Decoding human brain activity during real-world experiences

Hugo J. Spiers and Eleanor A. Maguire

The human brain evolved to function and survive in a highly stimulating, complex and fast-changing world. Attempting to ascertain the neural substrates of operating in naturalistic contexts represents a huge challenge. Recently, however, researchers have begun to use several innovative analysis methods to interrogate functional magnetic resonance imaging (fMRI) data collected during dynamic naturalistic tasks. Central to these new developments is the inventive approach taken to segregating neural activity linked to specific events within the overall continuous stream of complex stimulation. In this review, we discuss the recent literature, detailing the key studies and their methods. These analytical techniques can be applied in a wide range of cognitive domains and, thus, offer exciting new opportunities for gaining insights into the brain bases of thoughts and behaviours in the real-world setting where they normally occur.

Introduction

Understanding how our brain makes sense of continuous and complex inputs from the external world represents a central challenge in cognitive neuroscience. Functional neuroimaging offers a means to address this key issue, but, because many studies use simplified static stimuli, surprisingly little is known about how the human brain operates during real-world experiences. Exploring brain function with dynamic naturalistic stimuli is important for several reasons. First, it is vital to verify whether results obtained in experiments that used simplified stimuli actually hold true under natural conditions, particularly because findings are often assumed to generalize. For example, do brain regions such as the fusiform face area also show selectivity when faces appear in the real world? Second, some research questions can only be addressed with naturalistic tasks where there is little temporal regularity. To understand properly the neural substrates of driving a vehicle or navigating in a city, for instance, it is sub-optimal to use static regularized stimuli.

The need to complement highly controlled experimental manipulations has been acknowledged in the field of functional neuroimaging; consequently, the use of dynamic stimuli such as movies and virtual reality environments is increasing [1–18]. However, most extant studies involving naturalistic stimuli have designs where activity associated with each task (e.g. navigation or a control task) was averaged across blocks of typically 30–60 s duration (Figure 1a). This approach not only lacks fine-grained temporal resolution but also reduces the correspondence to the real world, which is rarely organized in a ‘blocked’ and orderly manner. For a true appreciation of brain function during real-world experiences, one key element that it is vital to understand is how to segregate neural activity during specific events from the continuous stream of complex stimulation of which they are a part. However, this presents a significant challenge because the lack of discrete stimuli means that standard experimental designs and analyses cannot be used (Figure 1c). Dynamic, continuous stimuli can evoke both transient and sustained responses within the same brain region or in different brain regions simultaneously, making data interpretation difficult. The unconstrained nature of eye-movements, multiple features in any given scene, and the lack of a specific task can give rise to ambiguity about what subjects were attending to or thinking about during the experience.

Recently, however, researchers have adopted a range of innovative approaches to analysing fMRI data collected during naturalistic tasks. The analytical methods tend to fall within three broad categories: (i) those based on subjects’ classification of events; (ii) those based on subjects’ behaviour and verbal reports; and (3) stimulus ‘blind’ analyses, which in general do not require information about the stimuli to be known before the analysis. Several recent reviews have already discussed one of the analysis methods from the third category, namely multi-voxel pattern analysis (see Refs [19,20]). By contrast our focus here is different. First, we widen the scope considerably to explore work from the first two categories, as well as additional stimulus ‘blind’ approaches. Second, our interest is in how these innovations have been applied specifically to the analysis of fMRI data acquired during dynamic naturalistic tasks.

We will consider each category of analytical method in turn, reviewing the key studies. Although a diversity of cognitive domains and scientific agendas are represented, two common themes are evident. Initial studies have focussed on investigating whether patterns of brain activity observed previously using experimental stimuli are mirrored during naturalistic tasks. However, it is also apparent that experience with the techniques is growing, and the ability to combine these methods with naturalistic stimuli is beginning to permit novel insights that would be difficult to gain using more traditional approaches. Future
developments, therefore, might lead to genuine conceptual advances. Given this potential, it is timely to consider the different techniques used, and their advantages and disadvantages, in order that researchers might identify new opportunities for experimental investigations involving naturalistic contexts that could add a new dimension to their work.

