Ethical Guidelines for rTMS Research
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Repetitive transcranial magnetic stimulation (rTMS) uses high frequency magnetic pulses to deliver electrical energy across the scalp and skull, permitting stimulation of the brain through the intact skull. In addition to being a valuable tool for basic research in neuropsychology, rTMS has promising therapeutic uses for the treatment of such conditions as depression, obsessive compulsive disorder, and epilepsy. However, the occurrence of seizures in some normal volunteers during rTMS has raised ethical and safety questions about this research.

In June 1996 an international conference was held in Bethesda, Maryland, to consider safety issues in the conduct of research involving the use of rTMS. What follows is an overview of rTMS research, a report of issues raised at this conference, and our own conclusions regarding the ethical guidelines that must be applied to future research involving this promising new biomedical technology.

Background of rTMS Research

Transcranial magnetic stimulation (TMS) is a technique introduced in 1985 that uses the principle of inductance to get electrical energy across the scalp and skull in order to produce changes in neural activity in the brain. It involves placing a small coil of wire on the scalp and passing a very brief and powerful current through it. This produces a magnetic field that passes unimpeded through the tissues of the head. The magnetic field, in turn, induces a much weaker electrical current in the brain that is capable of activating nerve cells in the cerebral cortex. If the primary motor area of the cortex is stimulated, twitches and easily recordable electrical activity are produced in muscles of the other side of the body.

A few years prior to the development of TMS by Barker and colleagues, others had devised a means of activating the brain through the scalp with electrical rather than magnetic pulses. This represented an important technological advance. Prior to this, brain stimulation required the removal of part of the skull, which restricted human investigations to patients who were being operated upon for other reasons. However, electrical transcranial stimulation can be painful and this has severely limited its use. TMS, on the other hand, is much less uncomfortable and has been widely applied in clinical and, to some extent, basic neurophysiology. Early on it was used successfully as a tool to evaluate the physiological state of the motor pathways in the spinal cord in diseases such as multiple sclerosis by measuring the time that it took for neural activity generated in the cortex by a single magnetic stimulus to produce a measurable response in a muscle. TMS is widely used for clinical purposes, particularly in Europe.

Specialized stimulating coils that produce a focal magnetic field have permitted TMS to be used to map the representation of the body in the motor cortex, much as it was done on the exposed brain by the pioneers of brain mapping such as Wilder Penfield earlier in the century. The combination of this mapping technique with MRI scanning has allowed the precise localization of the motor cortex on images of individual subjects’ brains. In addition to mapping, the production of muscle responses, TMS is widely used as a probe in physiological studies of the motor cortex and spinal cord. TMS can provide a measure of the functional state of the brain and has helped to elucidate the basis of simple motor behaviors. In 1988, Arnold Starr found that the size of the electrical response or motor-evoked potential (MEP) produced in a muscle by stimulation of the primary motor cortex was increased if the stimulus was given in the 1/4 second or so before the subject was able to move the muscle in response to the “go” signal in a reaction time task. This was evidence of a gradual process taking place in the motor cortex during the reaction time that began be-
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fore conscious perception of the
"go" signal and culminated in
movement. This process was found
to be slowed in patients with
Parkinson disease, who have trouble
initiating movement.6

Later, it was found that rTMS
can also be used to alter the func-
tional state of the brain in order to
influence behavior. For example, a
single stimulus to the motor cortex
given while a subject was prepar-
ing to move in response to a "go"
signal could have dramatic effects
on the reaction time, accelerating
or delaying the movement depend-
ing on the intensity of the stimula-
tion.7,8 In Parkinson disease pa-
tients, the abnormally slow reac-
tion time and retarded increase in
excitability of the motor cortex
prior to movement could be cor-
corrected by the application of a single
TMS pulse.6

Conventional (single-pulse)
magnetic stimulators are capable
of producing one pulse every 1-3
seconds and overheat rapidly
when required to do so for more
than a few minutes. However, in
1988 a new type of stimulator was
introduced that was able to pro-
duce trains of pulses at frequen-
cies of up to 60 per second (al-
though it was only fully effective
at up to about 25 per second). This
type of stimulation, repetitive
transcranial magnetic stimulation
(rTMS) has remarkable effects and
has opened a new field of research
in human neurophysiology.

