Can seizure-alert dogs predict seizures?

Stephen W. Brown\textsuperscript{a}, Laura H. Goldstein\textsuperscript{b,}\textsuperscript{*}

\textsuperscript{a} Peninsula College of Medicine & Dentistry, Chy Goveken, Three Milestone, Truro TR4 9LD, Cornwall, UK
\textsuperscript{b} MRC Centre for Neurodegeneration Research, Department of Psychology, PO77, Institute of Psychiatry, King's College London, De Crespigny Park, London SE5 8AF, UK

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Summary An index observation where a dog was trained to alert to, as well as respond to, human tonic–clonic seizures led to further research and refinement of training techniques. This was followed by anecdotal reports of pet dogs spontaneously anticipating human epileptic seizures. An industry has since developed training Seizure-Alert Dogs (SADs) to give humans warnings of their seizures. In some cases this has been accompanied by a reduction in seizure frequency. SADs may be trained along with the person with epilepsy, responding specifically to that person’s seizures, or may be trained separately. Recent sceptical reports of non-epileptic seizures in some people with SADs have cast doubt on dogs’ ability to anticipate true epileptic seizures. This may reflect selection criteria for training programmes as well as training methods used, but does not necessarily indicate that SADs might not be able to predict epileptic seizures. Whether the seizures are epileptic or non-epileptic, it is speculated that SADs probably alert to subtle pre-ictal human behaviour changes, but may also be sensitive to heart rate or olfactory cues. As yet, however, no rigorous data exist as to whether seizure prediction by SADS is better than chance, and what false positive and negative prediction rates might be.

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Background

The therapeutic use of companion animals in assisting diagnosis, treatment and management of various human health conditions, and in supporting carers, has attracted a certain amount of interest, although rigorous clinical trial data is currently lacking. The specific use of dogs in these situations falls into two main categories, “response” and “alert”. “Response” dogs assist the human by behaving in a specific and useful way when a particular event occurs, such as drawing the hearing-impaired human’s attention to the presence of a visitor at the door. “Alert” dogs are said to anticipate certain types of impending events and provide a useful warning to the human. As far as epilepsy is concerned dogs used in these two situations are referred to as Seizure Response Dogs (SRDs) who display specific

\textsuperscript{*} Corresponding author. Tel.: +44 020 7848 0218; fax: +44 020 7848 5506.
\textit{E-mail} addresses: stephen.brown@cantab.net (S.W. Brown), laura.goldstein@kcl.ac.uk (L.H. Goldstein).
behaviours during or immediately after a human seizure, and Seizure Alert Dogs (SADs) who display specific behaviours prior to any appreciation of an impending seizure event by the person with epilepsy or observer (Brown, 2005). Clinicians specialising in epilepsy will be familiar with carers and relatives of people with epilepsy occasionally making a claim that they can detect changes in the person’s appearance, presentation or behaviour that are premonitory to seizure activity even before the person is aware of the situation. Further discussion sometimes also reveals a claim that the family pet (usually, but not always a dog) may display specific behaviours prior to the person having a seizure, where no warning signs have been noticed by the person or their human carers or family (Pinikahana and Dono, 2009). In such cases the dog has spontaneously acquired the properties of a SAD.

The UK experience with SADs began with a particular index observation. A 28-year-old female with tonic–clonic seizures and a degree of physical disability asked for help from a dog trainer in training her 18-month-old cross collie to assist with her post-ictal recovery. Such training was relatively straightforward, but on completion the trainer decided to pursue the possibility of training the dog to warn the person that a seizure was imminent. Previously the dog had never shown any response to seizures. After three months’ training, the dog (using a vocal signal) was able to indicate that a seizure was imminent 20 min in advance of a tonic–clonic seizure. Publicity from this case led to many self-referrals to the trainer and provided cases for a pilot study (Strong et al., 1999; Brown and Strong, 2001).

Original studies

A pilot study (Strong et al., 1999) was carried out in collaboration with the UK charity (not-for-profit organisation) Support Dogs based in Sheffield, UK and involved 6 self-referred individuals aged 9–52 (3 male, 3 female) with tonic–clonic seizures. In two cases the possibility of additional psychogenic non-epileptic seizures (PNES) had been raised, although the clinicians involved had not made a definite diagnosis other than epilepsy. In all cases, SADs were successfully trained to provide a useful warning to the person of an impending seizure.

