Auditory effects of some Millennium celebrations in Germany

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Summary *We compared the effects of certain Millennium celebrations in Germany during the period 1997/1998 through 2001/2002. Ten festivities related to the turn of the year were analysed, including the huge Millennium events in Berlin and Frank-furt, using pure-tone audiometry up to 16 kHz. Results suggest that the Millennium celebra-tions caused relatively little auditory damage; in fact, in Giessen the Millennium festivities did not lead to more damage than during the normal turn-of-the-year-festivities. Over-all, 75 % of persons presenting at local ENT departments within 3 days were male, but 94 % of those with serious damage were men. The largest number of cases of damage to hearing occured in the age range 21- 30 years." Blank pistol shots were the major source of injuries. In nearly all cases of injury, the damage was caused by only one shot or explosion. This paper presents examples of auditory damage as well as the sound structure of a fire cracker and a blank pistol shot.*

Key words
acute acoustic trauma
acoustic impulses
Millennium celebrations
fire crackers
blank pistols

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Auswirkungen einiger Millenniums-Feiern in Deutschland auf das Gehör

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Zusammenfassung Um die Auswirkungen von Silvesterfeiern auf das Gehör zu untersuchen, führte die AG Hörforschung an insgesamt zehn Jahreswechseln Erhebungen durch. Erfasst wurden die Jahreswech-sel von 1997/1998 bis 2001/2002, wobei so vorgegangen wurde, dass jeweils zwei Personen der AG Hörforschung zum Jahreswechsel für einige Tage in der HNO-Klinik einer Universität waren und dort all diejenigen befragte und audiometrierte, die wegen Hörproblemen im Zusammenhang mit den Silvesterfeiern in die Klinik kamen. In Gießen geschah dies durchgängig, also fünf Jahre in Folge. Bei den Millenniumsfeiern - 1999/2000 - wurden zusätzlich Daten in Berlin erhoben (Charité und Freie Universität), ferner in Marburg/L., in Frankfurt/M. sowie im Klinikum Mannheim der Univ. Heidelberg. Die Befragung umfasste Angaben zu Ohr und Hörfähigkeit allgemein, sowie zum Hergang des Geschehens, das den Gang zur Klinik veranlasste. Audiometriert wurde von 125 Hz bis 16 kHz.

Im Zusammenhang mit diesen zehn Silvesterfeiern kamen insgesamt 90 Personen in die HNO-Kliniken. In Gießen, wo in fünf aufeinander folgenden Jahren Daten erhoben wurden, ließ sich keine erhöhte Fallzahl bei der Millenniumsfeier feststellen. In Anbetracht der riesigen Feiern zum Millennium in Berlin und Frankfurt kamen nur wenige in die HNO-Kliniken. Ihr Alter, bezogen auf alle zehn Jahreswechsel, lag zwischen 6 und 82 Jahren, wobei 70 % männlich und 30 % weiblich waren. Es dominiert eindeutig die Altergruppe von 21 bis 30 Jahren. 69 dieser Betroffenen wiesen ein Knalltrauma auf. Verursacher der Hörschäden waren in 42 Fällen Knallkörper, in 24 Fällen Gaspistolen, und in drei Fällen blieb die Art des knallenden Objektes unklar. 75 % der Opfer waren männlich, aber im Fall des schweren Knalltraumas waren 94 % der Opfer männlich. Gaspistolen sind Ursache vieler Hörschäden und Verbrennungen, wobei die Schützen sich teilweise selbst verletzen. In praktisch allen Fällen handelte es sich - nach Angaben der Betroffenen nur um einen einzigen sehr lauten Knall, der die Hörschäden verursacht hat.

Audiogramme zweier Opfer sind beispielhaft dargestellt. In einem Fall handelt es sich um die Auswirkungen eines starken Knallkörpers, der beide Trommelfelle zerrissen hat. Der andere dargestellte Schaden wurde von einer Gaspistole hervorgerufen, die jemand in einer Entfernung von etwa 2 m zum rechten Ohr des Opfers abgefeuert hat. Das Audiogramm zeigt den für solche Knallereignisse typischen Steilabfall oberhalb von 2 kHz. Um die Art dieser Knalle erfassen zu können, wurden Messungen mit einem für kräftige Knalle ausgelegten Kunstkopf-Mess-System durchgeführt, das Druckspitzen bis 188 dB aufzeichnet und auswertet. Aus dem Zeitverlauf des Drucks ist zu ersehen, dass diese Knalle nur etwa 2 ms andauern. Die Druckspitze bei der Gaspistole beträgt - in 1 m Entfernung - 177 dB, bei einem typischen, zugelassenen Knallkörper 163 dB. Bei den illegal eingeführten Knallkörpern ist mit erheblich höheren Werten zu rechnen.