CURRENT RESEARCH AREAS

The first demonstration that
rTMS was not simply another elec-
trophysiological tool came in 1990
when Alvaro Pascual-Leone and
his colleagues found that rTMS
applied over the area of the left
frontal lobe which controlled the
motor production of speech could
cause transient muteness, or
speech arrest.9 It became clear
that rTMS was able to produce
sustained interruptions of organ-
ized activity in specific areas of
the cortex, which would allow
neurophysiologists to map the loca-
tions of cognitive and perceptual
functions. This has been done suc-
cessfully for various forms of mem-
ory,10,11 the ability to name ob-
jects,12 the ability to learn motor
patterns,13 and visual perception.14

In addition to producing disrup-
tions, rTMS can produce facilitat-
ing effects on behavior. For exam-
ple, continuous rTMS of the motor
cortex with an intensity just below
the threshold for producing muscle
responses improves reaction time
and other parameters of motor
performance in Parkinson disease
patients.6 In unmedicated patients,
this effect persists for hours and
can bring speed of hand movement
and gait up to medicated levels.15
Here, rTMS appears to be replac-
ing neural excitation of the motor
cortex by other brain areas that is
deficient in Parkinson disease.
Although rTMS itself is not practical
as therapy because of the bulkiness
of the equipment, this work has
pointed the way toward a promis-
ing new form of treatment for
Parkinson disease. Recent work
has shown that treatment of the
motor cortex with low frequency
rTMS produces relatively long-
lasting depression of MEPS to test
TMS pulses.16 This is interpreted
as indicating an increase in in-
hibitory neural activity. This is a
potentially useful effect in epilep-
tics, which is a failure of inhibition
in the cortex. Treatment with elec-
trical pulses has been used to
block the generation of seizures in
animals17 and may be able to de-
crease the frequency of epileptic
events in humans as well.

Repetitive transcranial magne-
tic stimulation delivered to the pre-
frontal area of the cortex has ef-
effects on mood in normal individu-
als.19,20 Subjects show a small but
significant tendency to rate their
mood as being better after stimula-
tion of the right prefrontal area
and worse after stimulation of the
same area on the left. Building on
this work, Pascual-Leone et al. and
George et al. have also demon-
strated that daily treatment with
rTMS to the left prefrontal area
causes clinical improvement in pa-
tients with severe depression.21,22
Repetitive transcranial magnetic
stimulation is currently being test-
ed for therapeutic effects in other
psychiatric conditions, such as ob-
sessive-compulsive disorder, with
encouraging preliminary results.23
This recent work has resulted in
considerable attention from clini-
cians in psychiatry and neurology
and the lay public to what had
been an exciting, but little known,
area of neuroscience.

BASIS FOR CONCERNS:
ADVERSE EVENTS

In addition to its beneficial ef-
effects, rTMS has significant risks.
Transcranial magnetic stimulation
with conventional single-pulse
stimulators has produced epileptic
seizures in several patients with
predisposing brain lesions such as
strokes.24 At least one of these
patients also went on to develop
epilepsy, presumably as a result of
the underlying lesion. There is an
additional report of a patient with
amyotrophic lateral sclerosis and
no known history of seizure or any
other brain disorder who had a
secondarily generalized seizure
with single-pulse TMS.25 To date,
rTMS has caused seizures in five
normal volunteers and one de-
pressed subject. The first occurred
in a young woman participating in
an early study of the safety of
rTMS conducted at the National
Institute of Neurological Disor-
ders and Stroke (NINDS) before
the limits of safety for the intensity,
frequency, and duration for trains
of rTMS were known.26 Three
seizures occurred subsequently in
the same laboratory. The next two
were caused by trains that were
within published safety guide-
lines,28 but that were delivered
with very short intervals between
trains.29 Following these two
events another secondarily gener-
alized seizure occurred at the
NINDS. The set of parameter val-
ues used was on the edge of the
area thought to be safe and after
this event the NINDS safety table
was revised.

