midzone division increased after stimulation of cell proliferation.

Both types of division are associated with DRP1 accumulation. However, there are differences in other molecular players involved. Midzone division is associated with contact with the ER and with the polymerization of actin filaments through the ER-bound actin-polymerization protein INF2. In addition, the data suggest that MFF has a role in midzone, but not in peripheral, division. Peripheral division is associated with lysosomal contact and with FIS1.

Kleele and colleagues' careful work is valuable, because it clearly demonstrates that there is more than one type of mitochondrial division, thus enabling a more nuanced analysis of division factors based on the reason for division. Moreover, this work is a reminder that we need to walk before we can run when trying to map complicated biological processes such as mitophagy. Otherwise, our understanding of them might be hampered by an incomplete grasp of the earlier processes that lead up to them.

This work also raises exciting questions. Do other factors participate specifically in peripheral or midzone division? In this respect, MID51 and MID49 are particularly interesting because the current work does not provide conclusive results about their role. Other factors worth examining include cardiolipin, Golgi-derived vesicles and post-translational modifications of DRP1. Another issue to explore is whether cell-type-specific differences make a major contribution, a feature hinted at by the authors' investigation of different cell types.

A fascinating aspect to consider further is the complete compartmentalization of a different profile of calcium, ROS and membrane potential to the smaller portion of a mitochondrion undergoing peripheral division. Different characteristics on either side of the division site have been demonstrated previously for mitochondrial division[7].

One possible mechanism for this compartmentalization is that the inner mitochondrial membrane (the inner of the two membranes surrounding the organelle) undergoes division before the outer membrane, as has been suggested previously[8]. However, compartmentalization in the absence of an independent division of the inner mitochondrial membrane might be possible. This idea is supported by the observation that infoldings of the inner membrane, termed cristae, can maintain membrane potentials that are different from each other, even when in close proximity in a mitochondrion[9]. Another matter to consider is the source of the rising calcium levels in the smaller portion of a peripherally dividing mitochondrion. Calcium transfer from lysosomes is a possibility[10].

There are some other puzzles. The role of FIS1 in mammalian mitochondrial division has been controversial. Kleele and colleagues' work suggests that FIS1 is the DRP1 receptor for peripheral divison, and another study also suggests that FIS1 is a DRP1 receptor[11]. However, other studies[6] indicate that FIS1 depletion has a minimal effect on division, and alternative functions for FIS1 have been described[12,13]. Two explanations for this apparent contradiction are that the other studies on FIS1 were in contexts that did not favour peripheral division, or that the role of FIS1 in peripheral division might be indirect.

Something else to consider is the absence of an increase in mitochondrial calcium levels during midzone division. Previous studies[8,14] have shown that an increase in mitochondrial calcium precedes division events resembling the midzone division described by Kleele and colleagues. It would be interesting to examine the effect of suppressing the mitochondrial calcium uniporter (a protein that pumps calcium across the membrane) on midzone and peripheral division. A final question is whether there are only two types of mitochondrial division in mammalian cells. Given the large number of regulatory mechanisms, it is possible that variations on these two pathways, or completely independent pathways, remain to be found.

Rajarshi Chakrabarti and **Henry N. Higgs** are at the Geisel School of Medicine at Dartmouth, Hanover, New Hampshire 03755, USA.
e-mails: henry.higgs@dartmouth.edu; rajarshi.chakrabarti@dartmouth.edu

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Psychology

The sense of a conversational ending

Elizabeth Stokoe

How we feel about the duration of our conversations has rarely been studied. New research has asked people about the lengths of their conversations, and whether they end when they want them to.

Conversation has been described[1] as "the primordial site of human sociality". We all have a lifetime's experience to draw on if asked how it works, or when we reflect on the conversations we have participated in. But because conversation is something that we know tacitly how to do, scientific attempts to understand it are often relegated to the 'soggy' end of social psychology. Conversation certainly differs from other subjects of scientific scrutiny. For instance, black holes do not exist to be understood by people, whereas conversation exists only to be understood by people and to help us understand each other. Writing in *Proceedings of the National Academy of Sciences*, Mastroianni *et al.*[2] report how they have taken up the challenge of researching conversation scientifically.