Analysis using subjects’ classification of events

We begin with arguably one of the most straightforward means of analysing naturalistic stimuli. Two recent studies examined brain activity during the passive viewing of commercial movies [21,22]. To identify moments in the movie when stimuli of interest (e.g. faces, voices and colours [21]) or humorous events [22] occurred, a separate group of subjects watched the movie and recorded these events. This record was incorporated into the analysis to examine the brain activity of subjects who were scanned while passively watching the movie. In both studies, evidence for functional specialization was observed, for example, the fusiform face area was more active during scenes containing mostly faces [21], whereas humorous moments were associated with increased activity in areas associated with affective states: the insula and amygdala [22]. Despite the relatively uncontrolled nature of the task, these studies show that these particular functional specializations operate during continuous free viewing of dynamic natural stimuli, and that it is possible to identify them. Future work could reveal that in some situations functional specializations observed in highly controlled experiments might not be found in real-world contexts (or indeed vice versa), with potentially interesting theoretical implications. Although this approach offers a relatively uncomplicated means of decomposing complex dynamic stimuli, using independent viewers to record changes in stimuli ignores the fact that each scanned subject will have their own reactions to such events. Furthermore, the studies so far have simply extended current models of brain function, rather than addressing novel questions about brain dynamics.

By contrast Zacks et al. [23] addressed a question that would have been difficult to consider using traditional regularized stimuli. They wondered if there are brain regions that detect personally meaningful boundaries between ordinary daily events. Subjects were scanned while...
they watched movies of an actor performing an everyday task. To determine when boundaries occurred, afterwards the same subjects watched the movies again and pressed a button whenever they identified these events. Activity in the lateral occipital cortex and lateral prefrontal cortex was found to be greater at the boundary moments during the passive-viewing of the movies (see Figure 2 for further details). Although questions remain about whether the brain responses they observed reflect top-down or bottom-up influences [23], nevertheless this study made the novel observation that there are brain regions that track the temporal segmentation of ongoing complex actions. This study also indicates that a subject’s own (as opposed to independent raters’) interpretation of a

---

**Figure 2.** Human brain activity time-locked to perceptual event boundaries. (a) Four example movie frames from Ref. [65], describing the study by Zacks et al. [23]. Reproduced, with permission, from Ref. [65]. The movie shows the process of playing the saxophone, starting with taking the saxophone out of the case, assembling, playing, and then replacing it. (b) Schematic illustration of the experimental design of the experiment. During an initial scanning session, subjects passively watch the movie. In two later sessions the same movies were shown again, but this time, subjects were instructed to press a button (blue lines) whenever they perceived the end of one event and the beginning of another. These button presses were then used to examine each subject’s brain activity during the passively watched movie. In one of these scans, the subjects were asked to divide the movie into the largest units that seemed natural and meaningful (coarse units) and in the other scan to divide the movie into the smallest units (fine units). (c) The results of an analysis by Zacks et al. [23] of changes in brain activity time-locked to the event boundaries. Activity was specifically increased in the right and left lateral occipital cortex (not shown), middle temporal cortex (putative area MT), and the right frontal cortex following event boundaries. On the left are shown the active regions on the mean structural scan of the subjects and on the right are shown the time courses of activity occurring around the event boundaries for the two regions. The putative MT region, but not the right frontal cortical region, shows greater sensitivity to the coarse units than to the fine units. Adapted, with permission, from Ref. [23].
naturalistic experience can, and one might argue should, be used to extract information about their brain activity.

**Virtual reality, content analysis and verbal reports**

Although studies that involve watching movies are beginning to advance our knowledge of brain dynamics, passive viewing remains distinct from much of our everyday activities, which generally involve engaging with the world around us. Trying to ascertain the neural correlates of real-world interactions represents a huge challenge, given the physical constraints of the MRI scanning environment (where a subject’s head is immobilized in the bore of the scanner), and the variability in behaviour across individuals. To examine interactive contexts such as navigation, social interactions and vehicle driving with fMRI, many researchers have used virtual reality environments [1–6,10,24–33]. However, only two recent studies have explored brain activity during specific events and epochs during the ongoing interactive experience [24–29].

One approach has been to use content analysis [34] to explore brain activity during violent interactions [28,29]. Subjects were scanned as they engaged in combat with simulated characters in a first-person video game. The contents of a video recorded during the scan were scrutinized by the experimenters to segment the time course into epochs, such as potential danger or active fighting. During violent confrontations, activity increased in dorsal anterior cingulate and decreased in rostral anterior cingulate and amygdala. Other lines of evidence [35,36] suggest these changes might relate to a suppression of affective or empathic processing during violent interactions [28,29], alternatively, subjects might be less afraid during active combat than during periods of uncertainty building up to it. One problem with content analysis is that it cannot distinguish between events in which subjects are inspecting the environment from those in which they make decisions or plan actions. One means of disentangling these possibilities is to use verbal reports (Box 1).

