GIBSON, DUNN & CRUTCHER LLP
THEODORE J. BOUTROUS, JR., SBN 132099
H. MARK LYON, SBN 162061
ETHAN D. DETTMER, SBN 196046
1881 Page Mill Road
Palo Alto, California 94304
Telephone: (650) 849-5300
Facsimile: (650) 849-5333

JENNER & BLOCK LLP
PAUL M. SMITH
KATHERINE A. FALLOW
MATTHEW S. HELLMAN
601 13th Street, N.W., Suite 1200
Washington, D.C. 20005
Telephone: (202) 639-6000
Facsimile: (202) 639-6066

Attorneys for Plaintiffs
VIDEO SOFTWARE DEALERS ASSOCIATION
and ENTERTAINMENT SOFTWARE ASSOCIATION

UNITED STATES DISTRICT COURT

FOR THE NORTHERN DISTRICT OF CALIFORNIA

VIDEO SOFTWARE DEALERS ASSOCIATION and ENTERTAINMENT SOFTWARE ASSOCIATION, Plaintiffs, vs. ARNOLD SCHWARZENEGGER, in his official capacity as Governor of the State of California; BILL LOCKYER, in his official capacity as Attorney General of the State of California; GEORGE KENNEDY, in his official capacity as Santa Clara County District Attorney, RICHARD DOYLE, in his official capacity as City Attorney for the City of San Jose, and ANN MILLER RAVEL, in her official capacity as County Counsel for the County of Santa Clara, Defendants.	CASE NO. C 05-4188 RMW (RS) DECLARATION OF HOWARD C. NUSBAUM

I, Howard C. Nusbaum, hereby declare as follows:

Pursuant to 28 U.S.C. § 1746, I, Howard C. Nusbaum under penalty of perjury state as follows:

1. I received my B.A. with a major in Psychology from Brandeis University in Waltham, Massachusetts, in 1976, and my Ph.D. in cognitive psychology from the State University of New York at Buffalo in 1981. I was an NIH Postdoctoral Fellow in Speech, Hearing, and Sensory Communication in the Department of Psychology from 1981 to 1984 and an Assistant Research Scientist in the Speech Research Laboratory in the Department of Psychology at Indiana University from 1984 until 1986.

2. I joined the faculty in the Department of Psychology at the University of Chicago in 1986 as an Assistant Professor in the Committee on Cognition and Communication. In 1989, I was promoted to Associate Professor with tenure in the Department of Psychology and became a member of the Committee on Biopsychology. I was promoted to Full Professor in the Department of Psychology in 2001.

3. I became the Chair of the Department of Psychology in 1997 and I continue to serve in that capacity in my third term. I am currently on the editorial board of the journal *Brain and Language*, a journal that focuses on understanding brain mechanisms of language use, and I serve as a reviewer for a wide range of journals including but not limited to the *Journal of Cognitive Neuroscience*, *Cerebral Cortex*, *Cognitive, Affective and Behavioral Neuroscience*, *Psychological Science*, and *NeuroImage*. I am a member of the Committee on Computational Neuroscience at the University of Chicago, which grants Ph.D.s in neuroscience, and the Center for Integrative Neuroscience and Neuroengineering. I also serve on the Advisory Board for the Brain Research Imaging Center at the University of Chicago, and I am Co-Director of the University of Chicago Center for Cognitive and Social Neuroscience.

4. My research is in the area of cognitive psychology and cognitive and social neuroscience. This research examines the psychological and neural mechanisms that are important in learning, categorization, and attention and working memory (characterized sometimes as "executive function"). This work has included a study of the role of sleep in learning perceptual skills published in *Nature* (Fenn, Nusbaum & Margoliash, 2003), the role of attention in perceptual learning (e.g.,

Francis & Nusbaum, 2002), the role of working memory in communication (e.g., Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001), as well as experiments using functional Magnetic Resonance Imaging (fMRI) on the role of attention in understanding different speakers (Wong, Nusbaum, & Small, 2004), and the role of the motor system in face-to-face communication (Skipper, Nusbaum, & Small, 2005).

