed by an unpublished PET study) and may have been crucial in the bonding of large communities once they exceeded the size that could be managed by the conventional primate mechanisms of social grooming alone (Dunbar 2012). While laughter itself may be very old phylogenetically (Davilla Ross et al. 2009), and in its human form may long predate language (Dunbar 2012, 2014; Dunbar et al. 2012; Provine 1996), verbal jokes probably allow us to manipulate laughter and trigger it on a more reliable basis than is the case for slapstick (situational or visual) comedy, which depends much more on the serendipitous occurrence of events. Jokes are likely to have played a significant role in triggering laughter during the course of human social evolution, but only after the advent of language (which seems to have happened late: Dunbar 2009, 2014). Although it is, of course, possible to create nonverbal slapstick comedy deliberately, such comedy is likely to be rare by comparison with joke-based comedy for two reasons: first, visual humor may be less intrinsically amusing (and thus harder to effect), and second, slapstick gains its effect by its very spontaneity (for whatever reasons, someone actually slipping on a banana is much funnier than someone pretending to do so). Jokes give us control over laughter and allow us to trigger laughter wherever and whenever we like, thus speeding up the processes of social bonding and other social mechanisms that laughter originally evolved to underpin.

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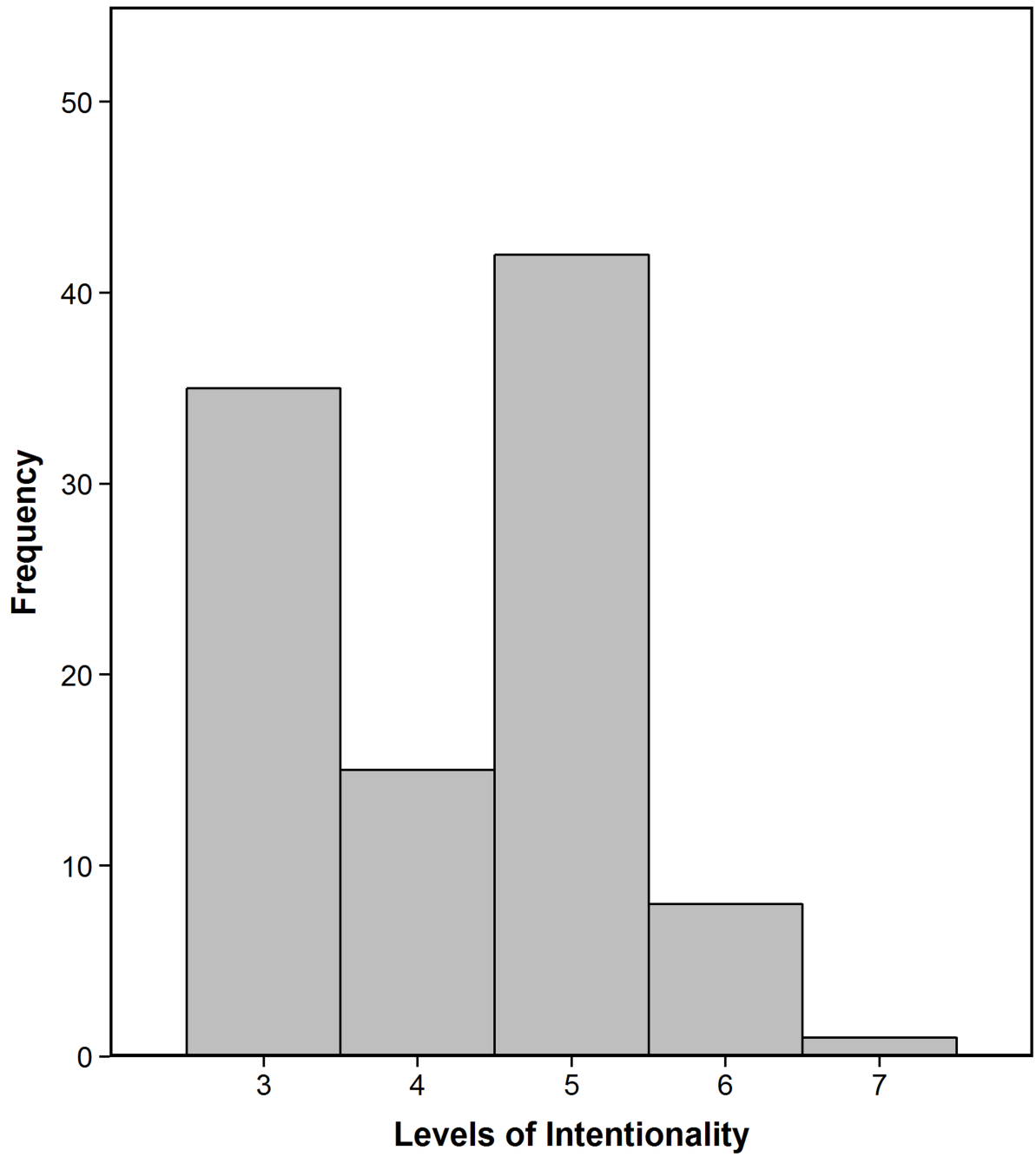