The authors felt that in these cases (both in trained dogs and in those who learn spontaneously) the mechanism is probably based on canine sensitivity to what are often subtle behavioural changes in humans. Important points in the training protocol used in these cases included introducing the selected dog to the human and socialising them together under supervision before training the dog to recognise and anticipate the person’s seizures using reward-based operant conditioning. No adverse effects on canine or human health or safety were observed.

The purpose was to provide the person with epilepsy with time to avoid coming to harm as a result of a seizure and to seek a safe environment where appropriate. In addition to this, however, all participants reported a decrease in seizure frequency. This was an unexpected finding and had not originally been regarded as an outcome. A further study with 10 people was therefore undertaken (Strong et al., 2002).
described by Strong and Brown (2000). It might be possible to design a randomised study with a waiting list control, but that would fail to show any specific effects of trained dogs.

Some later studies

Kirton et al. (2008) described a retrospective study of a training program for SRDs with some similarities, both in training technique and in outcome, to that used by Strong et al. (2002). Other than that, the subsequent literature mainly consists either of surveys of groups of families to solicit observations of pet dogs' natural responses to seizures, or of anecdotal retrospective reports of single cases or very small series, usually where the authors report cases involving PNES. There have unfortunately been no further prospective series reporting on specific training.

Surveys of groups of families

Dalziel et al. (2003) surveyed 63 patients of whom 29 had dogs. Nine of these dogs showed SRD behaviour and three also had SAD features. Those patients with SADs seemed more likely to have complex partial seizures and auras and this raises the possibility that the ‘alert’ anticipatory behaviour of the dog might actually be a behavioural response to an aura. Nevertheless the authors considered the findings to suggest that some dogs have an innate ability to alert and/or respond to seizures.

Kirton et al. (2004) in a Refractory Epilepsy Clinic for children aged 1–18 investigated children who had lived with a dog for at least one year and who had at least one seizure per month. Of 122 families who responded, 48 (39%) had at least one pet dog, the total number of dogs being 62. No dogs were specifically trained. Sixty-four percent of the children with dogs were female with a median age of 10. A total of 22 dogs from 20 families seemed to have learned spontaneously to react to seizures in a stereotyped way and could therefore be regarded as untrained SRDs. These tended to be larger animals (weighing >40 lb) compared to non-responsive dogs and were mostly cross breeds, although there was no difference in breed between SRDs and non-responsive dogs. The most common seizure response behaviour exhibited by SRDs was licking, especially of the face, which was described in 13 of the 22 cases. Nine of the 22 SRDs were also SADs. These tended to be larger animals, mainly female. Median anticipation time was described as 2.5 min (range 10 s–5 h). Although these often very long prediction windows may tend to be undefined, and the authors have not considered the potential for correcting statistically for random prediction with such intervals, Kirton et al. (2004) also indicate that the reported accuracy of alerting was high with a median sensitivity estimate of 80%. They also reported that anticipatory behaviours were never demonstrated without a seizure then occurring. However, response bias cannot be ruled out without more rigorous methodology. Sixty percent of families thought this ability in their dog was present from the first seizure. SAD behaviours were described as usually “protective”. There was some evidence that quality of life for the children was higher where there was a seizure-sensitive dog in the family.

Controversies

There are unfortunately very few reports of EEG or other physiological monitoring during alert and response behaviours. Ortiz and Liporace (2005) were able to study two patients with North-American trained SADs in an Epilepsy Care Unit undergoing video EEG telemetry. One patient had four seizures while awake and four while sleeping. The SAD slept through seven of these but did alert for the eighth seizure. For other epileptic events the dog awoke during the seizures and then alerted family members by barking/walking round the bed. The behaviour described was therefore of the SRD type even though the animal was referred to as a SAD. The dog in this case did not seem to monitor the patient during the hours of normal sleep, in contrast to the behaviour described in UK-trained SADs. The second patient had a North-American trained SAD present during one of her seizures which alerted her seven minutes before the seizure, but telemetry confirmed this to be a PNES. Studies of this type are likely to be rare, however, given the practical difficulties posed by having dogs present in seizure monitoring units (Ortiz and Liporace, 2005).