Spiers and Maguire [24–27] used a verbal report protocol combined with fMRI and a highly accurate virtual simulation of a real city (London, UK) to ascertain the neural correlates of navigation in a real-world context (Figure 3). During scanning, subjects (who were licensed London taxi drivers) responded to customers’ requests by delivering them to their required destinations, while driving a London taxi. Previous neuroimaging studies of navigation that typically averaged activity over blocks of 30–60 s, failed to capture the multi-faceted and highly dynamic operation of the human navigation system. Spiers and Maguire, by contrast, sought to gain an understanding of the navigation process on a second-by-second basis. Immediately post-scan and without prior warning subjects watched a video replay of their performance and were interviewed using a retrospective verbal report protocol (Box 1). This involved getting subjects to review their performance and report on what they had been thinking during their performance in the scanner. Subjects were able to produce detailed accounts of what they had been thinking during the navigation, and were also clear about exactly when they had experienced particular thoughts. This enabled a thorough specification of each subject’s individual fMRI time series in terms of onsets and durations of event and epochs. The precision of the timings was further tested using independent eye-tracking data that had been acquired during the scan, and analysis of subjects’ actual behaviour while navigating in virtual London. Analysis of the fMRI data revealed a complex choreography of neural responses comprising focal and distributed, transient and sustained brain activity, which fluctuated depending on circumstances and priorities. This variety of responses could not have been ascertained easily using a static traditional approach, where it is impossible to examine the continuous updating of one’s current state and spatial position. Thus, the study by Spiers and Maguire provided new information about the specific roles of areas within the known navigation brain network, and the time courses of their responses [24]. It also generated the first empirical evidence for a navigational guidance system in the human brain, revealing brain areas whose activity tracks proximity and direction to goal destinations during the course of navigation [27] and, thus, informing extant computational models [37–39]. Finally, despite the broad interest in and the importance of driving to daily life, little is known about how the brain supports driving behaviour. Results from a further analysis by Spiers and Maguire [26] now reveal how activity in several brain regions changes in response to the many different challenges faced when driving through a busy city. Thus, the combination of fMRI, post-scan verbal reports, and realistic and interactive virtual reality offer real potential for making genuine conceptual advances in understanding the brain basis of cognition in several domains. Although verbal reports and content analysis might not be suitable in all experimental contexts, they are under-used and more work is necessary to establish the parameters within which these approaches are most effective.

**Stimulus ‘blind’ analyses**

Even when stimuli, a subject’s behaviour and their verbal reports are analysed in detail, some patterns in an fMRI time series might still remain undetected. Several of the studies described so far, and indeed many fMRI datasets in general, are analysed using programmes such as statistical

---

**Box 1. Verbal report protocols**

A verbal report protocol is a procedure where subjects are asked to describe aloud their thoughts during a controlled psychological experiment [66]. A structured analysis of the descriptions given (the verbal reports) is used to provide insight into the subject’s cognition. For example, in an experiment involving a mathematical test, subjects might be set the problem: ‘what is 8*12?’. One subject might verbally report: ‘now, 2 multiplied by 8 is 16, and 10 multiplied by 8 is 80, so that would make 96’, whereas another subject might report: ‘hmm…I know, it’s 96’. These verbal reports provide evidence that each subject performed the task in a qualitatively different way, a fact that might be missed by only measuring accuracy and reaction time. As well as providing feedback on thoughts during an experiment, retrospective verbal reports can also be obtained where subjects are asked after an experiment to describe the thoughts they had during the testing. The use of retrospective verbal reports has proved useful for aiding the analysis of neuroimaging data [24–26,67,68] (see Figure 3).
Figure 3. Brain activity time-locked to spontaneous thoughts during navigation in a real city. (a) Subjects navigated to destinations in a virtual reality simulation of central London, UK (‘The Getaway’ © 2002 Sony Computer Entertainment Europe) and were subsequently interviewed with a verbal report protocol [24–27] (see Box 1). The virtual city-centre environment had accurate mapping of the street layout, detailed rendering of buildings and landmarks, and the inclusion of moving people and vehicles. Thus, it was possible to examine the subject’s behaviour as they moved through a (virtually) real and familiar environment. Example views from the simulation shown are (left to right): Piccadilly Circus, Trafalgar Square and the Millennium Wheel. (These images are reproduced with the kind permission of Sony Computer Entertainment Europe.) (b) A section of the region of London simulated with an illustrative route overlaid. (Reproduced by permission of Geographers’ A–Z Map Co. Ltd © Crown Copyright 2005. All rights reserved. Licence number 100017302.) (c) The route presented in (b) is shown on the left classified into a sequence of events and epochs of the different categories of thought extracted from one subject’s verbal report. On the right are the main thought categories with a colour key. (d) A schematic example of an fMRI time-series after classification of the verbal report, with the time-series segregated into different events and epochs corresponding to the different categories present. Each subject’s time-series was unique. (e) Example findings where activity during a particular thought category was compared with activity from events or epochs (as appropriate) during ‘coasting’, the baseline condition, where subjects reported navigating, but with no directed thoughts. Red box: left hippocampus active during customer-driven route.
Box 2. Methods for analysing fMRI responses to naturalistic stimuli