Schlüsselwörter
Knalltrauma
Impulslärm
Millenniumsfeiern
Knallkörper
Gaspistolen

Introduction

In 1997, we decided to study the auditory effects of the forthcoming Millennium Celebrations on a low-budget basis. We wanted to know the extent of the damage caused by these forthcoming festivities and to compare the findings with data from ordinary New Year celebrations. We therefore examined the effects of the annual New Year celebrations in Giessen, starting in 1997/1998 and ending in 2001/2002. In other words, the study covered two »normal« celebrations before the turn of the millennium, then the Millennium celebrations themselves and the following two »normal« celebra-tions. Because the festivities at the turn of the millennium in a small and quiet university town such as Giessen might neither be representative nor impressive, it was decided to include some more important locations in the study. Undoubtedly, the biggest events could be expected to take place in Berlin, the new capital of Ger-many, as well as in Frankfurt/Main, the financial centre of the country. Since January 1st is always a holiday, it was decided to cooperate with the ENT hospitals of the universities in these cities, because they are always on duty, and anyone can go there for treatment in case of injury. It was possible to arrange a cooperation with the ENT hospitals of the following universities: The Hum-boldt-University in the centre of Berlin, whose medical school is known as the Charite, the Free University of Berlin, located in the western suburb of Steglitz, the University of Marburg, the University of Giessen, the University of Frankfurt/ Main, and the University of Heidelberg, in this case, its Mannheim Medical Centre.

Procedure

Specially trained teams of two went to these ENT hospitals on December 31st and stayed there through January 3rd (in a few cases until January 4th) of the following year. Patients who came to these ENT hospitals during that time were asked to fill out our questionnaire, and their hearing was tested by extended high-frequency audiometry, covering the frequency range from 125 Hz to 16 kHz. This data was also given to the hospital. Wherever possible, we tried to retest these patients at a later date in order to track their recovery from the auditory damage. During these periods, patients came to these hospitals with many kinds of hearing illnesses. However, this study deals exclusively with those people who came because of problems directly related to the celebration at the turn of the year.

The questionnaire contained general questions on age, gender, education, job, hobbies, military service, music consumption, auditory performance, diseases of the ear in general, tinnitus and sudden hearing loss in particular, as well as the consumption of drugs and tobacco. An-other section was devoted to details of the celebra-tions for those persons who were affected by them. The types of fire crackers or pistols that caused the damaging im-pulses were our main interest. We asked for informa-tion on the distance and the direction of the object that caused the damage, and we also wanted details of the general situation during these events. We also asked who they thought might have been responsible for any negative effects.

Results

In all - from December 1997 through January 2002 - there were 90 such patients. An overview is presented in Table 1. This lists the number and gender of the new patients who came to these ENT hospitals because of problems related to the festivities at the turn of the year. We cooperated with the ENT hospital of our Medical School in Giessen every year, starting in 1997/

Patients admitted to the hospital due to turn-of-the-year festivities

	1997/1998	1998/1999	1999/2000	2000/2001	2001/2002
Berlin (Charité) *)	———	———	♀ 5 ♂ 2	———	———
Berlin (Steglitz)	———	———	♀ 1 ♂ 4	———	———
Marburg / Lahn	———	———	♀ 1 ♂ 2	———	———
Giessen	♀ 0 ♂ 8	♀ 2 ♂ 12	♀ 3 ♂ 8	♀ 3 ♂ 5	♀ 5 ♂ 10
Frankfurt / Main **)	———	———	♀ 6 ♂ 7	———	———
Mannheim	———	———	♀ 1 ♂ 5	———	———

Total : 90 persons ♀ 27 (=30%) ♂ 63 (=70%)

*) approx. 1.5 million celebrating **) approx. 300 000 celebrating

Table 1: *Numbers and gender of patients admitted to the ENT hospitals of the local universities, as a result of the festivities related to the turn of the year. During the Millennium celebation at the centre of Berlin - in the vicinity of the Charite Hospital- about 1.5 million people participated in the spectacle. In Frankfurt/Main, the number of participants was approximately 300 000.*

Tab. 1: *Anzahl und Geschlecht der Patienten, die im Zusammenhang mit den Silvesterfeiern van den HNO-Kliniken neu aufgenommen wurden. An den Feierlichkeiten zum lahrtausendwechsel im Zentrum van Berlin - nahe der Charite - nahmen etwa 1,5 Millionen Personen teil. In Frankfurt/M. betrug die Teilnehmerzahl etwa 300 000.*

1998. Scarce financial resources meant that it was only possible to send teams to the five other universities during the Millennium celebrations.

At this point, a few words on the various cities and towns are appropriate in order to give a realistic impression of the festivities at the turn of the year. Berlin is a bustling metropolitan area of about 4 million inhabitants. Of its two university medical schools, the Charite is located in the historical heart of the city, while the Steglitz Medical Centre is in the western part, characterized by relatively quiet residential areas. Marburg is a well-known and quiet university town of about 85 000 inhabitants. Giessen, only about 30 km south of Marburg, is also dominated by its old university. It is quiet and, with about 75 000 inhabitants, only slightly smaller than Marburg. Mannheim, peaceful and sleepy, has about 350000 inhabitants, and is home to a medical centre that is part of the University of Heidelberg. Frankfurt/Main, by contrast, can be called the high-powered financial centre of the country and has about 650 000 inhabitants. Its huge international airport dominates the city, together with the many financial institutions.