There have been other cases observed where dogs alerted to PNES in circumstances where the person with PNES believed themselves to have epilepsy and therefore believed the dog was a SAD. The subsequent discovery that the seizures were non-epileptic has caused some workers to exhibit scepticism about the possible significance of SRDs and the existence of true SADs. For example, Doherty and Haltiner (2007) described a two-year-old Blue Heeler who alerted and responded to the patient by laying across the patient’s chest prior to and during seizures and fetched help from neighbours after seizures. The dog was also said to predict the patient’s husband’s seizures, although whether or not these were epileptic is unclear. Video EEG telemetry captured events including pelvic thrusting, head bobbing movements, psychomotor unresponsiveness and post-event flaccidity and led to a diagnosis of PNES. The dog was not present during the monitoring, however and it is not stated whether the recorded events were typical of the patient’s seizures. Krauss et al. (2007) reported a series of six out of nine “patients that alert following seizure onset had non-epileptic seizures.” In one of these cases the dog abruptly licked the patient’s face 30 s prior to his seizure (observed during telemetry), while in another case the dog was reported to lick the patient’s head and neck to alert him, although the dog was not present during telemetry. Unfortunately the paper does not describe how the dogs were trained and since some, and probably most, North American SRDs/SADs are trained by using actors with simulated seizures rather than being socialised specifically with the person with epilepsy, it should not be surprising that the dogs respond to non-epileptic seizures. Therefore the paper does not provide any useful information in relation to SRDs/SADs in epilepsy.

The behaviour of the dogs in Krauss et al.’s (2007) report does raise a question as to whether the dog’s response reinforces PNES occurrence (Litt and Krieger, 2007). For example if the dog licks the person’s face or neck prior to PNES this might conceivably be an event that could trigger a PNES. Indeed, similar issues arise when considering epileptic seizures which could possibly be conditioned in this way.
Training protocol used by support dogs

This is the current method used by Support Dogs of Sheffield UK which is essentially that used in the two original studies (Strong et al., 1999, 2002). It differs from techniques used in other countries in the emphasis on socialising and training the individual dog with the person with epilepsy from the beginning. People with epilepsy often self-refer to the charity.

Inclusion and exclusion criteria

Applications must be supported by the physician treating the epilepsy and strict inclusion criteria are applied. There must be a confirmed diagnosis of epilepsy with at least 10 seizures per month which may consist of generalised tonic-clonic seizures, atonic seizures or complex partial seizures, not including seizures occurring in sleep. This is a stringent inclusion criterion, but allows adequate seizure occurrence to facilitate dog training. This raises the possibility of improvement in seizure frequency to represent "regression to the mean", which can only really be evaluated properly in a randomised trial. However, a previous reported study from this centre (Strong et al., 2002) from which data were presented earlier, used 4 or more tonic—clonic seizures/month as part of their inclusion criteria, and inspection of the raw data provided in the published paper indicates a similar pattern of results if those with 4—10 seizures per month are considered separately. Medical reports are obtained from the General Practitioner and the hospital specialist treating the epilepsy. If the applicant has been regarded as having PNES it is not possible for them to enter the program. The applicant must be able to keep an accurate seizure diary, must be currently over 16 years of age, and there must be a human carer available. There must be adequate support in the domestic situation to ensure that the dog’s needs can be met. There must be no changes to antiepileptic drug therapy for six months prior to enrolment and throughout the assessment training period. Enrolment may not be possible where there is already a pet dog in the family, and the person cannot have their own pet dog trained. The person must genuinely enjoy the close companionship of a dog and want to form a working relationship and be able to care for dog adequately. Training currently may not be possible if there is a vagus nerve stimulator device in place.