Various methods are available for analysing fMRI time-series collected during exposure to naturalistic stimuli (Figure Ia). One approach is SPM (Figure Ib), which models the data at each voxel as a linear combination of explanatory variables (regressors) plus a residual error term [40,41] using a general linear model. Another method, ICA, was originally designed to solve the cocktail party problem in which a set of independent voices (guests at the party) are mixed in the signal arriving at the ear, and must be separated out into the distinct voices [69]. In fMRI, the activity time-course is treated as the mixed voices and separated into several independent components that can then be related back to the stimulus [30,70] (Figure Ic).

A third approach, reverse correlation, finds peak responses in the time course where activity is significantly greater than the mean activity (Figure Id) and uses these to determine which features the voxel was most responsive to. MVPA, by contrast, involves training a classifier by feeding a subset of the sorted voxel activity patterns into a multivariate pattern classification algorithm, which learns the relationship between the voxel patterns and the experimental conditions (Figure Ie). Generalization testing then uses a brain activity pattern (not used in training) to test whether the classifier can correctly discriminate the experimental conditions associated with these patterns [19,20].

Figure I. (a) The example naturalistic stimuli from main text Figure 1c. Examples of how the different methods extract information from the activity time-course(s). (b) SPM: dark-grey vertical lines mark the onsets of specified events; red lines show the time-course of these events convolved with a haemodynamic response function. (c) ICA: the time course of two independent components (red and blue lines) are shown overlaid. (d) Reverse correlation: red lines indicate peak responses found to be significantly different from the mean activity. (e) MVPA: the grey-scale-coded fMRI signal time-courses from 50 voxels (white = high activity, black = low activity) from a test set are shown. Red and green boxes show periods classified by a trained classification algorithm into either state A (e.g. face in frame) or state B (e.g. no face in frame). The prediction from the classifier and the actual stimuli states are shown below.

parametric mapping (SPM). In SPM, a linear combination of the effects of interest (e.g. the events) plus a residual error are used to model the data and test for significant relationships between the brain activity and the events of interest [40,41] (Box 2). More recently, however, other approaches that are not standard in programmes such as SPM have been adopted to search for hidden patterns in brain activity. We use the term stimulus ‘blind’ analyses, to describe these techniques that in general do not require information about the stimuli to be known in advance of the analysis. Here we will consider three methods in particular that have been applied to fMRI data acquired during dynamic naturalistic tasks: (i) independent components analysis (ICA); (ii) a reverse correlation procedure; and (iii) multi-voxel pattern analysis (MVPA) (Box 2).