We have also observed a seizure
in a woman with severe depression
who was participating in a treat-
ment trial of rTMS. She re-
ceived rTMS to the prefrontal area
several times without mishap. The
seizure occurred after the subject,
without the knowledge of the in-
vestigators, began taking psychi-
atrial medications that lowered the seizure threshold. There is one
other report of a seizure caused by rTMS in a healthy man.26 None of
these subjects suffered lasting physical sequela. Most had electro-
encephalograms that, while predictably abnormal immediately
after the seizure, normalized within
in one or two days. Two subjects
had neuropsychological testing be-
fore and after the seizures.22,29
These initially showed mild recall
deficits, which disappeared within
24 hours. However, the first sub-
ject developed some degree of anxi-
ety about the possibility of a recur-
rent seizure. She reported becom-
ing acutely anxious whenever she
experienced any sort of muscular
cramping or discomfort in the
right arm, thinking it might be the
onset of another seizure. Having
been told by the EEG technologist
that the photic activation proce-
dure accompanying the electroen-
cephalogram after the seizure
could provoke epileptic activity,
she actively avoided flashing
lights, believing that they would
cause another seizure. There is no
evidence to suggest that a single
provoked seizure or even a series
of induced seizures, as in electro-
convulsive therapy (ECT) for de-
pression, makes another seizure
more likely in an otherwise
healthy individual.31

Despite the efforts of several in-
vestigators21,22 to develop TMS
and rTMS as diagnostic and locat-
ing tools for the study of epileptic
areas of the cortex, seizures in
epileptic subjects have been sur-
prisingly rare. This is probably
due to the fact that most subjects
have remained on their antiepilep-
tic medications during these stud-
ies. Only one seizure is reported
with single-pulse TMS in an
epileptic patient.34 With rTMS a
seizure was produced in an epilep-
tic subject who was being stimu-
lated on the side of the brain op-
posite to the epileptic focus.35 Per-
haps the greatest experience in
this area belongs to Tassinari and
coworkers at the University of
Bologna who, having administered
rTMS to over 60 patients with var-
ious types of epilepsy, have ob-
served seizures that appeared to
be induced by rTMS in two pa-

tients (out of 10) with progressive
myoclonus epilepsy and one (out of
four) with epilepsy partialis con-
tinue.36 Other investigators37 used
high stimulation intensities and
frequencies in an attempt to ac-
vate seizure foci in 10 unmedica-
ted patients and not only failed to
produce seizures, but caused sig-
ificant, if transient, reductions in
epileptiform electroencephalo-
graphic activity.

While seizure is the most obvi-
ous and acutely serious of the
risks of rTMS, other adverse ef-

teffects are possible. Several studies
have examined transient effects of
rTMS on cognitive, perceptual, and
motor functions after focal stimu-
lation, but few have looked for
longer-lasting, unintended effects
in these areas. In the first study of
the safety of rTMS,25 Pascual-
Leone et al. screened for various
types of deficits before and up to
two hours after maximum inten-
sity stimulation at a range of fre-
quencies delivered to several scalp
locations in 9 normal subjects. No
significant effects of stimulation
were found on the results of any of
these tests except in one subject
who had a generalized seizure (see
above). However, there were
trends toward shortening of motor
reaction time and improved short-
term verbal memory in the sub-
jects who received the greatest
number of stimuli and the highest
stimulation frequencies. The effect
on recall was most pronounced in
those subjects who had received
the most stimulation. In a subse-
quent safety study,16 we found sig-
ificant increases in finger tapping
frequency, but, as in the earlier
study, the only cognitive finding of
note was a trend toward enhanced
verbal recall.

In another study at the NINDS
aimed at examining the effect of
rTMS on a language task, in
which subjects received unpreced-
dented intensities and amounts of
stimulation, there was a signifi-
cant decrease in short-term memo-
ry scores when subjects were test-
ed within an hour after the exper-
iment.38 Unfortunately, these sub-
jects were not reexamined, so the
time course of their recovery is not

known. Other sources of harm
range from the simple and avoid-
able, e.g., possible hearing loss
from the noise generated by the
stimulating coil, to the highly
speculative but potentially sinis-
ter, such as the shaping of brain
pathways39 and maps40 by repeat-
ed activation with rTMS in a kind
of artificially imposed learning
known as long-term potentiation.

BASIC ETHICAL CONSIDERATIONS

The reported occurrence of
seizures in 9 research subjects dur-
ing the 7 years of rTMS research
lends urgency to the task of de-
veloping ethical guidelines for the
future conduct of rTMS studies.