Training program

If these criteria are met, both from the person’s point of view and after obtaining medical reports, including specific exclusion of PNES, the applicant is offered an initial interview with training staff. At this, the person is assessed for their commitment and ability to care for the dog and more information on seizure phenomenology and about the person is collected. If no contraindications are identified, the applicant is offered a two day admission to assess how they interact with and react to dogs generally, and what types of dog they may best bond with. If this initial admission is satisfactory, the person is placed on a waiting list until a suitable dog for that person becomes available, the suitability being based on the results of the two-day assessment. Once a dog is identified, there is another two-day admission with the selected dog where the trainer checks that the person and the dog can bond with each other. If the potential to bond is satisfactorily demonstrated, the next step is a three-week admission to try and commence operant conditioning in the context of increasing development of bonding. The dog is trained to make an extreme focus on the person’s face, referred to as “look at me” training. When a seizure occurs, the dog is rewarded. The reward, administered by the trainer is usually a food treat that varies with dog, and this particular reward is only used for seizures. Depending on how many seizures occur, the dog may or may not be acquiring a seizure alert pattern after three weeks.

This admission is followed by a home placement for the dog with the person. Video camera footage of daily activities in the home and continuance of the reward programme by the carer are continued for about two months after which there is a further one week admission to the assessment centre to review progress, top-up any training and use the opportunity to review the video record to check that the programme is being optimally applied. The expectation of the trainers is that the dog should be alerting to seizures by then. Further follow-up depends on progress, but there is opportunity for further admission for top-up training if necessary.

The program described above is currently costed at about £10,000 (~$15,000).

Types of dogs

Seize Alert Dogs are drawn from three sources; dog rescue centres, dogs otherwise specially donated to the charity from various sources and “career change” dogs who were previously involved as disability assistance dogs but who are no longer required in that role. All dogs are individually assessed by trainers for their ability to bond with humans and every effort is made to match up individual dogs with suitable applicants. To date, no specific breed or gender seems to be preferred; successful training is felt to depend on the person—dog bonding, which is very individual.

Alert behaviour

Although there are individual variations, in a typical premonitory alerting behaviour the dog will seek out the person and engage their attention by getting in their field of vision, staring at them and sometimes barking. In the initial studies which concentrated on tonic—clonic seizures, the warning usually came 15–45 min before the observable seizure onset (Strong et al., 1999, 2002). Trainers still regard the mean anticipation period for tonic—clonic seizures to be about 30 min, but shorter times, in the order of 15 min are observed with complex partial seizures. The action taken by the human after the dog alerts varies, and may for example include lying down and placing a cushion under the head, or going to lie on a bed.
Some questions answered

Two particular observations invite comment and occasionally lead to unhelpful speculation about the phenomena to which dogs might be alerting. The first of these involves dogs who appear to alert from another room to that in which the person is situated. The second refers to dogs that alert in the night. Those of us with knowledge of the field have been occasionally approached by journalists for opinions about the psychic abilities of dogs that these events seem to suggest. Fortunately review of video evidence from the home placement phase of training described above shows that a dog situated in another room in the house typically enters the room and appears to check the human every 15 min or so, and therefore shows alert behaviour as a result of their regular checking and observation of the human, rather than entering the room because they are displaying alert behaviour. Likewise, video scrutiny shows that the sleeping pattern of SADs seems to include waking regularly and looking at the human (Strong, pers. com.).

Some unanswered questions

Non-epileptic red herrings

If a dog can respond to or apparently predict PNES phenomena (Ortiz and Liporace, 2005; Doherty and Haltiner, 2007; Krauss et al., 2007) this does not necessarily mean that the dog cannot or does not respond to epileptic seizures. The issue might be more clearly realised as being about the behaviour they are trained to detect rather than whether or not that behaviour is part of an epileptic seizure or a PNES manifestation, even though their semiology may clearly differ (Mellers, 2005). Conditioning principles involved in either seizure alerting or responding would apply equally to both types of phenomena. There is a question as to whether people with abnormal illness behaviours are more likely to seek animals for support, as suggested by Krauss et al. (2007), so that PNES may be over-represented in the population of humans seizure support dogs of whatever type. It has been suggested, however, that given the cost of training SADs, patients might be usefully screened to ensure that the dogs are being provided specifically for people with epilepsy for whom a life-saving role is particularly important (Doherty and Haltiner, 2007).