In ICA, the fMRI activity is treated as a mixed signal that is mathematically divided into several statistically separate signals known as independent components. These independent components can then be related back to the stimuli to understand the relationship between the brain activity and the stimuli. It has so far been applied to fMRI data collected during movie watching [42,43], and simulated driving [30,31]. ICA applied to the former has confirmed that brain areas with known strong anatomical connections (e.g. within the language network) express similar activity patterns, and that correlations between activity in these regions increase during movie watching relative to resting conditions [42]. An ICA of fMRI data collected during simulated driving helped to separate the activity of groups of brain regions into transient, sustained and decaying patterns [30]. Thus far, ICA findings might have been ascertained with variations in standard analysis approaches, and in general have not provided any real conceptual advances. A further difficulty with ICA is the sometimes uncertain relationship between the brain patterns identified and the stimuli or behaviour (see Ref. [44] for a recent ICA–SPM combination technique that might offer some improvements in this regard). Nevertheless, it has recently been suggested that ICA might be able to detect activity changes that an SPM analysis could miss, including activity patterns inde-
dependent of the stimuli [43]. This might be particularly germane for increasing our understanding of brain activity during rest conditions and the function of the so-called default mode (e.g. Refs [45,46]).

An alternative approach to extract hidden structure from brain activity is reverse correlation [47]. Here, the neural activity is analysed to find particular features embedded in the stimulation sequence; so far, it has been used to examine fMRI data collected while subjects watched ‘The Good, the Bad and the Ugly’ (Figure 4) [47]. The activity time courses in several regions previously functionally defined during prior localizer scans (e.g. with static faces or buildings) were examined. Using the reverse correlation procedure, it was possible to find the greatest evoked responses for these regions and look back to the film frames to see what stimuli occurred just before these responses. For the face-related fusiform gyrus, the greatest peaks were associated with close-ups of face images, whereas the maximal responses

Figure 4. The reverse correlation method applied to passive movie-watching. (a) The averaged time course of the regionally selective component of the posterior fusiform face-related region, during the viewing of the film ‘The Good, The Bad, and The Ugly’ [47]. This region was defined in advance with the use of a functional localizer scan involving static faces. Time points significantly different from the baseline across subjects are marked in red. All 16 of the maximal peaks during the viewing of the film were associated with faces. (b) The movie frames that produced the highest activation in the fusiform face-related area, ordered according to descending signal amplitude. Bottom right, fusiform area is shown on an inflated brain. (c) The averaged time course of a regionally selective component of the collateral building-related region (defined by a functional localizer scan) during the viewing of the same film, with significantly different time points marked in green. Twelve out of the 16 marked peaks in the collateral building-related region were associated with indoor and outdoor scenes. (d) The movie frames that produced the highest activation in this region are shown, ordered in descending amplitude. Bottom right, collateral sulcus region is shown on an inflated brain. Images, reproduced, with permission, from Ref. [47].
in the building-related collateral sulcus were associated with outdoor and indoor scenes. In addition, the analysis revealed new information about another brain region. Movie frames occurring before peaks of activity in the post-central sulcus were found to contain mostly delicate movements, suggesting this region might play a role in action perception or action simulation. In showing the same naturalistic stimulus to multiple subjects, Hasson et al. [47] also looked for voxels that displayed similar time-courses across subjects, and was able to separate out ‘externally driven’ (stimulus-dependent) voxels from ‘internally driven’ (stimulus-independent) voxels [47,48]. As with ICA, it will be interesting in future studies to ascertain how these different brain networks are related to specifics of the stimuli and also the thoughts and day-dreams occurring in resting periods [49]. A limitation of the reverse correlation technique is that it relies on examining the features in movie frames before peak responses to infer which stimuli caused the response. Thus, it might prove optimal for a film such as ‘The Good, the Bad and the Ugly’, which has distinct cinematic pans of open vistas and close-ups of faces and hands, but might be less useful for films and stimuli with more complex content and displays.

A limitation that applies to the methods reviewed in this section so far is that they ignore the inter-relationships within subjects between the patterns of activity in all voxels measured at every time point and, thus, discard potentially useful information. MVPA is a method that uses this information to interrogate fMRI data. In MVPA, pattern classification algorithms are applied to fMRI data-sets to decode the information represented across their voxel activity patterns (Box 2) (reviewed in Refs [19,20]). Initially, a pattern classifier algorithm is trained to discriminate between different stimuli or perceptual and cognitive states based on the activity time courses of selected voxels during a specific training session. The trained classifier is then used to generalize to a non-trained fMRI dataset to determine what stimuli or perceptual and cognitive state occurred at each time point, given the activity patterns of the new data. Thus, MVPA can reveal whether or not that activity pattern is able to predict accurately when subjects were looking at particular stimuli, or were in a particular perceptual and cognitive state. Furthermore, by determining which regions contain the most discriminating voxels it is possible to learn what information is represented by these regions, and thereby inform current debates on brain function.