Requirements for Ethical Re-
search. Such guidelines must be
governed by three ethical and legal
requirements applying to all re-
search on human subjects.41 First,
there is the requirement for in-
formed consent. This means that
the subject's choice must be free
and voluntary and based on the
provision of all relevant informa-
tion. Subjects must be informed
of "any reasonably foreseeable
risks or discomforts" (45 CFR 46.116(9)(2)).
Because of the relative newness of
rTMS, subjects should also be told
that rTMS may involve risks to
the subject which are currently
unforeseeable (45 CFR 46.116(b)(1)).
Second, there is the requirement
that risks to the subject be "rea-
sonable in relation to the anti-
pated benefits" (whether for the
subject or in terms of the general-
zizable knowledge that may result)
(45 CFR 46.111(a)(2)). This re-
quirement of a favorable balance
of benefit to risk imposes a respon-
sibility of independent assessment
on investigators and IRBs. Al-
though current regulations privi-
lege the autonomy of research sub-
jects in determining whether they
are willing to accept the balance of
risks to benefits in a protocol,42
their judgments must nevertheless
be deemed "reasonable" in the eyes
of the investigator and the review
board. Third, there is the require-
ment of justice in the distribution
of the burdens and benefits of re-
search. This requirement is violat-
ed when research is conducted on
categories of patients rendered vulnerable by economic, social, or physical conditions or who are likely to bear only the burdens of research and not its benefits.

Suitable Categories of Subjects. Against this background, it is possible to identify those classes of patient-volunteers who, in view of the known and unknown risks, might be suitable subjects for rTMS research. One broad group of admissible research subjects are individuals suffering from neurological or psychiatric disorders for whom rTMS might provide significant clinical benefit. Both the risk-benefit and justice requirements of human subjects research support the appropriateness of this patient category, which includes adult patients with progressive myoclonus epilepsy and children with juvenile myoclonus epilepsy. These individuals must already deal with the physical and psychosocial risks of seizure on a recurrent basis as well as risks associated with high dosages of anticonvulsive medication. Slow rTMS might point the way to a new means of seizure control for these individuals and other forms of rTMS might provide a way of testing new seizure medications. Patients with refractory depression also fit into this class of suitable research subjects. Electroconvulsive therapy (ECT) is a therapeutic alternative for these patients (or has already been tried without success). The seizure risk of ECT is 100% and there are additional risks not present for rTMS, including use of a general anesthetic, memory loss, cardiac arrest, broken teeth, reactions to drugs, and so on. The risk of seizure and its attendant complications with current or foreseen TMS regimens is therefore on a far lower scale of magnitude than this existing alternative therapy. Additional categories of patients might be identified among individuals suffering refractory obsessive-compulsive disorder and other seriously disabling psychiatric conditions for whom there is evidence that rTMS might provide direct benefit.

Outside of the category of patient-volunteers for whom rTMS might provide clinical benefit, an additional category of suitable research subjects are patients with disorders that might not be treated by rTMS but which rTMS might help us better understand. Parkinson disease patients fit into this category. Although research suggests that rTMS can have the short-lived effect of reducing Parkinson symptoms, the primary benefit here lies in an improved understanding of the processes leading to this disease. It is this link between rTMS and Parkinson research that makes this patient class suitable, not the fact that Parkinson disease patients already face substantial independent psychosocial risks that mitigate the impact of seizure events. Ordinarily, on grounds of justice, subjects’ existing suffering and vulnerability is an argument against their inclusion in additionally risky research. In this case, this argument is overridden by the unfairness of denying these patients an opportunity to contribute, whether for themselves or others, to the future treatment or cure of a disease from which they suffer.

Normal Volunteers. Identifying the category of suitable patient-subjects raises the question whether normal volunteers should be allowed to participate in rTMS research. Some might argue against permitting this, since rTMS does not now appear to have the magnitude of scientific or clinical benefit that warrants imposing on healthy individuals the immediate and long-term risks associated with even a single seizure event. Although there is no evidence suggesting that rTMS-induced seizures will recur in a nonepileptic individual, studies in animals have shown permanent physiological changes in the brain, lowering the threshold of excitability (a phenomenon known as “kindling”). It cannot be said, with sufficient confidence, therefore, that a normal volunteer will not have another seizure as a result of the first one, nor can it be said that a subject potentially susceptible to seizures will not be pushed over the edge by repeated rTMS excitation. Quite apart from the reality of further seizure risk, there is risk of a subject’s continued anxiety about seizure recurrence. There is also a possibility that the subject may experience insurance and employment discrimination.