5. I started carrying out fMRI research in 1998 and have published three papers concerning the use of fMRI in understanding behavior and psychology. Although there has been a dramatic increase in the amount of fMRI research published in recent years, interpreting the results of fMRI studies can be extremely difficult. Measures of neural activity, such as fMRI provides, are only correlations with behavior and cannot be taken on face value as evidence of causality unless alternative explanations are ruled out. Moreover, behavior and brain activity do not relate in a simple, direct, and unique way. One of my papers, published in the *Proceedings of the National Academy of Science* (Cacioppo & Nusbaum, 2003) addressed problems in interpreting fMRI data regarding the brain mechanisms involved in making risky decisions under uncertainty. A second paper (Small & Nusbaum, 2004) addressed the problems of using fMRI to understand complex behavior that is sensitive to context. The third paper (Cacioppo, Berntson, Lorig, Norris, Rickett, & Nusbaum, 2003) provided guidance to social psychologists interested in using neurophysiological measures such as fMRI to understand complex social and emotional behavior. A copy of my CV is attached as Ex. A.

Purpose

6. I have been asked by counsel for Plaintiffs in this case to evaluate and comment on specific published research reports that have been used to support claims regarding the impact of violent video games on brain function. These reports represent the known research published on neurophysiological responses to exposure to violent video games and thus provide the putative basis for assertions in California State bill AB 1179.

7. I have reviewed specific parts of California State bill AB 1179, which regulates the sale of "violent" video games. I have been asked to give my opinion on the Legislature's "finding" in

SECTION 1 that "(a) Exposing minors to depictions of violence in video games, including sexual and heinous violence, makes those minors more likely to experience feelings of aggression, to experience a reduction of activity in the frontal lobes of the brain, and to exhibit violent antisocial or aggressive behavior. (b) Even minors who do not commit acts of violence suffer psychological harm from prolonged exposure to violent video games. (c) The state has a compelling interest in preventing violent, aggressive, and antisocial behavior, and in preventing psychological or neurological harm to minors who play violent video games."

Background on Effects of Video Game Exposure

8. To date, published research on the effects of playing violent video games starts with the specific assumption that playing video games with violent content leads to aggressive behavior, thoughts, and feelings. This assumption relies to a great extent on research by Dr. Anderson and colleagues (Anderson & Bushman, 2001; Anderson & Dill, 2000) examining aggression and the effects of media and video game exposure. Research on neural effects of violent video game playing generally assumes a causal relationship between exposure to violent media and aggressive behavior, thoughts, and feelings, and then sets out to show the brain activation that underlies this causal relationship. However, this underlying research has critical problems that mitigate any possible strong conclusions regarding the relationship between playing video games with violent content and aggressive behavior, thoughts and feelings, as well as any conclusions about the causal role of changes in brain activity in this relationship.

Video Game Exposure and Neurophysiology

Background Assumptions About Brain Functioning.

9. To my knowledge, the current research on the effects of violent video game exposure on neurophysiology consists of three published studies (Bartholow et al., 2006; Mathews et al., 2005; Weber et al., 2006) and two unpublished conference presentations (Kalnin et al., 2005; Wang et al., 2002). Three of these (Mathews et al., 2005; Kalnin et., 2005; Wang et al., 2002) reflect work carried out in collaboration as a research team with Dr. Kronenberger (see Kronenberger et al., 2005a, also). There are some common assumptions among these studies that are questionable at best and simply incorrect at worst.