As yet MVPA has mostly been applied to static and simplified stimuli or switches in perceptual or cognitive states [19,20,50–58]. However, a recent competition was held where international groups applied their own algorithms to fMRI data acquired while subjects watched a movie (http://www.ebc.pitt.edu/PBAIC.html) [59]. The results showed that MVPA is capable of decoding brain states in single subjects during the passive viewing of continuously varying dynamic naturalistic stimuli [19]. However, there are some potential draw-backs. The requirement for a training set requires a decision to be made in advance about which stimuli are to be classified. Thus, like SPM, it cannot determine new information about the relationship between time course and stimuli beyond those tested. However, it can still be considered a ‘stimulus blind’ technique, because once the classifier is trained, it can be used to classify stimuli or cognitive states in other datasets in which the state transitions are unknown. Currently generalization across subjects is also problematic using MVPA, for example, one person’s representation of a stimulus feature might elicit a different voxel pattern to another person’s representation. Nonetheless, MVPA continues to develop; Polyn et al. [55] showed that generalization across contexts was possible, with a classifier trained on the study phase of a memory experiment used to predict behaviour during the recall phase.

**Summary**

Here we described how researchers have recently applied several innovative methods to explore brain responses measured with fMRI during naturalistic tasks. These methods involve either a stimulus-driven approach (using stimulus classifications, behaviour or verbal reports typically analysed with techniques such as SPM), or a stimulus ‘blind’ approach (e.g. ICA, reverse correlations, and MVPA, to extract hidden patterns in the fMRI signal). Although relatively few studies have been conducted so far, the studies illustrate the advantages and disadvantages of these approaches. Importantly they show that it is possible to segregate neural activity during specific events from the continuous stream of complex stimulation of which they are a part. Thus far, as is often the case with new innovations, a central theme has been to test hypotheses derived from extant experimental data. However, novel insights are now beginning to emerge, and future work with these techniques promises much.

**Conclusions and future directions**

The human brain evolved to function and survive in a highly stimulating, complex and fast-changing world. Attempting to ascertain the neural substrates of operating in naturalistic contexts represents a huge challenge. One productive approach has been to examine instead simplified or abstracted stimuli in controlled fMRI experimental designs. However, important insights might be missed by not examining thoughts and behaviours in the real-world setting where they typically take place. The new approaches outlined here require more work to better understand, evaluate and optimize their use in a broader range of cognitive neuroscience domains. We have focussed on fMRI, but other scanning methodologies (e.g. electroencephalography, magnetoencephalography), or analysis techniques (e.g. structural equation modelling [60], dynamic causal modelling [61]) might also prove useful for examining brain activity during the viewing of dynamic naturalistic stimuli, and the inclusion of physiological measures such as skin conductance, heart rate and eye-movements could refine our understanding further [62–64].

However, combining naturalistic stimuli with the analysis methods described here is not trivial. We suggest that future work in this regard be directed at addressing questions that are either difficult or indeed impossible to ask using static or regularized stimuli. For instance, un-
derstanding social interactions, how we learn to find our way in new environments, the formation of autobiographical memories and decision making in the context of ongoing complex stimulation are just a few examples of where benefits might accrue. Thus, the endeavours of many cognitive neuroscientists might be all the more effective by inclusion of these innovations in their armamentarium.

Acknowledgements

H.J.S. and E.A.M. are supported by the Wellcome Trust.

References

18 Han, S. et al. (2005) Distinct neural substrates for the perception of real and virtual visual worlds. Neuroimage 24, 928–935
31 Carvalho, K.N. et al. (2006) Simulated driving and brain imaging: combining behavior, brain activity, and virtual reality. CNS Spectr. 11, 52–62

Elsevier joins major health information initiative

Elsevier has joined with scientific publishers and leading voluntary health organizations to create patientINFORM, a groundbreaking initiative to help patients and caregivers close a crucial information gap. patientINFORM is a free online service dedicated to disseminating medical research.

Elsevier provides voluntary health organizations with increased online access to our peer-reviewed biomedical journals immediately upon publication, together with content from back issues. The voluntary health organizations integrate the information into materials for patients and link to the full text of selected research articles on their websites.

patientINFORM has been created to enable patients seeking the latest information about treatment options online access to the most up-to-date, reliable research available for specific diseases.

For more information, visit www.patientinform.org