Although these risks raise a formidable barrier to the use of normal volunteers in rTMS research, we do not believe they altogether rule it out. Repetitive transcranial magnetic stimulation promises significant benefits in terms of scientific understanding of normal and abnormal brain functioning and clinical treatment for psychiatric and neurological disorders. We believe that fully informed normal volunteers should be permitted to participate in rTMS research when it is likely to produce generalizable knowledge of vital importance for the understanding of human neurophysiology or the amelioration of disease conditions. In such cases, research may go forward in conformity to the recommended guidelines listed below and subject to a further safety factor indicated in guideline 7.

The governing phrase in this recommendation is that research be “likely to produce generalizable knowledge of vital importance.” This phrase is adapted from current federal regulations governing research in which more than minimal risk is presented by interventions or procedures that do not hold out the prospect of direct benefit to the child-subject (45 CFR 46.406). Our application of this language to rTMS research on adult subjects expresses our belief that research posing significant neurological risks for normal subjects for whom the protocol promises no direct medical benefits must be of compelling scientific or therapeutic potential. This standard permits rTMS research that points the way to significant therapeutic advances and/or that strengthens (or weakens) significant hypotheses about brain function.

One example of such research is the use of rTMS to determine differences in the lateralization of mood response in depressed and normal subjects. Such studies have major implications for our understanding of normal mood and depression. Another example is a study using rTMS in the visual areas of the
brains of blind subjects to disrupt braille reading. Such a study may help confirm earlier PET scan results indicating that supposedly specialized areas of the brain can take over functions in a completely different sensory domain.

**Recommended Guidelines**

To assist IRBs and researchers, we propose the following guidelines for the conduct of all rTMS research. Guidelines 1-9 apply to the assessment of individual protocols. Guideline 10 applies to the rTMS research community as a whole, to manufacturers of rTMS equipment, and to funding agencies sponsoring this research. It goes without saying that all the usual requirements of valid scientific investigation should be established before IRB review. This includes data from appropriate safety studies in animal models. In the case of rTMS this requirement remains in force even though for specific applications of rTMS in humans there might be significant limitations on the use of animal models. Differing brain volumes and configurations, different ratios between stimulation coil size and head size, and the need for patient self-reporting will often render animal models inappropriate. Nevertheless, the burden rests on researchers to show why animal models cannot be used in specific rTMS experiments.

1. **Researchers must demonstrate that they are using the lowest risk form of TMS suitable for the research.** Evidence suggests that seizure risk is greatest in the use of high frequency rTMS with brief intertrain intervals. Because lower frequency rTMS and even nonrepetitive TMS may be equally suitable for inducing the desired effect in some circumstances, researchers should proceed from low risk to higher risk modalities. The burden of proof rests on them to justify each increment of risk.

2. **Researchers must adhere to well-developed exclusion criteria.** Adverse events have occurred in subjects with family histories of epilepsy or who were taking medication that lowered their seizure threshold. The research community is responsible for developing, disseminating, and applying exclusion criteria based on this and other information. Because seizures in a woman can endanger a child she is carrying, consideration must also be given to the standards to be applied to fertile women in rTMS research, including such matters as appropriate means of reporting pregnancy status and preventing conception.

3. **Researchers are responsible for insuring full and informed consent on the part of research subjects.** This includes discussion of the history and consequences of adverse outcomes. Subjects must be made aware of the possible psychosocial risks of seizure, including risks to employment and insurability. Subjects must be reminded frequently that they are permitted to withdraw from research at any time. Only evidence of full and voluntary consent and procedures to guarantee it can justify the use in rTMS research of students or colleagues whose careers may depend on the researcher.

4. **Researchers must be well trained and experienced in the use of rTMS and research should only take place in clinical settings equipped for seizure control.** Researchers must be familiar with the warning signs of seizure and at least one on-site member of the research team must be a medical doctor able to predict, forestall, and treat seizures.

5. **There must be continuous monitoring of subjects during rTMS research.** Appropriate use of EMG and EEG must accompany all rTMS studies. Efforts must be made to develop ways of ensuring continuous monitoring even when stimulation makes the placement of electrodes difficult.

