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Pauses in doctor–patient conversation during computer use: The design significance of their durations and accompanying topic changes

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Abstract

Talk is often suspended during medical consultations while the clinician interacts with the patient's records and other information. This study of four general practitioners (GPs) focused on these suspensions and the adjacent conversational turns. Conversation analysis revealed how GPs took action to close conversations down prior to attending to the records, resulting in a 'free turn' that could be taken up by either GP or patient. The durations of the intervening pauses were also analysed, exposing a hitherto unobserved *10-second timeframe* within which both GP and patient showed a preference for the conversation to be resumed. Resumption was more likely to be achieved within 10 s when the GP's records were paper-based rather than computer-based. Subsequent analysis of topic changes on resumption of talk has revealed a *5-second timeframe*, also undocumented; when pauses exceed this timeframe, it is rare for the previous topic to be resumed without a restatement. Data recorded in the home suggest that these timeframes are also present in family conversations. We argue for considering the two timeframes when designing systems for use in medical consultations and other conversational settings, and discuss possible outcomes.

Keywords: Medical interaction; Conversational pauses; User interface design

1. Introduction

The continuing spread of personal digital technologies has brought about radical changes in how society interacts with information. Previously the dominant medium was paper: people wrote letters on paper, kept paper-based appointments diaries, took notes with pen and paper, and paid bills with paper cheques. Since the 1980s these activities have been increasingly replaced by interactions with digital devices, most of which are descended from the original personal computers. One instance of this can be seen in primary health-care, where general practitioners (GPs) have migrated from keeping paper records to using networked personal computers or terminals during their consultations, a migration on which this paper focuses.

GPs' use of computers during consultations reveal yet another change that digital technologies have brought about, namely their intrusion into everyday face-to-face conversations. These intrusions take many forms and occur in many contexts. For example, a question may be raised at the dinner table, and one diner will insist on looking up the answer on his Blackberry while the others wait. A mobile phone rings, causing the current speaker to break off and turn aside in mid-sentence. An attendant at an airport information desk responds to an urgent question with, "Just a second, I'll check," and then consults a computer in silence for over a minute. Often it is as if the conversation has gained an additional participant, with whom only the user of the technology can communicate. The face-to-face conversation goes into suspense.

Inevitably the frequency of such intrusions is increasing as digital devices become smaller, cheaper, more versatile, easier to use and more universally networked. Twenty-first century talkers have had to learn to deal with the intrusions

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the devices cause. Meanwhile, however, little progress has been made towards designing technologies that interfere less with face-to-face talk. Indeed the question of how such a goal might be attained remains largely unanswered.

This paper presents some findings about the impact on face-to-face conversations of using computers and other artefacts such as paper records. The findings have emerged from a study of conversations between GPs and patients, in which the analytical focus was on the pauses occurring when the GP consulted the patient's records. Clear evidence has emerged of a preference, shown by both GPs and patients, to resume the conversation before such a pause exceeds a *10-s timeframe*. Evidence has also emerged of a *5-s timeframe*, beyond which a change or a restatement of the conversation's topic is usually necessary when talk resumes.

The existence of these timeframes has not, to our knowledge, been documented until now. They are present whether the GP is using paper- or computer-based records. We have also found evidence of the timeframes in conversations recorded in family homes. This suggests that they are not a by-product of the doctor–patient relationship, but are a natural rhythm in conversation. If so, they may have widespread implications for interactive technologies design.

Our analysis indicates that when our GPs used computers, rather than paper, the pauses were more likely to overrun the 10-s timeframe. When this occurred it was sometimes the patient who broke the silence, occasionally with a distracting remark:

GP: [after checking patient's pulse] Okay, that's fine. [turns to computer, starts typing] (11.8 s pause)
Patient: I 'ad cream for arthritis and it's fine doctor.
GP: [turns to patient] D'you want some more?

This was one variety of problem faced by GPs as a result of the time required to perform interactions with computer-based records. More serious, however, was their difficulty in maintaining the current topic of conversation, which tended to lapse when a pause exceeded the 5-s timeframe. If indeed GPs are being hindered from returning to the current topic after a short pause, they may be spending valuable time on topic restatements or responses to off-topic remarks. This is undesirable in a public health system like the UK's, where consultations average less than 10 min in length and must therefore be conducted under time pressure.

In this paper we describe the discoveries that led us to focus on pauses in conversation, and present the results of analysing pause durations, primarily in medical settings but also in the home. We point out certain aspects of these results that led us to analyse in detail the conversation before and after each pause. We focus in particular on the actions GPs took to achieve the silences they needed for attending to patients' records, and the actions by which conversation was later resumed. We also show how this resumption was affected by whether it occurred within or beyond the 5-s timeframe. To illustrate these actions we have included transcribed passages like the one above. We draw conclusions on how interface designs might take into account the 5- and 10-s timeframes in conversation.

2. Background

Our investigations have been influenced and assisted by a range of published research. In particular, we have built on work by colleagues at the Xerox Research Centre in Cambridge, UK, where our project began. The work in question included ethnographic studies by Heath, Luff and Greatbatch of GPs' use of computers (Greatbatch et al., 1993), and research into performance criteria for interactive systems by Alex Taylor and the first author (Newman and Taylor, 1999).

The studies led by Heath (1986) grew out of his seminal work on doctor–patient interaction, which he based on his extensive video recordings of paper-supported consultations. From similar observations of GPs' computer use, he and his colleagues showed that both GP and patient were structuring their talk around the GP's interactions with the computer (Greatbatch et al., 1993). In particular, they described how patients appeared to avoid interrupting the GP's typing, by synchronizing an unsolicited remark with a visible boundary in the GP's text entry, such as pressing the Enter key to complete a command. They noted that when the GP resorted to handwriting, these boundaries were less prominent, and patients were less likely to try to synchronize their remarks. On the basis of their observations, Greatbatch et al. were able to make a number of suggestions about the design of GPs' computer systems.