The authors focused on the question of whether conversations end when people want them to, and gathered data from two studies. In the first one, individuals (806 in total) taking part in an online survey were asked to recall the most recent conversation they had in person, report its duration and indicate whether it ended when they wanted it to. If they indicated that the conversation didn't end when they wanted, they were asked to estimate how much longer or shorter they would have liked it to have been. Participants were also asked how they thought the person they were speaking to might have answered the same questions. These conversations were mostly between people who were familiar to each other; 88% were between those who had known each other for at least a year, and 84%

of the participants spoke to the person in question at least a few times each week.

The authors explain that their second study was designed, in part, to deal with the limitations of the first, such as relying on participant recall of an event and accessing only one party's view of the interaction. In the second study, the authors brought 366 previously unacquainted participants from university study pools into the laboratory for a one-hour experiment. Participants were paired up to have a conversation about whatever they wanted, for any duration, up to a maximum of 45 minutes. This was followed by another task until the 60 minutes were up. The participants answered the same questions as those used in the online survey.

The authors concluded that the conversations evaluated in both studies almost never ended when both individuals wanted them to, and rarely ended when even one person wanted them to. Interaction with intimates or strangers made no difference to this mismatch. Participants were unaware of when their partner wanted to end the interaction, or that their own perceptions were so different from their partner's. For example, in laboratory conversations, there was a 46% discrepancy between the actual and desired duration. Interestingly, the authors excluded 57 of the pairs because they spoke for the full 45 minutes and did not end their conversations.

The study's novelty is in its examination of how people feel about their conversations at this level of empirical scrutiny. It represents a clear advance in psychology, in getting closer to where the action of social life happens, especially in the second study. One future direction for research might be to record or analyse the laboratory conversations themselves, and to ask participants to use transcripts to inform their responses. Transcripts would help the participants to identify precisely the point at which they wanted the conversation to end, and help researchers to understand exactly what each party was doing at the time. Were they mid-story, repeating something or giving a minimal or an expansive response? People show how attuned they are to tiny nuances in social interaction even as it unfolds[3], and transcripts might enable the authors to gain extra insights about their findings.

Some have commented that, despite psychology being a discipline associated with "professional people watchers"[4], psychologists rarely investigate "where moment-to-moment behaviour naturally happens"[4], or deploy "direct observation of actual behaviour"[5]. Indeed, Mastroianni *et al.* say that scientists know little about conversation: "how it starts, how it unfolds, or how it ends." One possible direction for future research, therefore, is to combine laboratory studies of the kind conducted in the second study by Mastroianni and colleagues with investigations of naturally occurring talk.

For more than 50 years, the cumulative science of conversation analysis has examined audio and video recordings of anywhere from single cases to thousands of cases of conversation. One benefit of augmenting laboratory studies and surveys with such data and methods is to avoid the limitations of post-hoc survey methods as identified by Mastroianni *et al.*, as well as the limitations of laboratory settings. All conversations have a reason for occurring, whether mundane or dramatic. In the authors' second study, the reason was to be a research participant, making the experimental setting itself the 'invariant occasion' for the conversations that happened[6]. We know, however, that people interact differently when they are in a simulation or experiment compared with their behaviour in life 'in the wild', because the reason for the event and their stake in its outcome are different[7,8].

"There are tremendous real-world benefits to analysing conversation with close scrutiny and rigour."