6. **Research must be conducted within the best multidimensional limits of safety for the intensity, frequency, and duration for trains of rTMS.** It is the responsibility of the rTMS research community to develop evidence-based safety limits for the conduct of rTMS research. These safety limits must be constantly reviewed and updated with reference to reports of adverse events. (See below, guideline 10.)

7. **When normal volunteers and other individuals not likely to receive direct medical benefit from the research are involved, additional margins of safety must be imposed on research.** These safety margins would be created by lower intensities, frequencies, and durations of stimulation than those identified as safe by previous experience with rTMS. The research community is responsible for developing and applying quantitative standards for safety in studies on the various subject groups. Additional safety margins should be proportionate to the perceived value of the research. Studies likely to produce less valuable generalizable knowledge require a larger additional margin of safety than studies of greater value. Presuming the full and informed consent of subjects, studies pointing the way to significant therapeutic advances and/or that test significant hypotheses about brain function may approach more closely to established safety limits.

8. **There must be objective assessment of patient condition following rTMS.** Apart from those instances where adverse events have occurred there have been no reports to date of significant or enduring side effects of rTMS. However, such side effects cannot be ruled out, including possible cognitive alterations or impairments. Where cognitive effects are involved, it is not sufficient for investigators to rely on subjects' reports of their mental state, since the ability to assess one's condition may be impaired. Objective assessment of patient condition by competent clinicians is required on a continuing basis (as per guideline 9).

9. **There must be clinical assessment of subjects at regular intervals following research until there is a reasonable certainty that the subject has not been harmed.** The longer term risks of rTMS are unknown. At higher levels of stimulation, enduring neurological and histological changes are a possibility, leading to alterations of seizure threshold or cognitive...
changes in subjects. Provision must be made in all protocols for continuing contact with subjects and the maintenance of a record of subject reports and assessment. No time limit should be placed on this responsibility. IRBs can determine whether this requirement may be waived for some very low risk rTMS research.

(10) The rTMS research community is responsible for developing and maintaining an international registry for adverse outcomes and, in the longer term, a database of rTMS research. Such a registry should be up-to-date and immediately available to researchers throughout the world. Internet access is strongly recommended. Institutional review boards must see to it that researchers have utilized this registry in developing their exclusion criteria and safety parameters. In the absence of full information about the total number of protocols and subjects involved, however, reports of adverse outcomes alone are not an accurate measure of risk. For this reason it has been argued that what is needed is a full database of rTMS research. Such a database would certainly be of great value, and should be developed, even on a pilot basis. The research community, including manufacturers of rTMS equipment and funding agencies, should assist in the development of this resource. However, delays in funding and publishing such a database should not impede the immediate development of an adverse outcomes registry, since this registry can help investigators identify newly discovered risk factors of which they should be aware.

LARGER ETHICAL ISSUES

Because of the promise and dangers of rTMS, society as a whole has a stake in the future directions taken by this new biomedical technology. This suggests two additional areas of concern and responsibility for the rTMS research community. One has to do with the immediate risks of abuse of this technology. We have noted that rTMS has been shown to have both positive and negative effects on mood. Because of its noninvasive nature and seeming harmlessness at low intensities of stimulation, irresponsible researchers or others inside or outside the laboratory may be tempted to use rTMS for unauthorized research or recreational purposes. Researchers and manufacturers must work together now to prevent this by developing adequate laboratory security procedures and, when necessary, by working with governments or regulators to prevent this equipment from falling into inappropriate hands. In the laboratory, use of rTMS by researchers on themselves must be subject to IRB review in accordance with the guidelines for all rTMS research.

A second area of concern is the unknown and speculative long-term risks and benefits associated with society's future development and employment of this technology. Repetitive transcranial magnetic stimulation holds the prospect of a powerful new, noninvasive way of modifying or influencing brain function. Many of the issues raised a generation ago by the work of José Delgado and others in connection with the direct electrical stimulation of the brain remain relevant and may even be accentuated by the development of rTMS. In the area of genetics, the research community has taken a proactive stance by helping develop various federally funded programs devoted to studying the ethical, legal, and social implications of the Human Genome Project. Although it is probably too soon to initiate an effort of this magnitude in the case of rTMS, longer-term and larger social implications should be on everyone's mind. An effort should be made on an ongoing basis to include discussion of these issues in conferences and publications dealing with ethical issues raised by rTMS.

REFERENCES