Fig. 1. Distribution of the number of intentional states involved in each of the 101 jokes sampled

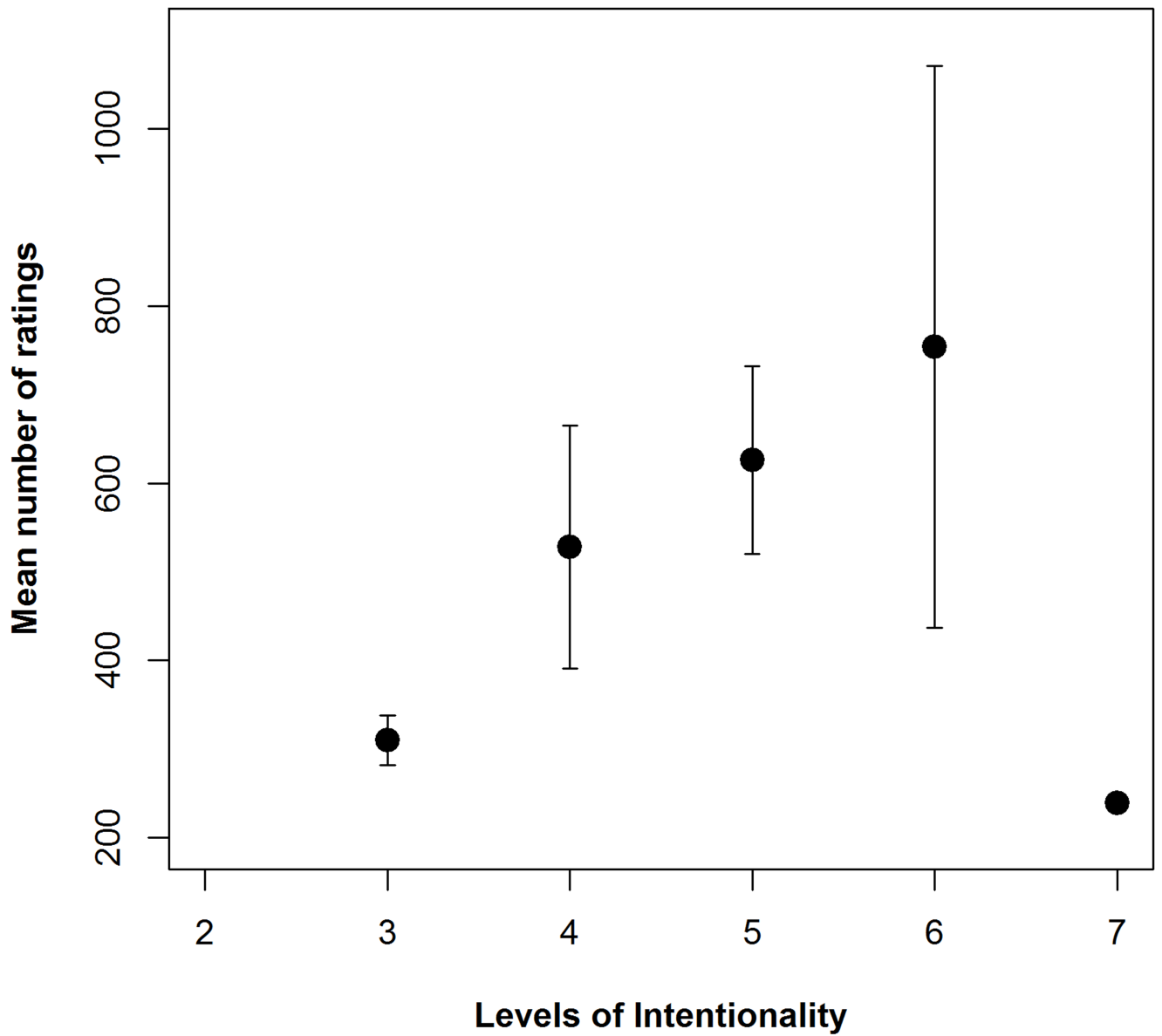


Fig. 2. Mean number of 'ratings' of all jokes as reported online (Steinberg 1999) (bars indicate 1 *SE*)