The authors conclude that people cannot coordinate what each participant wants from a conversation, in terms of ending it at a mutually satisfactory time, according to their responses when asked later. This striking observation tells us something interesting about the difference between what happens inside a conversation and what people say about it afterwards. As Mastroianni *et al.* point out, analysis has shown that conversations have 'closing rituals', which are systematically coordinated. In other words, a typical conversation does not usually end abruptly; it must be brought to a close[7]. Endings take shape through highly routine practices, such as making arrangements ("So let's sort out what time on Monday"), or restating the reason for the conversation ("Well, I just wanted to see how you were doing"), combined with a 'terminal exchange'[9] such as:

A: Okay
B: Okay
A: Bye bye
B: Bye

Endings are so systematic and recognizable that it can be easy to locate in transcripts the place at which someone wants the conversation to be over, whether by giving a delayed or minimal response or by saying something that indicates they are moving to draw the conversation to a close.

For example, in a study of individuals calling their doctors[10], receptionists often initiated the end of a call before the caller was ready. In the following example from that study, the caller 'wants' the call to continue after the receptionist has started to end it with "Okay then", followed by "Thank you". The square brackets indicate when both spoke at the same time. The final four lines are a classic 'terminal exchange'.

Receptionist: Okay then,
(pause of 0.5 seconds)
Caller: [So it's th-]
Receptionist: [Thank you,]
(pause of 0.5 seconds)
Caller: That's the sixteenth?
Receptionist: The sixteenth,
[at ten pa]st eleven.
Caller: [Okay then.]
(pause of 0.3 seconds)
Caller: Ten past eleven, thank you.
Receptionist: Thank you,
(pause of 0.2 seconds)
Caller: T[hank you,]
Receptionist: [Bye]
Caller: Bye.

Furthermore, there was a correlation between surgeries in which the receptionists, rather than the callers, moved to initiate the ending of the call and lower patient-satisfaction scores with the surgery in general. Scrutiny of conversation transcripts reveals why this type of scenario creates dissatisfaction: in this case, the individual had to push past the receptionist's move to end the call to get their appointment confirmed.

When one party walks out or puts the phone down on another, we have the exact definition of mismatched desires regarding a conversation's ending. In the following call[11], a salesperson 'cold calls' a company with the goal of selling printing systems (transcript simplified). Even when the call is nearing its end, the client still uses components of the terminal exchange before hanging up.

Client: Well we're happy with, uhm, the people that we're currently using.
(pause of 0.3 seconds)
Sales: I'm sure you are, but I wanted to find out when the contract's up for review so then I can c[all maybe nearer the time]
Client: [Yeah no we're happy with wh]o we're currently using.
(pause of 0.5 seconds)
Sales: You don't know when the [contract's up for re]view?
Client: [Okay. Thank you.]
(hangs up)

Asking 'when did you want the call to end?' is the wrong question here, because the conversation is likely to be unwanted by the client in the first place, and, once in it, the parties

involved want different outcomes.

Both the medical and the sales calls show that, and indicate how, individuals 'want' their conversations to end at different points. We can identify this in real settings in which we understand the authentic purpose of the conversation. It would therefore be interesting to apply Mastroianni and colleagues' methods to the analysis of such transcripts and recordings, to ask individuals later, on reflection, to identify at what point they wanted to continue or end the conversations.

What about conversations between loved ones — such as those recollected in the online survey? In the following conversation[12] (transcript simplified) between Sue (not her real name), a young person with learning disabilities and in residential care, and her dad, Sue asks her dad to bring her extra pocket money when he visits. This is followed by the first turn that moves to close the conversation:

Dad: Right, well, I'm gonna get on now, I'll be there for about half past nine tomorrow morning.

But the conversation continues for a further 45 seconds before another pre-closing event occurs:

Dad: Right, well I'm going to go now, darlin'.
Sue: Yeah I've got to finish my cards off.

Only after three more pre-closings, including those expressing love (Dad: "Okay, lovey?" Sue: "yeah"; Dad: "I love you"; Sue: "love you"), do they bring the call to its end.