10. Kronenberger et al., (2005a) and Weber et al. (2006) take as a starting assumption (and Mathews et al., 2005 refer to) a neural model of aggression and violent behavior proposed by Davidson et al. (2002). In simple terms, this model assumes that there are two broad sets of brain regions that are important in violent and aggressive behavior: (1) the limbic system (including the amygdala), and (2) a set of prefrontal and frontal cortical systems associated with a variety of functions including attention, motor behavior, and executive function. This model, which is an untested theory, proposes that increased sensitivity in the amygdala (the first region) and decreased responsiveness in the orbitofrontal and vemtromedial prefrontal regions (the second set of regions) may lead to aggressive behavior. It is important to note that this model is similar in terms of its proposed patterns of brain activity to another model proposed by Davidson et al. (2002) to explain depression *without* aggressive symptoms.

11. A common assumption among many of these studies is that reductions in brain activity (e.g., as seen in Mathews, et al., (2005) (fMRI study), or Bartholow et al., (2006) (brain electrical activity)) reflects a kind of neural deficit. This is simply wrong. Reductions in brain activity can occur for a number of other reasons, including expertise in a skill (Poldrack et al., 2005).

12. Another common assumption is that there is a causal relationship between brain activity and behavior such that showing a change in brain activity in any particular study may predict future aggressive behavior (e.g., Bartholow et al., 2006; Mathews et al., 2005; Weber et al., 2006). In fact, brain activity is only correlated with behavior. Any particular measure may reflect other kinds of thoughts or unexamined physiological changes.

13. There is an assumption made by Mathews et al. (2005) and Weber et al. (2006) that gross psychological functions can be traced to single brain areas. For example, the assertion of an effect of video game violence on executive cognitive function (Kronenberger et al., 2005a) leads to a prediction that there should be effects of video game violence on frontal cortex (Mathews et al., 2005; Weber et al., 2006). Based on this kind of assumption, changes in neural activity within a brain region are assumed to predict specifically changes in the psychological function. Thus, under this theory, if dorsolateral prefrontal cortex ("DLPFC") were assumed to be the area responsible for self-regulation, a change in processing within that area should reflect a change in the psychological

process of self-regulation. That claim is problematic. For example, one classic example of the problems underlying this kind of assumption comes from fMRI research arguing that our psychological expertise in face perception (as demonstrated in various behavioral studies, e.g., Yin, 1969) is mediated by a single brain region called the "fusiform face area" (Kanwisher, McDermott, & Chun, 1997). The claim of this research is that this area of the brain responds uniquely to information about faces and provides no information about other visual patterns (claim one) and that this area is the part of the brain responsible for perception of faces and no other area of the brain has the necessary information (claim two). But in a more sophisticated analysis, researchers using fMRI demonstrated (Haxby, Gonbini, Furey, Ishai, Schouten, & Pietini, 2001) that the fusiform area of the brain conveys sufficient information to distinguish among objects besides faces, such as houses, cats, and chairs (contrary to claim one) and that many other parts of the brain outside the fusiform area have sufficient information to classify faces (contrary to claim two). Any particular part of the brain may be and typically is (as demonstrated by scientific research) associated with a wide range of psychological functions.

14. Dr. Kronenberger and his colleagues have argued that exposure to video games with violent content leads to aggressive thoughts and behavior because video game exposure has an adverse impact on neural mechanisms related to self-control and executive functioning (e.g., Kronenberger et al., 2005a; Mathews et al., 2005). There is no evidence to support this argument. The research presented by Dr. Kronenberger' research team addressing "executive functioning" cannot be used to this conclusion for several reasons.

15. First, there is no clear evidence in Kronenberger et al. (2005a), Kalnin et al. (2005), or Mathews et al. (2005)[1] that exposure to violent media has a reliable adverse effect on self-control or, for that matter, performance on the Stroop task (a cognitive test used by Kronenberger and his co-authors).

---

[1] My citations to Wang et al. (2002, Kronenberger et al. (2002a), Kronenberger et al. (2005), Kalnin et al. (2005), and Mathews et al. (2005) refer to a series of studies conducted by Dr. Williams Kronenberger and his colleagues.