Seen against this background, it is surprising how few people carne to the hospitals, especially in the larger cities of Berlin and Frankfurt. Comparing the numbers with those for Giessen over the five years (Table 1), it is obvious that the Millennium celebrations did not result in any more auditory damage than in the years before and after this once-in-the-lifetime event. Looking at the gender of these patients, we can see that, over-all, 30 % of them were female and 70 % were male. Since there is no reason to assume that a smaller percentage of girls and women celebrate than boys and men, there must be other reasons for these results.

The age and gender of these 90 persons are shown in Fig. 1. The youngest was a 6-year-old boy, and the oldest an 82-year-old woman. The group between 21 and 30 years of age was clearly the most affected. It can be assumed that the distribution shown in the graphic is primarily the result of unusual behaviour during the celebrations and does not reflect the overall participation of the age groups involved. A similar age distribution was seen in the victims of attacks with toy pistols, although there was a shift to a lower ages range. In the latter case, the most dangerous age is between 7 and 9 years *(Fleischer* et al. 1999a).

Audiograms of the persons were analysed and compared to the aging of the ear typical for Germany according to our data, which is based on 4 400 men *(Fleischer* et al. 2000). Combining all the information available, we concluded that 21 out of the 90 persons listed above did not suffer from auditory damage as a result of the festivities. Hence, 69 persons over-all showed auditory damage related to these festivities. In Fig. 1 they are marked by a grey dot inside the squares that represent one person in the graphic. In order to determine the severity of such damage, the individual audiograms were compared to the auditory performance that is normal in Germany for men at this age. Typically, there are notches in the audiograms as a result of strong impulse noise. If these notches are

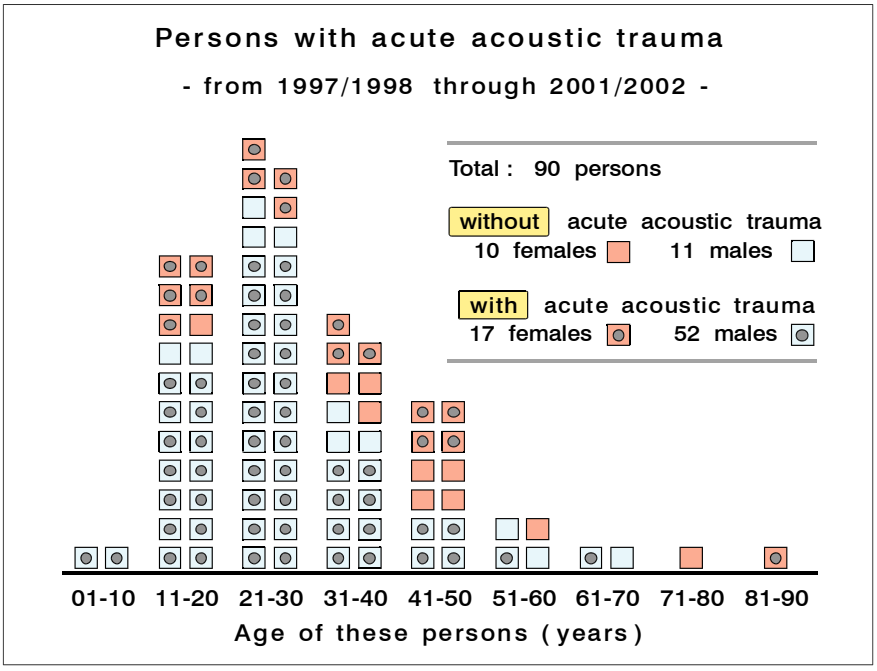

***Fig. 1**: Age and gender of persons admitted to the ENT hospitals. Each person is represented by a square in the graphic. A circle within the square indicates whether they suffered from acute acoustic trauma or not.*

***Abb. 1**: Alter und Geschlecht der von den HNO-Kliniken aufgenommenen Patienten. Jede Person ist grafisch durch ein Quadrat repräsentiert. Es wird angezeigt, ob die Person ein Knalltrauma aufweist oder nicht.*

20 to 39 dB below the usual performance at this age, this is considered as slight damage. Cases with notches of 40 to 59 dB below are considered to be of medium severity. Victims with negative effects of 60 dB or more or with wide-band ranges of bad hearing are classified as having severe damage. As mentioned above, these principles were applied over the entire frequency range tested, i.e. from 125 Hz through 16 kHz. However, most of the damage occurs at frequencies above 2 kHz. All told, there were 16 cases of severe damage, 25 cases of medium damage and 28 cases of light damage in at least one ear.