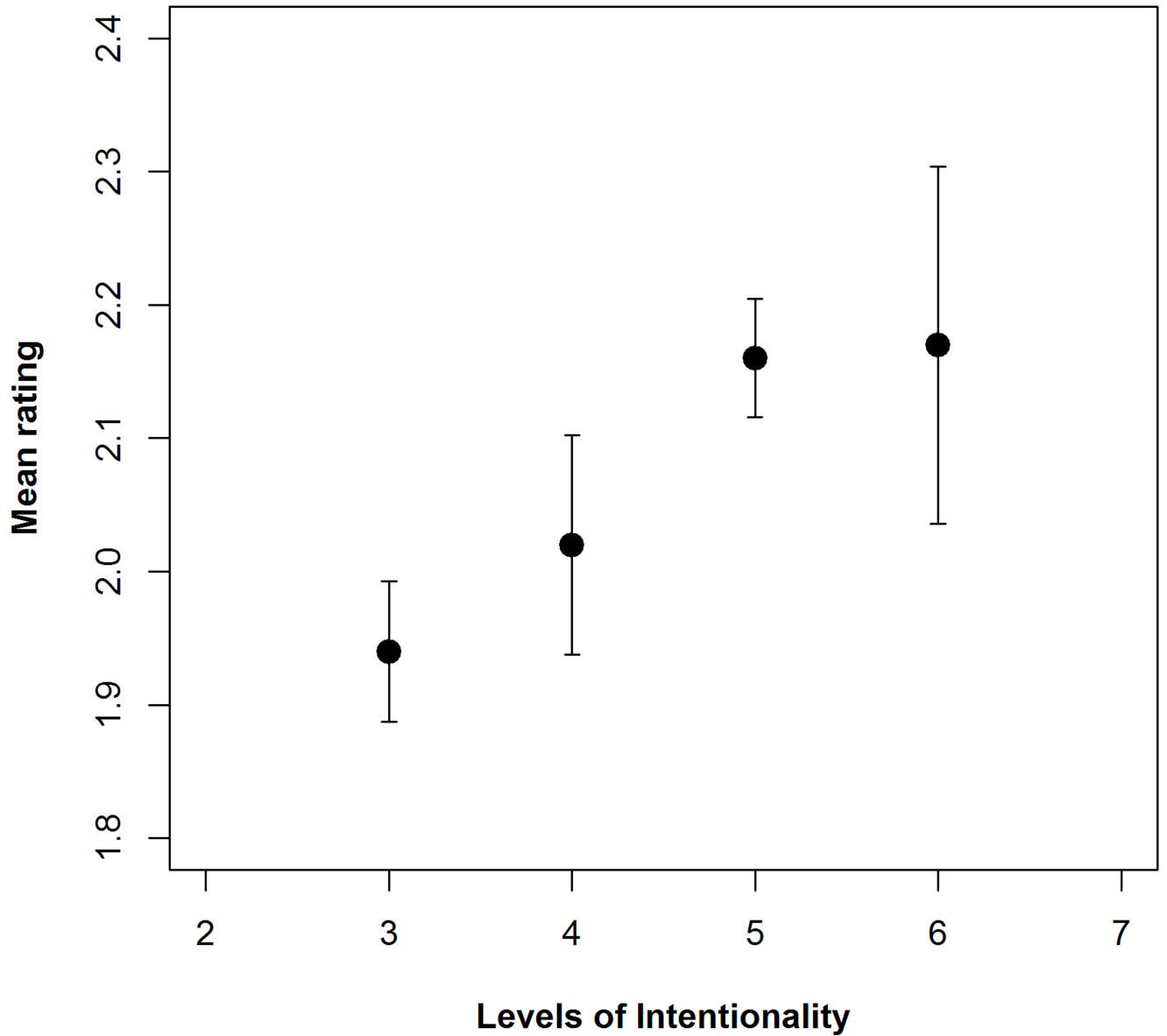


Fig. 3. Mean ratings of funniness of jokes at each of the four levels of intentionality commonly include in the joke database (bars indicate 1 *SE*)