How do you show that you care about someone? Mastroianni *et al.* rightly point out that conversation is the "bread and butter" of our psychological and physical health, and this is clear to see in Dad and Sue's conversation. Staying longer in the conversation than external constraints allow (such as in a film scene in which people in a lift miss their floor to keep talking) is one way to do it. Closing rituals are so systematic that the conversational machinery allows us to see how the reopening of closings happen.

Mastroianni and colleagues' findings are compelling. Some media headlines about their study (see go.nature.com/3sgIkup), such as "only 2% of conversations end when we want them to", focused on the disconnect between the desired point for a conversation to end and its actual end. Although the headline news might be the scale of the disconnect, reducing conversations such as this chat between Dad and Sue to 'who wanted what' damages the empirical reality of their conversation and misses its purpose.

There are tremendous real-world benefits to analysing conversation with close scrutiny and rigour. For example, returning to the doctor's surgery, the same research[10] showed that when receptionists proactively confirmed an individual's appointment time and date, rather than doing so only in response to a request for confirmation, the conversation ended collaboratively. Moreover, proactive confirmation was associated with higher patient satisfaction, and the finding was used to train receptionists.

Do conversations end when people want them to? Mastroianni *et al.* conclude that the answer is almost certainly no. Asking people to report on their conversations has shown this clearly. Apart from situations such as in an argument, people generally do not say, "I want this conversation to end." They might tell other individuals, "I was trapped in that conversation for hours", or "I don't want to talk to her", but, in real conversation, people usually convey such things tacitly. This is why examining conversations, including using transcripts, is informative. It is clear, as Mastroianni *et al.* state, that "The more we learn about conversation — about how it begins and ends, runs and stalls, delights and disappoints — the better positioned we will be to maximize its benefits."

Elizabeth Stokoe is in the School of Social Sciences and Humanities, Loughborough University, Loughborough LE11 3TU, UK.
e-mail: e.h.stokoe@lboro.ac.uk

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Planetary science

Iron and nickel vapours present in most comets

Dennis Bodewits & Steven J. Bromley

The detection of iron and nickel vapours in a broad range of Solar System comets, and of nickel vapour in a comet from outside the Solar System, provides a glimpse into the organic chemistry of young planetary systems. **See p.372 & p.375**

Comets are agglomerates of dust and ice — leftovers from the era of planet formation. For most comets, their distance from the Sun keeps their temperature below a few hundred kelvin, which is still hot enough for water ice and other volatile compounds to sublimate (be converted directly from solid to gas). Comet nuclei are mostly obscured by a surrounding cloud of gas and dust called the coma. Therefore, knowledge of comet surfaces and their composition must be inferred from observations of the coma. Typical telescopic observations of cometary comae do not detect metals, because temperatures at comet surfaces are too low for these elements to sublimate. However, two papers[1,2] in this issue report the discovery of metal atoms in cometary atmospheres, begging the question of where these atoms come from.

There have been several space missions to comets, including Rosetta, Deep Impact and Stardust. These missions have shown that comets are relatively small (typically, just a few kilometres in radius), and might be responsible for moving volatile materials around in the inner Solar System after the planets formed[3]. Such missions provided detailed studies of individual comets, but Earth-based observations have determined the chemical composition of larger numbers of these bodies[4,5].

At optical wavelengths, the spectra of light emitted by comets coincidentally resemble those of flames. They have a broad, continuous part (caused, in flames, by hot soot; in comets, by dust that reflects sunlight), combined with the emission features of molecules and their fragments, such as hydroxyl (OH), cyanide (CN) and dicarbon (C_2) groups. Until now, emission lines of metals — iron, nickel and other heavy elements — were thought to be absent from comet spectra. The detection of lone metal atoms in comets has been limited to specific situations, including sample-return missions (Stardust[6]) and bright, 'sungrazing' comets such as Ikeya–Seki, which plunged into the Sun[7].

Manfroid *et al.*[1] (page 372) used atomic models to predict at which wavelengths, and