16. Second, there is a fundamental flaw in the logic of all the brain imaging studies that are discussed by Dr. Kronenberger's group (including Kalnin et al., 2005, Mathews et al., 2005; Wang et al., 2002). The logic of these studies assumes that a particular pattern of brain activity is a unique and specific predictor of violent or aggressive behavior. While a pattern of brain activity might be associated with a pattern of aggressive behavior, that same pattern might be associated with many other patterns of behavior. As a result, a pattern of brain activity does not cause or uniquely predict a single pattern of behavior.

17. Third, Kronenberger and his colleagues looked at the effects of violent media generally – television and video games – and thus their research does not support any conclusions about the effects of video games in particular. Kronenberger et al. (2005b) nevertheless suggests that his research on the effects of violent media generally can be applied to ascertain the effect of exposure to video games specifically. The rationale for this appears to be a correlation they have reported that shows that exposure to violence in video games is correlated with exposure to violence in other media. The implication is that because exposure to one form of entertainment is associated with exposure to both, total exposure can be treated as a proxy for the specific causal effects of exposure to video games. However, to the extent that there is concern specifically with the effect of video game exposure, this assumption represents a serious confound that makes valid scientific inferences impossible. Since there is no research that establishes that video game exposure has exactly the same effects as exposure to violence in television or movies, they cannot be treated as equivalent in their effects, even if some children would tend to be exposed to all such media. Measures such as the Media Exposure Measure (e.g., as used in Kronenberger et al., 2005b) aggregate both television and video game exposure. As a result, any research based on such measures cannot provide evidence regarding the specific effect of video game exposure.

Interpretations of fMRI Activity and Other Measurements

18. Mathews et al. (2005) state that activation of certain regions in the frontal lobes occurs during emotional regulation, attention, and inhibitory control. However, emotional regulation, attention, and inhibitory control are complex functions distributed over a broad set of brain areas that involve aspects of the frontal lobes as well as other brain regions. For example, while the DLPFC is

active during tasks that involve visual attention (e.g., looking for your car in the parking lot), it is not specifically or uniquely implicated in emotional control or self-regulation – contrary to statements about the DLPFC made in Mathews et al., 2005 (*see* Davidson et al., 2000). The frontal lobes have a lot of neurons and different cortical areas (e.g., different parts such as sulci and gyri) and represent a very broad range of functions that also include motor control and planning, and encoding of information into memory (e.g., for remembering what you had for breakfast this morning). Also, many of the functions that are specifically attributed to only the frontal lobes, e.g., attention, involve a broad network of brain areas outside the frontal lobes (e.g., superior parietal cortex and the thalamus). Although different parts of the frontal lobes may be involved in different psychological functions, few, if any, carry out only a single function and few, if any represent the only brain areas involved in that function. Mathews et al. (2005) and Weber et al., (2006), argue that reduced activation of certain brain areas may be associated with a wide range of problems, including difficulties in attention, self-monitoring, and impulse control, among others. This is presented so that it implies a causal relationship (explicitly stated by Weber et al.), between the reduced activity in these brain areas and these behavioral or psychological problems, but that causal relationship cannot be inferred (e.g., see Uttal, 2001), for several reasons.

19. First, reduced activity in specific brain regions is not a clear, unique and specific "marker" of psychological or behavioral problems. Activity in "these regions" can decrease as a result of expertise in attention (e.g., Poldrack, Sabb, Foerde, Tom, Asarnow, Bookheimer, & Knowlton, 2005) as well as deficits in attention.

20. Second, reduced activity in some regions of the brain may be accompanied by increased activity in other regions, reflecting a change in the distribution of brain activity, but not necessarily a deficit of any kind. For example, in a comparison of younger and older adults who perform comparably on certain tasks involving memory, the younger adults show less activation than the older adults in some of the brain areas (Reuter-Lorenz, 2002) referred to by Wang et al. (2002) and Mathews et al. (2005). The younger adults are typically thought of as performing better at these tasks, and they show a change in the distribution of brain activity that is similar to that noted by Mathews et al. (2005) as reflecting the effects of violent media exposure. In the case of younger

adults, the reduction has nothing to do with violent media, but rather probably shows increased brain *efficiency*. Thus, changes in brain activity level downward or upward cannot be interpreted in a single, simple way. Moreover, changing the relative distribution of brain activity cannot be interpreted in any simple way.