Available case reports certainly suggest that PNES can be associated with response behaviour in dogs. If there is such an effect in PNES, however, it does not rule out effects in true epilepsy and the thrust of at least some of the literature could be described as unhelpful in assessing the effect in genuine epilepsy.

To what are the dogs alerting?

The consensus from those who spend time reviewing the video evidence is that dogs probably alert to specific and subtle human behaviour (Strong, personal communication). Companion dogs have evolved a close relationship with humans which is facilitated by close attention to human behaviour and anticipation of aspects of human behaviour that have consequences for the dog, such as going out or being fed. Most people who have pet dogs will recognise this. It is perfectly possible that some relevant human behaviours might not be obvious to humans themselves but are noted by dogs because they signify anticipation of reward. It is not currently possible to state whether dogs are sensitive to subtle changes in human respiratory rate, or whether their acute hearing may enable sensitivity to human heart rate changes, or whether some olfactory phenomenon may play a part. It is possible that more than one mechanism may be relevant.

The possibility has been raised that seizure activity manifesting as the behavioural component of a partial seizure prior to generalisation might account for at least some situations. It could be speculated that odour or other autonomic characteristics might be detected by a dog where human observers might lack sensitivity, e.g. changes in human heart rate might be heard by a dog. Certainly changes in heart rate can precede the onset of a clinically observable seizure by seconds or minutes (Sevcencu and Struijk, 2010). Patients with PNES are more likely than those with epileptic seizures to report a range of autonomic symptoms (Goldstein and Mellers, 2006) including chest pain, palpitation, shortness of breath and sweating just prior to or during their PNES. There is clearly a need for more careful observation to identify the phenomena to which SADS are actually responding.

Other issues

Apart from the very few cases where dogs have been present in clinical monitoring situations, all other accounts rely on self-report, using diaries or questionnaires (Doherty and Haltiner, 2007) which may raise legitimate issues of reporting bias in terms of whether all seizures are reported in relation to whether or not the dog alerts/responds. In addition, people with SADS may be a highly selected or self-selected sample (Kirton et al., 2008). This issue is no different from the consideration of potential bias in self-reporting of seizures that might underlie whether or not adults appear to be able to predict their own seizure occurrence (Haut et al., 2007; Litt and Krieger, 2007). Maiwald et al. (2011) studied a small number of patients who reported being able to predict their seizures on the basis of prodromal symptoms. On the basis of prospective time-tracked data using personal digital assistants they concluded that such events did not provide a reliable and statistically significant basis on which patients could necessarily predict their own seizures. This argues strongly for more tightly controlled prospective studies of SADS’ alerting abilities, especially if such alerting abilities are thought to occur in response to pre-ictal changes in the person with epilepsy.

It is of course noteworthy that patients using SADS are likely to be those for whom conventional treatment has not led to satisfactory seizure control, and any improvement in seizures or associated quality of life may be beneficial. It may be the case that people with epilepsy may experience reduced anxiety and increased independence if they believe their seizures may be pre-warned and that they can be alerted, for example, if outside their home. The therapeutic effects of contact with dogs more generally has aroused interest in helping recovery from physical injury.
Can seizure-alert dogs predict seizures?  

(e.g. Hastings et al., 2008) and, for example, in improving psychological function in elderly people with Alzheimer’s disease (Mossello et al., 2011) and psychiatric disorders (Moretti et al., 2011).

It is interesting to consider the role that assistance dogs may play in other disease areas. There are now diabetes assistance dogs who have allegedly been trained to alert their owners to hypoglycaemic episodes. It is suggested that they are responding to the subtle scent that hypoglycaemia creates. There are no published studies, but the training organisations suggest that their dogs are never 100% accurate in prediction, and quote a figure of 85–90% accuracy (Dogs4Diabetics; Alert Service Dogs). There are also Cancer Detection Dogs that are claimed to be trained to detect the smell of bladder cancer in urine. Otherwise most of the general literature on Assistance Dogs is mainly concerned with helping people with mobility problems or sensory impairments (e.g. Sachs-Ericsson et al., 2002). As with SADs for people with epilepsy (Dalziel et al., 2003), the person with the illness will have to learn to recognise the dog’s warning behaviour, may not be able to take the dog everywhere with them if buildings do not provide access to animals and will also have to develop new relationships with replacement SADs when the dog reaches the end of its working life.