Looking at the numbers in Fig. 1, it can be seen that males are more affected by auditory damage than females. Of the 69 victims with auditory damage, 75 % were men or boys. This emphasizes the well-known fact that women are much more cautious and circumspect. Such an attitude helps them to avoid damage of all kinds.

How about the impact of the big events? The largest Millennium celebration in Germany took place right in the middle of Berlin, around the Brandenburg Gate, with approximately 1.5 million participating. Only seven people came to the ENT hospital in the Charite, located near-by, and they all had auditory damage. Another big event happened in Frankfurt/Main. Along the Main river and the adjacent area around the historical city hall, there was a huge celebration with about 300 000 participants. A photo of this celebration appeared on the cover of Time Magazine. Yet there were only nine cases of acute acoustic trauma at Frankfurt University ENT hospital, about as many as in the little town of Giessen during a normal New Year celebration. Furthermore, in three of these nine cases, the damage occurred several hours before the Millennium celebration, indicating that it had nothing to do with the event.

Of course, visitors of these festivities could have gone to other hospitals with ENT departments, even on January 1st, a national holiday. Or they could have waited and gone to an ENT-specialist in private practice. However, since January 1st 2000 was a Saturday, they would have had to wait for more than two days before getting medical treatment. Hence, it is likely that at least the more severe cases went to these university ENT hospitals without too much delay (see below). When we look at the three other ENT hospitals in the study, in Berlin-Steglitz, Marburg and Mannheim, the impression is the same. Only a very few people went there for treatment because of damage inflicted during the Millennium celebrations.

Visitors of these festivities suffer not only from the noise caused by various fire crackers, but also from the reports from pistols using blank cartridges. Such weapons are used for personal protection and to scare away birds in vineyards and orchards, but, unlike real weapons, any German adult can buy them. An overview of the objects that caused acute acoustic trauma in the 69 persons affected is shown in Fig. 2. As expected, fire crackers were responsible for most of the damage - 42 out of 69 cases (61 %). However, in 24 persons (35 %), auditory damage was caused by blank pistol shots. Three other causes were also recorded.

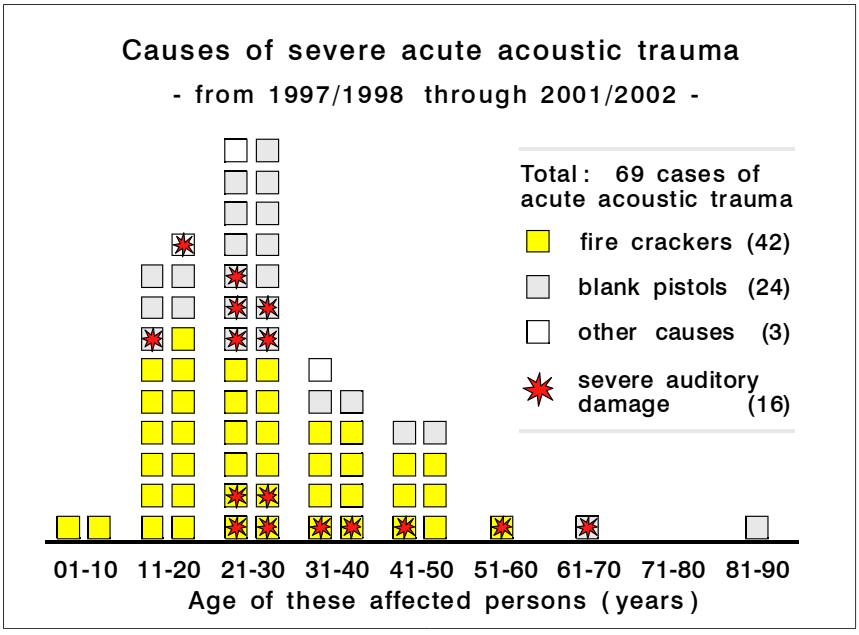

Fig. 2: *Persons who suffered from acute acoustic trauma. The causes of auditory damage are also indicated. Blank pistol shots are very dangerous. Most affected persons were in the 21 - 30 age group.*

Abb. 2: *Personen, die ein Knalltrauma erlitten. Die Ursache des Horschadens ist angegeben. Schreckschuss-Pistolen sind sehr gefiihrlich. Am stiirksten betroffen ist die Altersgruppe von 21 bis 30 Jahren.*

One was a rocket in a pyrotechnics display that was set off close by and which may have exploded prematurely. The second was an unidentified object that exploded, and the third was a slap to the ear inflicted on a 39-year-old woman as a result of a heated argument during the Millennium celebrations. While this slap caused a laceration of the left ear drum, there was only a minor auditory effect, seen as a shallow notch in the audiogram of the left ear. A loss of 25 dB extended from 1 kHz to 4 kHz. Severe damage is indicated in Fig. 2 by a little red star symbolizing an explosion. It is apparent that the use of pistols firing blank cartridges produced 7 of the 16 cases of serious damage. The unknown exploding object mentioned above also resulted in serious damage. The distribution of damage in this graphic reveals that the use of pistols is most widespread in the 21 – 30 year age group. This group also has the highest rate of severe damage, 9 out of a total of 16 cases.