21. Bartholow et al., (2006), Weber et al. (2006), and Dr. Kronenberger's group (Mathews et al., 2005; Kalnin et al., 2005; Wang et al., 2002) suggest that reduced brain activity reflects some kind of neurological deficit. Moreover, based on the Davidson et al. (2002) model, the appearance of reduced neural activity in the frontal lobes coupled with increased activity in the amygdala is treated as a diagnostic pattern of risk for aggression. But Weber et al. (2006) report evidence that rejects this prediction, showing some increases in anterior cingulate activity and decreases in amygdala activity while playing violent video games—exactly the opposite of the results reported by Dr. Kronenberger's research group. Furthermore, just as decreases in activity in a brain region does not have a unique interpretation (e.g., "functional deficit"), increases in brain activity in particular regions do not have a unique interpretation. As noted previously, patterns of fMRI data simply correlate with patterns of behavior and causality cannot be inferred from this association of measurements.

22. Moreover, I am relatively certain that I could design a task that in normal participants would produce the pattern of brain activity described by Dr. Kronenberger's group without any risk of producing aggressive behavior. For example, presenting listeners with recorded speech with emotional content can increase, over some baseline resting level, the fMRI measured response in the amygdala and temporal lobes. If one group of subjects (a memory group) had to hold certain words in memory from sentence to sentence, and another group (a passive listening group) only had to listen and understand, the memory group would show more prefrontal cortical activity and in the amygdala and temporal lobes and, relatively speaking, the passive listening group would show less activity in prefrontal cortex than the memory group. But this would certainly not cause them to have aggressive thoughts or behaviors.

23. It is also important to note that the amygdala can show patterns of activation in situations without any threat or negative emotion whatsoever. For example, in a listening task with

different sounds in both ears, the amygdala is activated (Pollmann et al., 2004), and in making choices under statistical uncertainty the amygdala is activated (Fukui et al., 2005).

24. There is often an impression from research reports that brain images from fMRI are direct reflections of neural activity. It is therefore tempting to infer that reductions in these measurements demonstrate reductions in brain activity. However, these neurophysiological measures do not actually directly depict neural activity. Real neural activity (as measured by post-synaptic potentials or firing rates some of which are grossly measured by scalp electrodes) increases metabolic activity (which is measured by "positron emission tomography" (PET) neuroimaging). Increased metabolic activity increases the "blood oxygen-level dependent" (BOLD) response in the brain. fMRI measures the BOLD response and therefore does not directly measure brain activity, but instead measures a change in the oxygenation of blood due to the metabolic activity that is a consequence of brain activity. Moreover, sometimes in fMRI studies what appears to be a sign of neural activity is instead simply a major supply of blood or a consequence of poor analysis and what appears to be an electrical neural signal may be a motor artifact.

25. It is also very important to understand that the analysis of fMRI and ERP (event-related brain electrical potentials measured from scalp electrodes) data depends on mathematical models chosen by the researcher. The data that are presented in tables or in colored displays imposed on gray scale images of the brain are highly abstracted statistical models of the fMRI measurements and not the actual brain or BOLD measurements themselves. Thus, the results that are reported in any particular fMRI study depend entirely on the analytic assumptions of the underlying model chosen by the researcher. The impression that these images from fMRI are direct depictions of neural activity in the brain is incorrect. For example, group data (e.g., as shown in Kalnin et al., 2005; or Mathews et al., 2005) can indicate activity in one area of the brain, even when no single participant actually shows activity in that area (e.g., due to spatial averaging of activity across subjects).