Since this work by Heath and Greatbatch, observational studies have continued to augment the body of knowledge about medical interaction. Behaviours similar to those documented by Greatbatch et al. have been noted in Pearce et al. (2009) and in Booth et al. (2004). In some studies, the focus has been on a specific aspect of the consultation, such as the "By the way, doctor" introduction of a new topic by the patient (Campion and Langdon, 2004). Taken as a whole, these observational studies document a wide range of conversational features that occur in the context of computer use by GPs.

Other studies have relied on quantifying overall dimensions of medical consultations, such as the amounts of time spent by doctor and/or patient on different types of activity. This enabled certain activities to be selected for more detailed analysis. For example, Margalit et al. (2006) measured total time spent by GPs in computer use, and found correlations with certain patient behaviours. In particular, increased computer use was generally accompanied by a reduction in the number of questions asked by the patient. McGrath et al. (2007) observed six GPs during a total of 50 consultations, and measured the time spent by the GP interacting with the computer during each consultation. They were able to distinguish between 'high usage' and 'low usage' consultations, and found a number of differences in GP–patient interaction. During high-usage consultations, for example, patients asked significantly more questions than during low-use consultations, and focused these questions more on their medical conditions. The authors viewed this as a positive communicative effect; but they also noted that high-use consultations were of considerably longer average duration. Earlier studies of this kind are described in Warshawsky et al. (1994) and Ohtaki et al. (2003).

Unlike the work of Greatbatch et al., the more recent studies provide disappointingly few suggestions on how to design better computer systems for GPs. Rather, the authors look for less technology-oriented applications for their findings, such as improving the training of GPs (McGrath et al., 2007). Of course, designing a new system for GPs presents the researcher with considerable challenges, for example, in conducting user tests. These, coupled with the demands made on HCI researchers to publish highly novel designs, may explain why studies of GPs rarely lead to improved system designs.

To improve a design, one must know how to measure improvement. In other domains of interaction design this imperative has been taken on board. Instances can be found in Zhai et al.'s (2002) work on keyboard designs, and Kristensson and Zhai's (2004) subsequent designs for shape-based word entry, both aimed at increasing the number of words entered per minute. Gray et al.'s (1993) widely cited comparison of telephone operator workstations involved establishing call-handling times for each of the types of call that operators received. In the domain of robot-assisted search and rescue, Murphy and Burke (2005) redesigned a robot interface, increasing the likelihood of finding trapped victims by a factor of nine. For us, embarking on the project described here, the main challenge was to identify analogous design criteria by which GP systems could be assessed and improved.

Our approach to this challenge has relied heavily on conversation analysis methods. The timeframes that eventually emerged can be viewed as instances of the various seemingly natural rhythms in talk that a number of conversation analysts have described. Sacks, for example, notes that people answering the telephone may remark on having expected to hear from a caller because of the elapsed time since their last interaction. In other cases the answering person will remark that they were, coincidentally, on the point of contacting the caller because it seemed 'about time' to do so (Sacks, 1992).

An important aspect of pauses in talk is, for us, the pair of conversational turns that precede and follow each pause. The work of Sacks et al. (1974), identifying the constraints on this turn-taking, is especially relevant to our study. They examined the conversational *turn positions* at which a change of speaker may occur, showing that constraints generally apply to the turn that follows this position; in this sense, *sequential relevance* is projected from turn to turn. For example, strong constraints apply when a question is

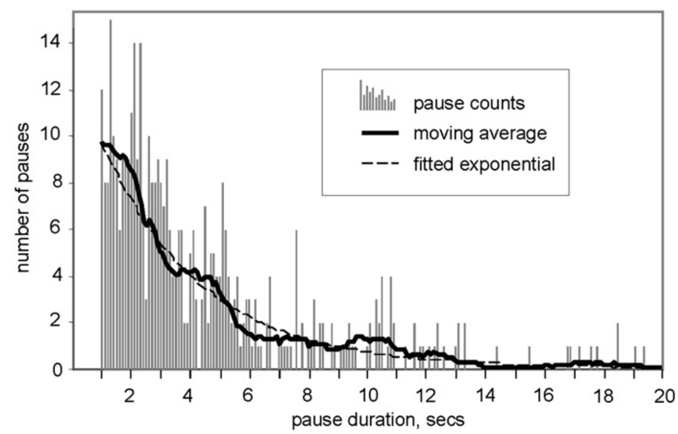

Fig. 1. Distribution of the durations of all 430 recorded suspensions of conversation during doctors' interactions with information. Vertical bars show the number of suspensions at each 0.1 s interval. The solid line shows a moving average of 16 adjacent values; the thinner dashed line shows the fitted exponential.

asked, constraining the next speaker to answer. A weaker constraint arises when an invitation is issued, and either an acceptance or a refusal may be returned. Weaker still are the constraints that apply when a remark is made on a topic in hand, providing for the next speaker simply to produce an activity that is 'on-topic,' whatever that may mean.

Sacks et al. suggest that there are certain turn positions, relatively few in number, in which the prior turn places no constraint on the initiation of a new topic. These structural positions may occur after completion of an opening sequence, as in Example 1a, or after a closing sequence of the kind shown in Fig. 1b (Schegloff, 2002). In effect they create a *free turn* for a next speaker (Schegloff and Sacks, 1973), in which he or she can act unconstrained by the prior speaker, for example by initiating a new topic.