Of the 69 people with acute acoustic trauma, 34 (49 %) had damage that affected both ears. This is of interest because it is generally assumed that shots or other strong impulses only affect one ear in nearly all cases. Two cases where powerful noise impulses led to serious damage are presented in Fig. 3. In the first case the fire cracker exploded about 30 cm from the head, on top of a door post. Presumably it was let off as a joke. Bone conduction is indicated, but it has to be emphasized that bone conduction is often erratic

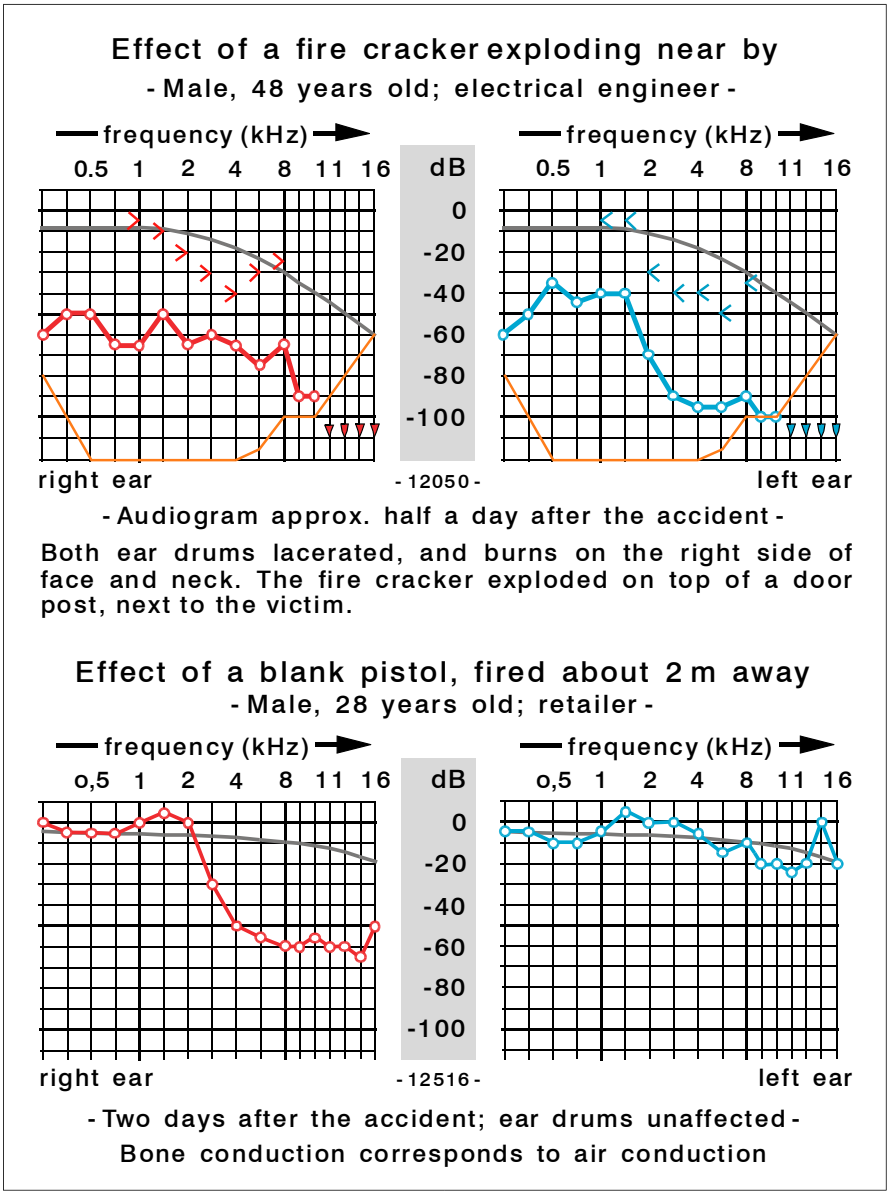

Fig. 3: *Audiograms of two persons affected. Pure-tone audiometry up to 16 kHz. Audiometer: Hortmann CA540; headset: Sennheiser HDA200. The smooth grey line indicates the »normal« performance for German males at this age, based on data from 4.400 persons collected by our group.. Auditory effect of a powerful fire cracker (top) and of a blank pistol shot (bottom). The pistol was fired to the right of the victim, about 2 metres from the ear.*

Abb. 3: *Audiogramme von zwei betroffenen Personen. Reinton-Audiometrie bis 16 kHz. Audiometer: Hortmann CA540; Kopfhorer: Sennheiser HDA200. Die glatte, grau dargestellte Linie repräsentiert die in Deutschland in dem Alter »normale« Hörfähigkeit, nach einer Analyse der AG Hörforschung, basierend auf Hörtests von 4.400 männlichen Personen. Oben ist die Auswirkung eines starken Knallkorpers auf das Gehör dargestellt und unten diejenige einer Gaspistole. Die Gaspistole wurde rechts vom Betroffenen abgefeuert, in einer Entfernung von etwa 2 m.*

after such traumatic exposures of the ear. The suspension system of the ossicular chain is severely torn by the massive impulse, leading to a reduced ability of the ear to protect itself against unwanted vibrations. Hence, it often appears that bone conduction is greatly »improved« shortly after such a traumatic event. Auditory performance that is normal in German men the same age as the victim is indicated by the smooth grey lines in Fig. 3.