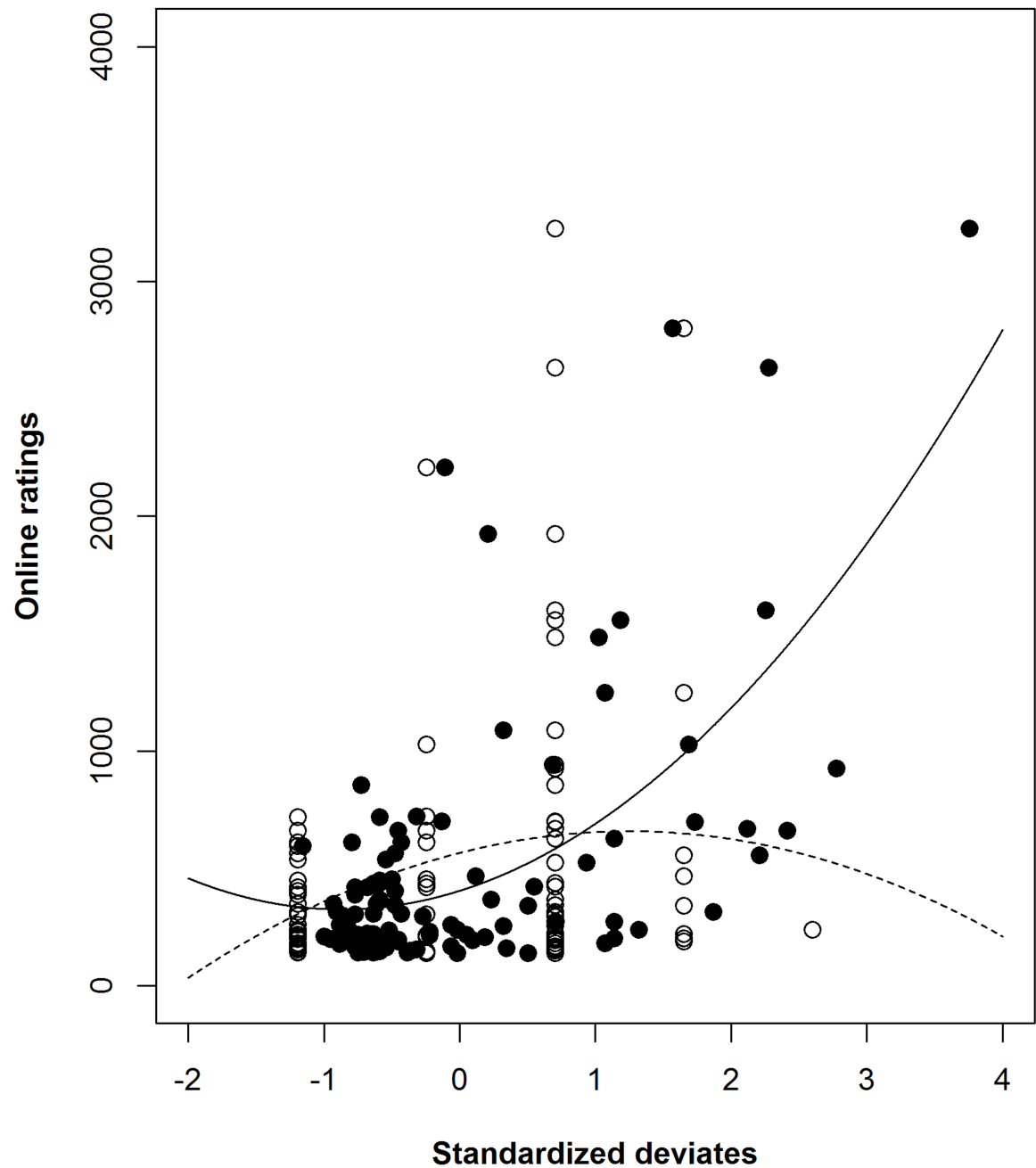


Fig. 4. Ratings for individual jokes plotted against standardized normal deviates for intentionality rating (open symbols and dashed line) and word length (filled symbols and solid line). Standardized deviates (Z-scores) have been used to scale both measures so their effects can be compared directly. The regression lines are the best fit quadratic relationships.

Table 1

Regression analysis for the data in Fig. 4.

Independent variable	Equation	$F_{2,98}$	p
Intentionality	$y = 571.1 + 181x - 62.9x^2$	4.03	0.021
Number of words	$y = 405.6 + 181.3x + 103.9x^2$	31.2	<0.001

In each case, the quadratic equation has a higher r^2 than the equivalent linear equation.