Example 1a. From Schegloff (2002)

N:	H'llo?
H:	Hi
N:	HI
H:	Howar yuhh
N:	Fine how'r you,
H:	Oka:y,
N:	Good (0.4)
H:	mkhhh hhh
N:	**What's doin'?**

Example 1b. From (Schegloff, 2002)

Kiddo:	We'll see.
Ma:	When you and Vicki comes home. When Mark comes home. (1.0)
Kiddo:	Uhright. (0.2)
Ma:	Uhright?
Kiddo:	Yeah.

Ma: Okay.
Kiddo: Uhright.
Ma: What else?
Kiddo: Nothin'.

Three important properties, identified by Sacks et al. (1974) and exhibited by these structural positions, are as follows:

(a) the *closing down* of talk on the current topic,
(b) the resultant creation of a *free turn*, and
(c) an opportunity for the next speaker to move to *further matters* (shown in bold in the examples).

We return to these properties later when we present our analyses of doctor–patient conversations.

3. Pauses in talk when information resources are used

Our research, like the work presented in Greatbatch et al. (1993), has focused on conversations taking place in the presence of GPs' *interactions with information*. These interactions included reading and searching through paper documents, handwriting on paper, searching through computer records and entering computer data. Our principal study, of medical consultations, focused initially on how the use of computer- and paper-based systems affected GPs' ability to conduct their consultations within the limited time available. We anticipated that opportunities might emerge to improve the systems; our first step towards this goal was to understand how they were currently being used.

3.1. The study of medical consultations

During two separate weeks in 1998 and 1999 we observed and videotaped four GPs working in primary-care medical centres in east London. The four participating GPs typically scheduled one or two consultation periods each day, lasting up to two hours, during which they saw a dozen or more patients for 5–10 min each. We videotaped six consultation periods, collecting between 1 and 2 h of recordings from each GP, for a total of nearly 7 h consultation data covering 52 consultations.

The GPs we studied performed interactions with information in every consultation. They checked patients' records, read hospital correspondence, made notes, filled in forms, looked up the side effects of medications and prepared prescriptions. At the time of our data collection, each of the two medical centres was equipped with a network of text-only terminals, connected to a computer running an Integrated General Practice System, supplied by Vamp Medical and complying with requirements drawn up by the UK's National Health Service (NHS), who also covered the system's cost. All four GPs had at least 3 years' experience of using the system, but were nevertheless still relying quite heavily on paper-based records.

Although all four GPs had identical computers in their offices, they varied in how they used the two information media:

- D1, male, not a touch-typist, preferred to use his computer only to check the list of patients waiting to be seen and to print prescriptions; otherwise he relied almost exclusively on paper notes and handwriting;
- D2, male, also not a touch-typist, always used his computer, except when obliged to read paper correspondence or to complete pre-printed paper forms;
- D3 and D4, female, both touch-typists, used both media extensively, showing a slight preference for using paper.

Our recordings therefore promised to cover a useful cross-section of how medical information, including paper- and computer-based records, was being used.

3.2. The distribution of pause durations

The conversational pause is recognized as an important resource in the organization of conversation, conveying meaning through its position in the talk, its duration and the gestures that may accompany it (Tannen and Saville-Troike, 1985). The duration of a particular pause can therefore be of some relevance to the analysis of a conversation, but the larger-scale analysis of pause durations has received little or no attention. We found we needed to conduct such analyses when, while studying our GPs' interactions with their paper and computer records, we noted the presence of pauses and the regularities in their durations. We believe our findings to be original.

It was, therefore, in the course of investigating GPs' interactions with information that we started measuring the durations of the accompanying pauses. We noted every pause in the recorded data, other than those of less than 1 s. The remaining 430 pauses were measured to an accuracy of 0.1 s, and their details were stored in an Excel spreadsheet along with transcripts of the surrounding conversational turns.

The distribution of the 430 pauses' durations is shown in Fig. 1. It follows an exponential decay; that is, the number of pauses of a particular duration, t, is roughly proportional to $\lambda e^{-\lambda t}$, where λ is the exponential parameter. The estimated value of λ here is 0.206 ($0.187<\lambda<0.226$, 95% confidence) and was determined using the least likelihood parameter estimation (Kanji, 1999).

Fig. 2 shows the distributions of durations in the two conditions of computer use and paper use during the pause. The distribution is not greatly affected by the GP's choice of resource. However, there are more short pauses and fewer longer pauses when paper is used. This difference is significant with $\lambda=0.261$ ($0.230<\lambda<0.293$, 95% confidence, $N=265$) for paper and $\lambda=0.154$ ($0.132<\lambda<0.179$, 95% confidence, $N=165$) when computers are used.

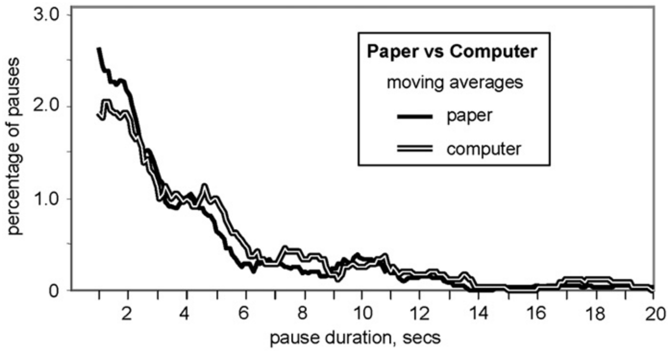

Fig. 2. Distributions of pause durations, the solid line showing those pauses occurring during paper use by the doctor, the double line those occurring during computer use.