Fire crackers come in many different forms, some manufactured in the EU with its restrictions on energy output. However, many other crackers used in Germany are illegally imported from Eastern Europe or East Asia, and it is well known that at least some of them are very powerful and dangerous. While the persons affected nearly always know what type of device (e. g. a fire cracker) caused the damaging acoustic impulse, the name of the product and the manufacturer are practically always unknown. In order to give at least some idea of these impulses, we measured the sound structure of fire crackers that are popular and legal in Germany. We took acoustic measurements using an artificial head that is designed specifically for strong impulses and can measure signals up to 188 dB linearly. It was a so-called »normal« fire cracker that produced the impulse shown on the right in Fig. 4. At 1 metre laterally distant from the measuring ear, the peak pressure was 2.84 kPa, corresponding to a peak of 163 dB. Duration of the impulse is quite short, lasting only about 1.5 msec. A shot from the G3 rifle used by the German army is by comparison about five times longer.

As already mentioned, pistols that fire blanks are quite dangerous, and their auditory effect can be seen in the lower part of Fig. 3. This audiogram shows the damage caused by a blank pistol shot, fired about two metres away from the right ear of the person affected. While the low frequencies are apparently not affected, there is a deep trough on the right side above 2 kHz. An audiogram like this is quite typical of an acute acoustic trauma. Since the person affected in this case was a retailer without noisy habits, it is not surprising that his left ear showed relatively good hearing. There may be some minor effect at around 11 kHz resulting from the pistol shot. In more severe cases, however, we sometimes observe that it is the ear which is not primarily affected that can be damaged much more severely. Again, the smooth grey line shows the auditory performance that is typical for German men at this age.

There is another interesting aspect. All persons affected were thoroughly questioned about the circumstances of the event that caused the damage. As is usual in studies dealing with the effects of short (needle-like) impulses, there were people with deep notches in their audiograms within the frequency range of about 11 to 14 kHz. An examination of the data

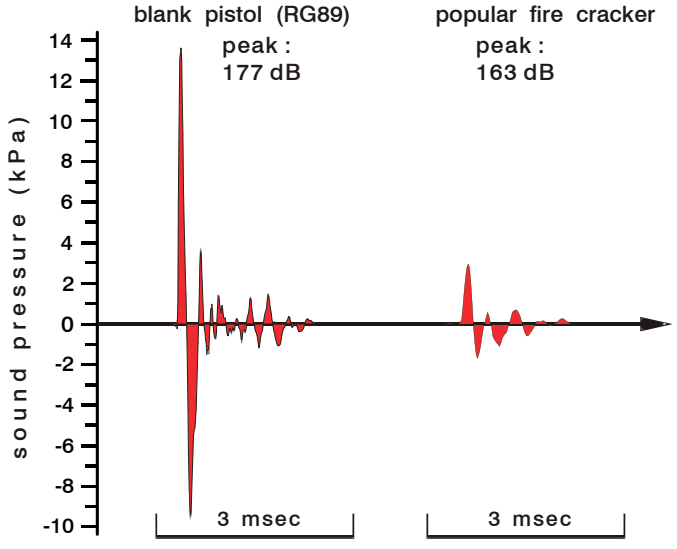

Fig. 4: *Structure of two acoustic impulses, measured with a customized impulse dummy. Both impulses are presented in identical coordinates. In the EU, it is illegal to expose the unprotected ear at the workplace to peak pressures above 200 Pa (= 140 dB), measured at the ear.*

Abb. 4: *Druck-Zeitverlauf zweier Knalle, gemessen mit einem speziell für starke Knalle entwickelten Kunstkopf. Beide Knalle sind in identischen Koordinaten dargestellt. In der EU ist es verboten, das ungeschützte Ohr am Arbeitsplatz Knallen auszusetzen, deren Druck-spitze oberhalb von 200 Pa (= 140 dB) liegt, und zwar gemessen am Ohr.*

available revealed that the exploding object was within 1 metre of the affected ear in practically all of these cases. This means that it was more or less a near-field condition that caused the damage. However, if the impulse is extremely powerful - like a blank pistol shot fired less than 1 metre from the ear - the narrow notch dramatically widens to both lower and higher frequencies. This permanent damage is characterized by a very steep slope at 2 kHz or 3 kHz. Such steep slopes are the traces of at least one very powerful impulse.