Summary and conclusions

Some domestic dogs seem to show identifiable behaviours in response to epileptic seizures in their significant humans. Of these, a proportion seem to be able to display premonitory behaviour to seizures while the person with epilepsy and their carers are still unaware of the impending event, as described above. In at least some cases, untrained dogs may react adversely to human seizures with negative consequences for both dog and human. It is not known how frequent such adverse reactions are, or how to predict which dogs will show adverse reactions.

Although there is a limited scientific literature on this topic, it does seem that some dogs can be trained both to respond to and provide useful premonitory signals to human seizures following specific individual training with the significant human using a systematic operant conditioning based approach. Such cases may be associated with a decrease in reported seizure frequency. Therefore, the potential value of dogs trained in this way lies firstly, in providing a useful warning of impending seizures so that a safe environment can be achieved and secondly, in providing an adjunct to other treatments such as antiepileptic drugs (AEDs).

If reliable warning of seizures can be given by a dog where the human previously could not self-predict seizures, it is feasible that this could contribute to reduction in anxiety and help increase independence and quality of life. Taking part in more activities in general may play a part in reduction of seizure frequency. There is also the possibility that the alerting behaviour of the dog can increase the level of human arousal and play a part in aborting a seizure, although we currently lack data on the frequency of ‘false-positive’ alerts.

Some dogs are also able to show stereotyped response patterns to PNES. It is less clear whether in such cases reliable premonitory behaviour is also displayed. It is also unclear whether the presence of a PNES alert dog has any useful effect on PNES frequency, since most of the case reports available refer to people with seizures severe and frequent enough to require intensive monitoring in specialist units.

The observed reduction in seizure frequency in a number of cases where specially trained SADs are used makes it unlikely that the seizures are a consequence of the dog’s alerting behaviour, especially since the training requires SADs to expect a reward when a seizure occurs. However, it is not clear to what trigger(s) SADs are responding. Subtle behavioural or mood changes in the human may be sufficient explanation in some cases, but the possibility that dogs can sense and respond to physiological changes in humans, such as heart or respiratory rate or pheromone production cannot be excluded. Bearing in mind the variable length of warning before seizures that is described, it would seem reasonable to allow for several mechanisms to be relevant, with different ones applying in different situations and possibly corresponding to different seizure types.

The only systematic prospective studies using specially trained dogs have supported three hypotheses; that dogs can be trained as SADs, that this can be done safely without hazard to dog or human, and that such training may be associated with reduction in reported seizure frequency. Starting with these observations there is therefore a need to design and carry out a larger scale controlled trial of the specific training protocol described above. Careful consideration would have to be given to identifying the conditions for the control group. There are no helpful systematic reports of the outcome where dogs are trained by other means such as with simulated seizures or with a person with epilepsy different to the intended significant human. Indeed, the only contribution these training methods have made to the scientific study of the subject may be the presumably inadvertent observation that dogs may respond to PNES. Therefore it is probably more appropriate to limit research to specifically trained dogs, at least for the foreseeable future.

Group Discussion

The Group Discussion elaborated on a number of the issues raised in the talks.

1. The difficulties in undertaking a randomised controlled trial were further highlighted but it was considered that a waiting list control design might be the best design option.
2. Although cats can alert people to their oncoming seizures, the typical response of a cat would be to run away rather than stay with the person and this makes them less suitable for the role of an alert animal.
3. Once exposed to a SAD this may influence the ability of the person with epilepsy to detect their oncoming seizures and may increase their epilepsy-related awareness and their ability to implement countermeasures. Thus the loss of a dog at the end of a study, for example, might not necessarily mean that the person reverts to the pre-study status quo in terms of seizure control.
4. The influence of SADs in reducing anxiety and improving quality of life of the person with epilepsy may be
similar to that seen in terms of the benefits of pets to people with a range of psychiatric disorders, although the mechanisms here may additionally include the benefit of providing the person with confidence in that their seizures can be pre-warned thereby making them more willing to engage in activities out of the home.

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