In our visual inspections of these charts we noted a feature in the 4–6 s range of all series; another feature occurred at around 10 s in the two series for D3 and D4. This led us to perform additional analyses.

4. Conversation around pauses in consultations

For the reasons just explained, our interpretation of individual pauses has drawn primarily on methods of conversation analysis, as described in Sacks (1992). In applying these to the conversations surrounding each pause, we noticed differences in their structures according to who broke the silence and whether this coincided with completion of the interaction. We present here the principal differences, illustrating them with examples and including drawings showing each of the GPs' offices. As before, we show pauses by their durations in seconds, enclosed in parentheses.

4.1. Preferences displayed by witnesses to longer interactions

In Example 2 a GP (D1) is taking handwritten notes and conversing with G, the grandmother of a small boy suffering from a skin complaint:

Example 2.

1. D1: [*writing*] She should try and avoid the more [*stops writing, looks up*] biolo-, um
2. G: She uses all the non biological stuff anyway.
3. D1: Yeah. [*looking down at notes, resumes writing*] That's what I mean.
4. G: She always has, because he was born with the eczema.
5. D1: [*nods*] Okay. So she already knows about it. [*still writing, see* Fig. 3]
6. (9.0)
7. D1: [*lifts pen to start a new line*]
8. G: And dad said [*D1 stops writing and looks up*] to tell you that if you thought he needed to see a, a skin specialist they're in Boots. Just to tell you.

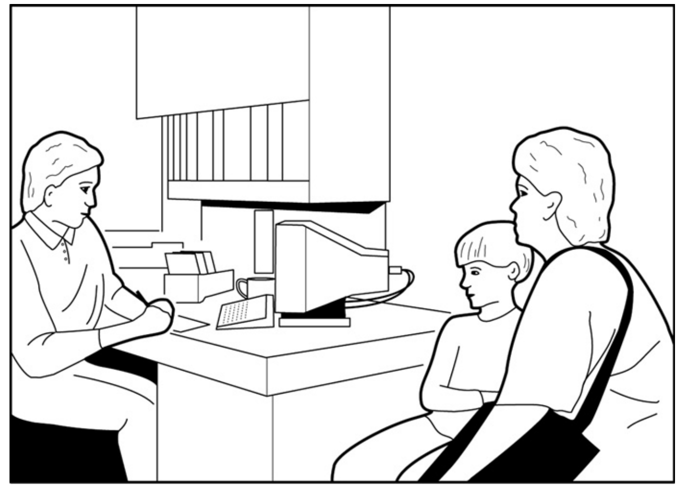

Fig. 3.

9. D1: [*smiles*] Oh I don't think it's that bad.
10. G: Well I've just told (0.5) what I've been told.
11. D1: Yeah.

In line 5 the GP initiates the suspension of talk. This involves completely closing down the conversation, which he achieves with the aid of three components: first by bodily shifting attention to writing; second by closing the current topic, on appropriate fabric conditioners, through an acknowledgement token (‘‘Okay’’); and third, through a ‘state summary’ (‘‘So she already knows about it’’). The patient orients to this suspension initiation by not continuing ‘on topic.’ Thus suspension of all talk is mutually achieved, and clearly separated from the ensuing writing, in a manner similar to that described by McGrath et al. (2007, p. 110).

Following 9.0 s of silence the patient, in line 8, lifts the suspension of talk and marks that she is now moving onto a further matter (‘‘And dad said…’’). As noted in line 7, the GP has just lifted his pen to start a fresh line, and the patient may be orienting to a perceived system-use boundary in the manner described in Greatbatch et al. (1993).

A similar sequence of interaction occurs in the next example (quoted earlier), in which the GP (D2) is examining the patient (P1) and then turns to his computer.

Example 3.

1. D2: [holding stethoscope to P1's neck]
2. Take a big breath [opens and closes mouth] Hold it.
3. (4.0) Okay, all right. And again.
4. (5.0) Okay, that's fine.
5. [turns, starts typing, see Fig. 4a]
6. (11.8)
7. P1: [D2 finishing up typing] I 'ad cream for arthritis and it's fine doctor.

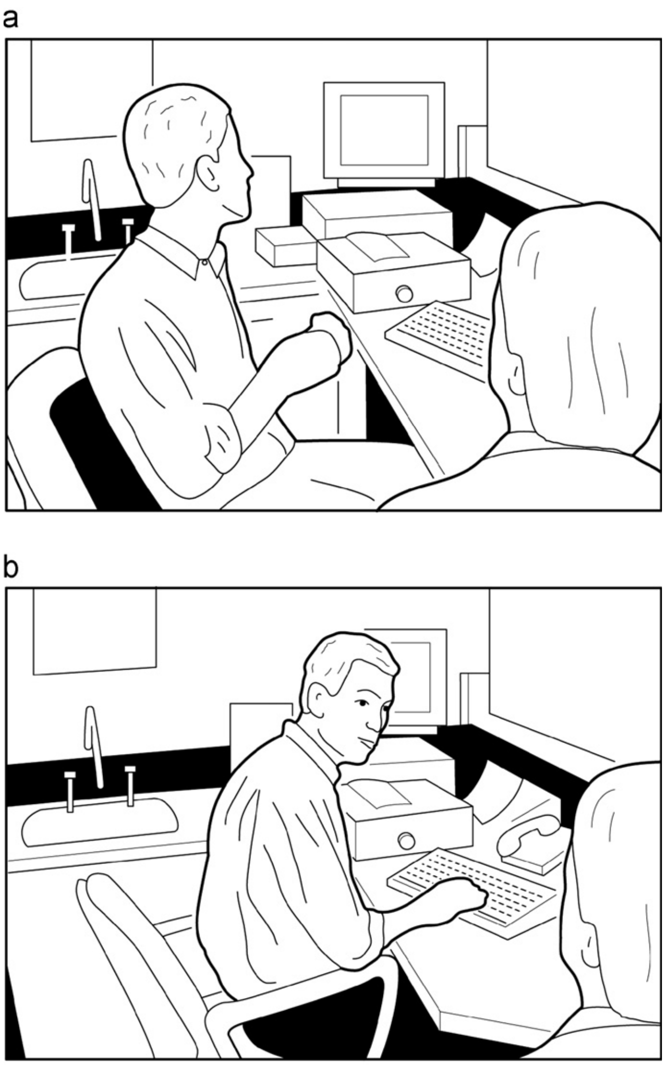

Fig. 4.