The sound structure of a blank cartridge fired from a powerful German pistol is shown on the left in Fig. 4, measured using the system mentioned above and also at a distance of 1 metre from the measuring ear of the impulse dummy. Hence, it can be directly compared to the explosion of the fire cracker shown on the right of Fig. 4. Obviously, the impulse of the pistol is much more powerful. While the fire cracker transported to the measuring ear had roughly the same amount of acoustical energy as half a day's work at a continuous level of 85 dB(A), the pistol emitted about ten times as much again. In this case too, the pistol shot was very short, lasting for about 2 milliseconds altogether. Considering the accidents during these celebrations, we have to keep in mind that illegal fire crackers in particular can be much more powerful than the one shown in Fig. 4. However, the most important factor is the distance between the cracker and the ear(s) involved. Reducing this distance by half increases the energy emitted to the ear(s) fourfold. There is an additional increase in pressure very close to the ear because the head acts as a barrier to the emission of sound. Clearly, the distance between the ear and the exploding object is of utmost importance for the development of auditory damage. The smaller the distance, the greater the danger to the ear.

When we consider all of the data collected, a number of interesting aspects become apparent. Practically all of the persons affected attributed their injury to one brief event, either to a fire cracker exploding nearby or a pistol being fired at close range. Thus, it was not the generally very noisy environment during these festivities that caused the damage to these individuals. Instead, a few, relatively rare events involving strong impulses did actually result in injury. It is therefore understandable why there were so few accidents during these large Millennium celebrations. Obviously, the high level of more or less continuous noise in these huge events is not so critical, especially since the sound level was caused to a great extent by loud music. On the other hand, it is very dangerous for the ear if some freaks in a quiet backyard fool around with crackers or fire pistols recklessly. This explains why there were so many accidents in a sleepy place like Giessen, as shown in Table 1. It also gives us an understanding as to why 26 % of the damaging accidents occurred before the actual turn of year, in other words, before midnight on December 31st. Those relatively few people who could not wait until the start of the New Year were obviously fiddling around on the fringe of the large events in a more or less quiet environment.

We also wanted to know what happened after the injury occurred. Understandably, the majority of the persons affected (64 %) went to the hospital within 24 hours, and another 30 % during the following day. So only 6 % of the persons affected came to the hospital after a time lag of more than two days, and all of these were males.

Ten persons suffered severe auditory damage in both ears, and in six of these cases blank pistol shots caused these injuries. Five people suffered from burns to the face, neck and hands. In four cases, this damage was caused by fire crackers and in one case by a blank pistol shot. Four people had their ear drum(s) lacerated. Fire crackers caused three of these lacerations and one resulted from a massive slap to the ear. Bearing in mind other experiences with pistols, it can be said that we did not see a single accident where a pistol caused the ear drum to rupture. One person was especially unlucky, because he suffered both from lacerations of the ear drum and burns to the face.

All told, there were 16 cases of severe auditory damage, with 15 of the persons affected being male. Many men and boys are much more reckless than females. In a study on the auditory damage caused by toy pistols *(Fleischer* et al. 1999a) it was shown that 95 % of both victims and perpetrators were boys.

With 69 persons affected of such injuries documented, we wanted to know who might be responsible for these accidents. Every person affected was asked for his or her opinion. To no-one's surprise, 53 (77 %) of them said that somebody else was responsible. However, 11 (16 %) said that the accident was their own fault. Interestingly, all of those who admitted that it was their own fault were male, except for a 12-year-old girl. Five persons stated that it was unclear who was at fault. But probing a little bit deeper revealed unexpected details. Of the 11 persons affected who blamed themselves, six were injured by pistols. In other words, these six people hurt themselves by firing blanks from a pistol. Furthermore, of the five people who were unsure who was to blame, three also suffered injuries from blank pistol shots. It is reasonable to assume that

they would not have hesitated to point an accusing finger at somebody else, had they not pulled the trigger themselves at the time of the accident. Thus, nine out of a total of 24 persons affected of blank pistol shots appear to have suffered injury as a result of firing the pistols themselves.

Because of the relatively short period of contact with the persons affected, it was not possible to examine the long-term effects caused by these events. Can we assume that at least those 38 persons who suffered medium or severe auditory damage may have been permanently injured?

Tinnitus was not of primary interest, but one special cases should be mentioned. A 45-year-old woman had suffered auditory damage during the New Year festivities of the previous year and had therefore decides to avoid pistol shots and explosions in the future. One year later — during the Millennium celebrations — she stayed at home and indoors, but she heard the noise outside nevertheless. Her tinnitus increased so dramatically that she went to the hospital for treatment. — This is a clear example of tinnitus as a warning signal from the brain.

Discussion

In occupational medicine, it is customary to characterize the danger of the acoustic environment by measuring the Leq{8h). This normally gives the average energy level (loudness) over a time span of 8 hours, corresponding to a usual work shift. Over the last five decades, a lot of effort has been devoted to working out the risk to the ear caused by loud sound, as summarized and shown in *Burns* (1973), *Dancer* et al. (1992), *Sataloff* and *Sataloff* (1993), *Dieroff* (1994) and *Axelsson* et al. (1996). The importance of impulses at the workplace and the way impulses are measured and rated has been studied by *Henderson* and *Hamernik* (1995), *Osterhammel* (1997), *Lutman* (2000), *Toppila* et al. (2001), *ZeTa* (2001) and others. An overview of the current procedures relating to the evaluation of noise-induced auditory damage is included in *Feldmann* (2001). While everyone agrees that impulses are dangerous to the ear, the exact acoustic details are still unclear.

Basically, there are two modes of dangerous exposure to sound: one is continuous noise at a high level, the other is represented by powerful impulses. Hence, we need to clarify which is more dangerous to the ear: continuous noise or powerful impulses. Details of this problem are discussed in *Riledi* und *Furrer* (1946), *Henderson* et al. (1976), *Pfander* (1994), *Fleischer* et al. (1999a, 1999b) and *Fleischer* et al. (2000). Many authors have recognized that powerful impulses are especially harmful, starting with *Rau* (1856), who observed that soldiers had very poor hearing because of having to fire rifles and guns. Details on the effects of powerful acoustic impulses are presented in *Riledi* und *Furrer* (1946), *Pfander* (1975, 1994), *Dancer* et al. (1998), *Fleischer* et al. (1999a, 2000), *McBride* and *Williams* (2000) and *Mudry* (2001). Strong acoustic impulses have led to many severe cases of acute acoustic trauma in remote parts of China, where people are not exposed to any industrial noise *(Fleischer* 2002).

This study focuses on New Year celebrations that are usually very loud, but are also dominated by powerful impulses. Originally, we wanted to measure the noise level during the famous Millennium celebrations, but good measuring equipment is so expensive that we did not want to use it for hours on end in an environment where many people could be expected to be staggering about fooling around with explosives and hurling empty bottles into the air. However, we participated in the event in Frankfurt, right in the heart of the city on the banks of Main river. For about two hours it was extremely loud and the estimated noise level was somewhat more than 100 dB{A). This was not only due to the official fireworks that were let off from two barges in the middle of the Main river. In addition, thousands of people were letting off their own fire crackers everywhere. All this together created an extremely loud, but relatively uniform acoustic environment. However, the most impressive sound sources were the powerful amplifiers connected to huge loudspeakers about 2 m high, set up on truck trailers parked at the sides of the roads. These were all sponsored by a local music station. About two dozen of them were distributed within the main area of the festivities and they were all playing the same music. It was so loud that the low frequencies they emitted could be felt underfoot over quite some distance. On a few occasions, they even caused visible ripples on the surface of the river, which was illuminated by the fireworks.

While »normal« festivities may certainly not have been quite so loud, they were nevertheless also dominated by a more or less uninterrupted period of noise. However, all the victims of auditory damage spoke straight away of a certain explosion or a shot that had obviously caused their injury. Even in an excessively loud area like in Frankfurt, all we saw was damage caused by powerful acoustic impulses. Such strong impulses are obviously much more dangerous to the ear than a high level of continuous' noise. Away from the big events, we can assume that the background noise

was much lower, but here, too, impulses caused the auditory damage. Hence, we can state that infrequent but powerful impulses caused the damage, regardless of the background noise at the site. This is supported by the findings of *Pfander* (1975), *Smoorenburg* (1993), *Dancer* et al. (1998), *Fleischer* et al. (1999a), *Just* et al. (2000), *Nondahl* et al. (2000), *Fleischer* (2002) and others.

As a consequence, the overall Leq does not correctly characterize the auditory risk in situations where there are powerful impulses. Apparently, it is necessary to evaluate continuous noise and strong acoustic impulses separately. Considering the really very small amount of damage documented in this Millennium study, it becomes apparent that, even during the huge events in Berlin and Frankfurt, no auditory damage giving rise to a need for urgent an immediate attention can be attributed to the high level of continuous noise. This supports the assumption that, in situations like these, the ear reduces its sensitivity, which in turn prevents auditory damage. Powerful impulses, on the other hand, bring peak levels of 170 dB and more to the ear and this is beyond anything the ear can handle safely. Furthermore, impulses are so extremely fast that the ear is unable to respond to them. That is why strong impulses are so harmful.

When it comes to recognizing and preventing noise-induced auditory damage, taking audiometric measurements up to 16 kHz is very useful as the earliest and most severe damage normally occurs in the frequency range above 4 kHz. Because noise-induced damage at very low frequencies is quite rare, we use a slightly different method to plot the audiogram, compressing the lower frequencies and spreading the relevant frequencies between 8 kHz and 16 kHz. Since the effects of aging are also much greater at higher frequencies, such a procedure also favours the clear presentation of pure-tone hearing as well as the differences between persons of different ages.

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