8. D2: [turns to P1, see Fig. 4b] D'you want some more?
9. P1: Please.

Here we see the GP twice instructing the patient and then listening to patient P1's neck (lines 2 and 3). P1 does not respond verbally to the instructions, however, but remains still and unresponsive in the manner described in Heath (1986, pp. 107–114). In line 4 the GP completes his examination and initiates a suspension of the talk with a summary token "that's fine" and by bodily turning to his keyboard. In line 7, following an 11.8 s silence, the patient lifts the suspension by moving onto another matter ("I 'ad cream for arthritis"). The GP picks up on this change of topic ("D'you want some more?") in line 8.

4.2. Preferences displayed by those engaging in longer interactions

Our analyses of conversation suspensions are suggesting that it is not just witnesses to interactions who orient to a suspension threshold of approximately 10 s, but also those who are interacting with information, viz the GPs in our study. Example 4 shows the first few turns in a consultation between the GP (D4) and a patient (P3), who is expecting results from some tests:

Example 4.

1. D4: What's happening?
2. P3: Ermm, everything's fine actually, it's only that I wanted to come and make sure you're getting the results actually, because it's been a long time.
3. D4: [*looks at record*] That's right, I haven't seen you for ages, have I?
4. P3: No.
5. D4: Mm. [*pulls out and unfolds letters*]
6. (7.8)
7. D4: What were all these results?

The GP's suspension of talk, in line 5, involves similar components to D1's suspension in Example 3. D4 closes the topic of P3's concern about results, commenting instead that "it's been a long time" since P3's last visit, which P3 acknowledges. D4 then attends to extracting some letters from P3's record envelope and separating them into two sets. After 7.8 s of silence D4 resumes the conversation with the question "What were all these results?"

4.3. Suspension-resumption sequences

In the preceding examples we observe a 'suspension-resumption' sequence in talk. It incorporates the same three structural components identified by Sacks et al. (1974) and mentioned above: *closing down* of talk on the current topic, which results in creating a *free turn*, and which may offer an opportunity for the next speaker to move to *further matters*.

Closing down is usually undertaken by the GP. The resultant opportunity to speak may be taken up by the GP; we see this in Example 4. Alternatively the patient may seize the free turn, and the GP then has the opportunity either to talk to the matters raised by the patient, as in line 8 of Example 3 above, or to dismiss them as in line 9 of Example 2.

There is an unusual characteristic of these free turns in medical interaction. At a structural position like this when the conversation has been closed by one party, the other party would normally take up the free turn immediately as shown earlier in Examples 1a and 1b. The conversation would thus continue with the usual absence of gap or overlap between speakers (Sacks et al., 1978). In this case, however, there is a silence, which may be broken by either party. We account for this by the fact that the GP, in closing talk on the topic, shifts attention to interacting with information. The topic has been closed and the talk suspended, but the actual interactional session has not been closed. Rather it remains open, offering a timeframe within which either GP or patient may take up the free turn.

The free turns also have an important property, previously described by (Button, 1987), concerning resumptions of closed-down topics. It is common for conversational turns to be closed down when they have, in some sense, run their course. This has been illustrated earlier in Examples 1a and 1b. The suspensions we are observing here, however, are motivated by the GP's need to refer to the patient's records, and this may be too urgent to justify carrying through the current topic to a natural closure. Sometimes the GP is able to refer quickly to the records without closing the conversation, as in line 3 of Example 4 above, where P3 has said, "It's been a long time," and D4 is able to check the date of P3's most recent appointment and respond without a pause, "That's right, I haven't seen you for ages." After a full closure and a lengthy free turn, however, the GP faces extra work in opening the previous topic. This is illustrated in the next example, involving D2 and a patient with back trouble:

Example 5.

1. D2: How long have you been off? It's been quite a while hasn't it? [*filling in form*]
2. P11: Yes it's been about four weeks.
3. (13.1)
4. D2: It's just so disabling isn't it?
5. P11: Pardon?
6. D2: It's so disabling, having back trouble. It's just a…
7. P11: Yeah.

Here we see in the line 4 an example of what Button has termed a *back reference*, a restatement of the topic of a closed-down conversation. We also see an instance of a related problem in consultations: an unsuccessful attempt to avoid restating a prior subject. We found a number of examples of this problem in our data, indicating that GPs may on some occasions err on the side of avoiding such restatements.

These findings led us to study interactions involving shorter pauses, well below 10 s in duration. These usually occurred when the GP's interaction with information was itself relatively short. We took the same approach as before, analysing the conversations on either side of the pauses, looking in particular at cases where the resumed talk referred back to the topic of the suspended talk.

4.4. Suspensions during short interactions

In our next example the GP (D4) is interleaving her note-taking with her questioning of a patient complaining of stomach pains (P5). This leads her to pause while reviewing the patient's on-screen medical history:

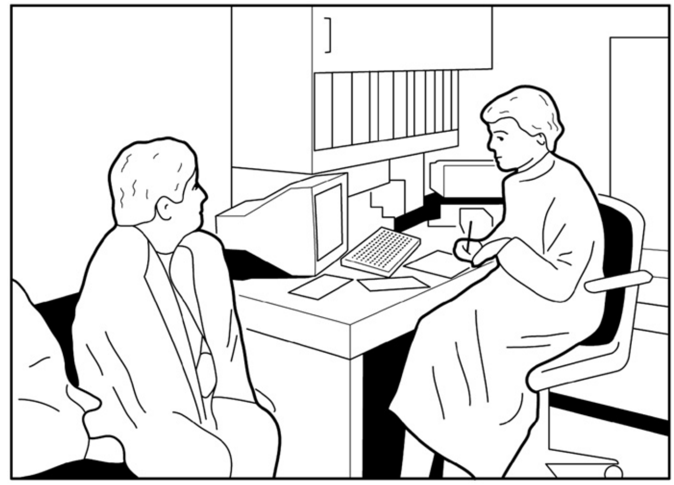

Fig. 5.

Example 6.

1. D4: You've had cancer?
2. P5: Mhm.
3. D4: And that was back in eighty six? [*bends head, writes*]
4. P5: And that was basically diagnosed bone cancer.
5. D4: [*looks up at screen*] Oh, yes. [*looks down, continues writing*]
6. (3.0)
7. D4: [*looking up at screen, see* Fig. 5] And whereabouts in the bone was that? [*turns to P5*]
8. P5: The back, spine.
9. D4: Was it?

At line 5, prior to D4's pause, there is a notable absence of any action by her to close off conversation, other than to lower her gaze to her notes. After 3.0 s D4 lifts the suspension by asking P5 for clarification ("And whereabouts in the bone was that?"), thus maintaining the topic without a restatement.

In Example 7a, D3 is preparing a prescription for her patient P8, who asks for a particular medication, Thyroxine:

Example 7a.

1. P8: And my Thyroxine please.
2. D3: Let me see when you last had your blood test for your thyroid. [*leafing through paper notes*]
3. (4.9)
4. D3: [*reading notes*] You're due (0.5) oh no, it's September you had it. Yes.

D3 responds to P8's request by raising a related matter, the date of P8's most recent blood test, which she looks for in P8's paper notes. After 4.9 s silence she starts, on line 4, to announce a date she has found, but pauses briefly and appears to correct herself ("You're due… oh no"). She then announces September as the date and confirms it ("Yes").

In Example 7b, however, we see how Example 7a continues, with a somewhat longer pause:

Example 7b.

3. (4.9)
4. D3: [*reading notes*] You're due (0.5) oh no, it's September you had it. Yes.
5. (7.0)
6. D3: September? You had a blood test?

In line 6, D3 asks her patient to confirm the date, offering her earlier answer ("September?"). However, she also immediately restates the topic ("You had a blood test?"), a clarification that she was able to omit on line 4 ("It's September you had it."), following a shorter pause.

Example 8 shows a more extreme after-effect, following a pause of nearly ten seconds:

Example 8.

1. D3: [*putting tube away in drawer*] We like you to be up to four hundred
2. P4: Yeah.
3. D3: [*turns to desk*] If we can [*starts writing*] (0.8) But it's still up. [*starts writing notes*]
4. (9.6)
5. D3: Can you take penicillin?
6. P4: Yeah.

Here, P4 has just taken a lung capacity test. D3 is commenting on the result, and then starts to take some notes. After a pause of nearly 10 s she asks P4 a question on a topic (reactions to penicillin) that has no obvious relevance to the previous topic.

These cases have presented several orchestrations of talk and information actions around pauses of different length. The speaker who lifts the silence has varying success in maintaining the current topic of conversation and its context. In Examples 6 and 7a,7b, D4 curtails her note-taking to 3 s, then picking up the subject (bone cancer) with the reference, "And whereabouts … was that?" In Example 7a, D3 is able, after a 4.9 s pause, to resume talking about the patient's blood test as "it". In neither case is there a need to restate the subjects explicitly, as "the cancer" or "the blood test." But immediately after her resumption, and a subsequent seven-second pause, D3 returns in Example 7b to the same topic, but has to restate it ("You had a blood test?"). In Example 8, D3 pauses for nearly 10 s, and then changes the topic entirely.

4.5. *Distribution of short pauses*

Examples like these suggested to us that topic change might be a factor when interactions and pauses are relatively short in comparison to the 10-s timeframe. We therefore coded all 430 pauses according to whether the topic was 'unchanged', i.e., retained without restatement (as in Examples 6 and 7a), or was 'changed/restated', i.e., restated (as in Example 7b) or changed as in Example 8.

Our method for distinguishing between these two types of pause relied on preparing an edited set of all transcripts of the conversational turns around pauses. In each transcript we replaced the durations of the pauses with a simple indication that a pause occurred, to avoid biasing the outcome. We then arranged the transcripts in a random order. Our coding was based on whether the turn following the pause appeared to comply with rules of uninterrupted conversation, for example, as described in Sacks et al. (1974). Thus the following sequence would comply, according to this criterion, and would be labelled 'unchanged':

P: And that was basically diagnosed bone cancer.
D: Oh, yes. (pause)
D: And whereabouts in the bone was that?

The following sequence would not comply, and would be labelled 'changed/restated':

D: We like you to be up to four hundred
P: Yeah.
D: If we can. But it's still up. (pause)
D: Can you take penicillin?

A pause that could not be placed with confidence in either category was coded 'not confident.' Nearly half of the pauses—208 in number—fell into this category.

Coding was done primarily by the first author. The third author independently conducted a sample of 57 of the 430 pauses to validate the coding. This produced 50 codes matching those of the primary coder. Of the seven mismatches, six were resolved by holding a meeting to clarify the coding criterion. The outcome, of 56 matching codes out of 57 (98%), gave high confidence in the validity, consistency and reliability of the first coding. The distributions of the remaining 221 'confident' cases are shown in Fig. 6.

As Fig. 6 shows, the exponential parameters for the two conditions are significantly different. With a topic change or restatement, $\lambda = 0.125$ ($0.106 < \lambda < 0.146$, 95% confidence, $N = 156$), but with no change $\lambda = 0.583$ ($0.509 < \lambda < 0.662$, 95% confidence, $N = 222$). Using these estimates we calculate that 90% of pauses with no topic change or restatement are shorter than 4.95 s (between 4.48 s and 5.53 s with 95% confidence), whereas with a topic change, 90% of pauses are shorter than 19.40 s (between 16.82 and 22.67 s with 95% confidence).

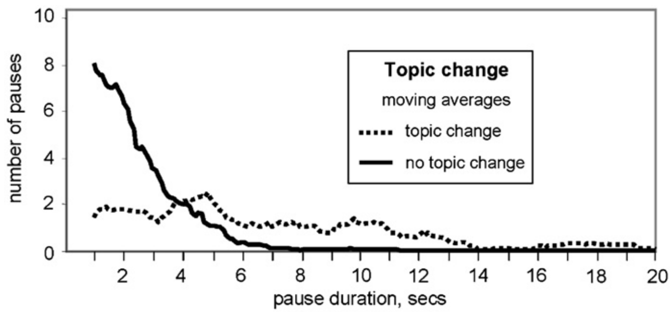

Fig. 6. Distribution of pause durations when the topic changes (dotted line) and when it remains unchanged (solid line). Moving averages, 16 adjacent values, 0.1 s intervals.

This analysis thus indicates clearly the presence of a 5-s timeframe within which the resumption of conversations without topic change is almost always achieved. The broken line shows that conversations resumed with a topic change had a much wider distribution of durations.

4.6. Intermediate remarks made during lengthy interactions

One further behaviour that we observed, and that contributes to our understanding of pause durations, relates to the unavoidably lengthy interactions that the GPs sometimes had to carry out. These interactions included reading letters, filling in forms and typing multi-item prescriptions. Such tasks, which sometimes lasted more than 2 minutes, were rarely completed in total silence. Instead the GP resorted to 'topping up' the available silence by making a series of brief displays of engagement in the form of *intermediate remarks*. Here, for example, we see D4 making two such displays, on lines 7 and 9, while reading correspondence:

Example 9.

1. D4: You're ask–, you're saying [*picks up letters*] about the results from what's been happening in the hospital?
2. P7: Yes, they discharged me from there. [*D4 sitting back and reading letter, scratching back of her head*]
3. D4: Hm.
4. (4.2)
5. P7: [*D4 sits up*] They (inaudible) [*D4 leafing through letters*] refer back to say your doctor (inaudible) [*D4 reading letter*]
6. (6.6)
7. D4: Right.
8. (3.2)
9. D4: They really pass the buck don't they?
10. P7: [*turns towards her husband sitting next to her, smiles, turns back to D4*]
11. (2.7)
12. D4: So this is [*looking at P without raising head*] regarding getting some IVF treatment?
13. P7: Yeah. [*nods, D4 looks back at letter*]
14. D4: Okay.

The production of these seemingly trivial intermediate remarks ("Right" and "They really pass the buck…") presents the GP with non-trivial choices of timing. While the remark can be introduced early in the silence without a topic change, leaving it till later not only forces a topic change but risks resumption on this topic by the patient. The remark may be misinterpreted by the patient and treated as a resumption, as illustrated in the next example:

Example 10.

1. D3: So let's make it the second of February.
2. If I've done that. [*turns to form, writes*]
3. P8: That's all right.
4. (10.5)
5. P8: [*exhales heavily*] Hhhh.
6. (3.0)
7. D3: [*stops writing, looks up at P8*] Poor old you! [*resumes writing*]
8. P8:How old?
9. D3: [*still writing, smiles, see* Fig. 7] Poor old you, I said.
10. P8: [*laughs*] Ho oh, I see.
11. D3: I hope these tablets work for you.

This example is taken from an earlier point in the same consultation as Examples 7a and 7b. D3, after closing down the talk, begins to fill out a form, a task that will ultimately take her 43 s. After 10.5 s the patient P8, who is watching D3 closely, exhales audibly. D3 continues to write for 3 more seconds, and then makes an intermediate remark ("Poor old you") while briefly suspending writing. P8 appears to hear only "old" and "you" clearly, and checks with D3 whether she is raising the matter of P8's age ("How old?"). This prolongs the conversation for several more turns.

Fig. 7.

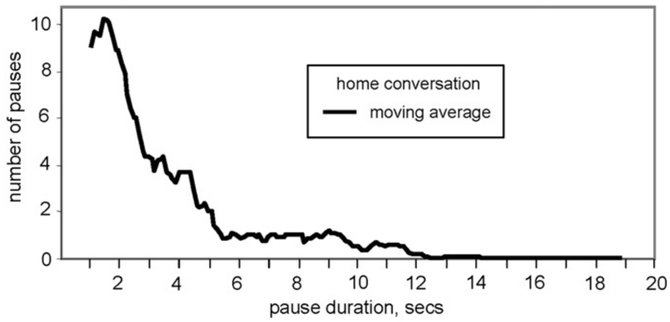

Fig. 8. Distribution of pauses in home conversation. Moving averages of 16 adjacent values at 0.1 s intervals.

4.7. Pauses in home conversation

We were keen to eliminate one other possible source of the two features in Figs. 1 and 2, namely the special relationship between doctor and patient. The observations made by Heath about patients' difficulties in obtaining GPs' attention, and GPs' tendencies sometimes to mishear what patients had said, suggested that there might be special constraints on pause durations. We therefore conducted a similar analysis of pauses in conversations occurring in the home.

The data we used for the home-conversation study had been collected at around the same time as our own recordings by the Institute of Communications Studies at the University of Leeds, who made the data available to us. Each of 32 homes was equipped with video cameras in three rooms, and recordings were made on 10 successive days in each home, during the roughly 6 h when the families were at home and awake. We selected two families whose joint activities sometimes involved use of a computer or calculator, for example when updating the family business's accounts or tutoring a neighbouring child in mathematics. We analysed approximately 4 h of these data, in which we found 342 pauses of one second or longer. The distribution of these pauses is shown in Fig. 8.

Again, the chart shows departures from the exponential in the region of 5- and 10-s duration. We regard this as further evidence that these are critical points in conversational pauses around which the participants organize their turn-taking.

5. Discussion and conclusions

In summary, we are observing two *timeframes* in the pauses in two-party conversations that occur when one party interacts with a computer, paper records, or another information resource. One of these timeframes, 10 s in extent, is treated by the parties as a preferred period within which either party may resume the conversation. In the medical consultations we observed, nearly 90% of all resumptions occurred within 10 s.

A second timeframe, spanning the first 5 s of conversational pauses, covers a preferred period for resuming on *the same topic*, without restating it, after a conversation has been suspended during interaction with information. We found that 93% of all resumptions which maintained the previous topic occurred within 5 s.

These timeframes have emerged from a study of medical consultations in which the conversations were between GP and patient. Our second study, drawing on video data collected from families at home, indicated that similar timeframes are present in their conversations. This suggests that the timeframes are present in conversations generally – at least within the UK – and are not a by-product of the doctor–patient relationship. The timeframes must, we think, have physiological and cognitive sources.

5.1. Possible sources of the timeframes

An explanation for the 10-s timeframe lies, we suggest, in the properties of *speech breathing*, i.e., human respiration during speech. This typically uses between 25% and 40% of the speaker's vital capacity, which for adult males averages about 4 l. At a laryngeal flow rate of 130 ml/s, this gives a duration of 7.7 s at 25% use, and 12.3 s at 40% use (Hodge, 2007). McFarland has conducted studies that confirm these predictions (McFarland, 2001), and Winkworth et al. (1995) have published charts showing women's speech breathing cycles reaching 8 s.

Drawing breath introduces a break in speech that can facilitate turn-taking. The tendency of such breaks to occur at regular intervals must, we suggest, promote a concentration of speaker changes around this point. We are unaware, however, of any research supporting this hypothesis.

The five-second point, beyond which it is rare for the previous topic to be resumed, cannot be explained in terms of respiration. It seems more likely to us that topic retention is memory-constrained. Maintenance of the topic, in the sense we mean here, involves voicing a reference that links the new turn back to the previous turn. A quick and effective link can be created by a pronoun reference, e.g., "When did it begin?" or "I saw him last week," provided this reference is unambiguous. After an extended pause, the speaker's recall of the previous conversation may be inadequate; yet if speakers choose not to make a full back reference, their pronoun reference may not be understood.

5.2. Designing technologies for use during conversation

For some time after the 10-s timeframe emerge from our data analysis, we explored its implications for the design of GP support systems. A striking aspect of this timeframe is, we suggest, that both participants exhibit the same preference to break the silence before the timeframe expires. In a sense, therefore, they are both seeking the same goal. No matter who speaks first, they will both achieve their preference. The clock will then be reset and the next pause can run a similar course. We found little evidence that this pattern of events presented either participant with a problem that urgently needed to be solved.

The 5-s timeframe, which came out of further analysis, appears to us to be less benign. Here a timeframe overrun is likely to disrupt the conversation by inappropriately deflecting it away from the current topic. This deflection may not serve the preferences of either participant—its prevention may simply lie beyond their capabilities. As the pause continues beyond the timeframe, the previous topic is increasingly unlikely to survive unless restated.

For these reasons we suggest that, of the two, the 5-s timeframe is most deserving of designers' attention. We believe doctors and patients would gain significant benefits if fewer pauses were to overrun this timeframe, and we think this may be achievable through redesign of GP support systems. At present, these systems show signs of having been designed without clearly defined, soundly based performance targets. Inefficient features are common; for example, a leading product requires the GP to make selections from a drop-down menu containing 50 items, a task that is likely to be lengthy and error-prone. The situation is probably not helped the industry's focus on achieving response times rather than task performance times.

We would suggest that a more appropriate target, validated by our research, is to design systems that assist the GP in keeping pauses to 5s or less. This does not imply that the tasks themselves must be completed within 5 s, for they almost always persist for longer, by several seconds, than the accompanying pause. Indeed our data suggest that if tasks are completed within 8 s, only one-fifth of the accompanying pauses will exceed 5 s in duration—a proportion that needs further investigation. We suggest, therefore, that an eight-second task could be considered as a target for future GP support systems.

We are fully aware that compliance with this requirement alone is not going to result in disruption-free consultations. However, there are three substantial benefits to be gained from following the approach we have taken. First, other crucial design criteria, similar to our timeframes, may be discovered. Second, design targets like the sub-8-s task can be tackled a step at a time, and will pay off even when less stringent targets are achieved. Third and perhaps most important, research in this area can achieve a greater influence on the design of systems for medical practitioners.

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