26. In addition to fMRI, Kronenberger has made claims about the effects of violent media using certain "neurocognitive" tests. Neurocognitive tests are behavioral tests used primarily by clinical neuropsychologists and neurologists to make diagnoses of organic behavioral dysfunctions (without making any accurate claims about the specific brain location of the dysfunction). However,

these are not scientific research tools closely calibrated to reflect, in their results, an accurate picture of brain activity, as implied by research in Dr. Kronenberger's group (e.g., Kronenberger et al., 2005a). While it is true, in fact tautological, to say that behavior reflects brain activity, and vice versa, it is not true that brain dysfunction such as damage from stroke can be accurately (say to the measurement accuracy of fMRI on the order of millimeters or even centimeters) located in the brain from neurocognitive tests.

Claims About Activation Of Regions Dealing With "Emotion"

27. Some researchers have claimed an ability to measure a person's "emotional" response to violent media through fMRI. These researchers posit that increases in neural activation in the amygdala and other areas signal an increase in emotional responses that could lead to aggression. For example, Murray (2001) reported a study, which is *not* about video game experience or exposure, in which brain activity was measured for children viewing boxing scenes from a *Rocky* movie compared to a movie of animals at play or about children's literacy. This study demonstrated neural activation in areas (such as the amygdala and hippocampus) that are claimed to reflect negative emotional responses such as fear (e.g., Murray, 2001; Weber et al., 2006). Murray suggests that the study shows that violent media causes an increase in "negative" emotions. That conclusion is incorrect for a number of reasons.

28. First, it is important to note the amygdala has been associated with brain functions that have nothing to do with aggression or threat. For example, researchers have observed that similar activation in the amygdala is consistent with judging unpleasant words (Maddock, Garrett, & Buonocore, 2003), negative facial expressions (Phillips, Young, et al., 1997), or body expressions (Hadjikhni & de Gelder, 2003), decisions with uncertainty (Fukui et al., 2005), and when pairs of different sounds are presented to both ears (Pollmann et al., 2004). In all of these instances, no violence or threat or stress or emotional experience for the viewer is involved. This amygdala activity may reflect understanding of an emotional scene in the *Rocky* movie, just as the activity in the hippocampus (another part of the "frontal lobes" referred to by Drs. Kronenberger and Murray) may reflect recognition of faces or places seen earlier in the movie (Dezel, Habib, et al., 2003), and the posterior cingulate may be active due to remembering things the actors had said previously in the

movie (Fujii et al., 2002). The frontal lobe regions referred to by Murray (2001) as being active while watching *Rocky* include areas that are also used to understand another person's physical actions (cf. Farrer & Frith, 2002). Thus, this collection of brain areas may also reflect a higher level of engagement in trying to follow a movie with a plot, actors talking, and physical action (some of which is emotional or has emotional consequences), rather than anything specific to the effects of violence.

29. Mathews et al. (2005) and Weber et al. (2006) and Kalnin et al., (2005) cite a theoretical review by Davidson, Putnam, & Larson (2000) for the proposition that a pattern of reduced brain activity in the frontal cortex and increased activity in the amygdala in "emotionally provocative tasks" is found in people with greater amounts of aggressive behavior. It may be relatively easy to produce this same pattern in normal subjects simply by presenting the right kind of stimuli and tasks without any change in aggressiveness at all. In any event, ithis same pattern of reduced frontal activity and increased amygdala activity also is found in another population not mentioned in these studies– people with clinical depression (Davidson, Pizzagalli, Nitschke, and Putnam, 2002). Clinical depression also produces the same kind of brain pattern, but clinically depressed patients are the least likely clinical population to display aggressive behavior. It should be noted that whereas the prediction of the model is that violent games should increase amygdala sensitivity, and Kalnin et al. (2005) report this, Weber et al. (2006) report exactly the opposite findings—reduced amygdala activity in response to violent video game exposure.

30. Further undermining the claims made by these researchers, the handful of studies in this area have yielded conflicting results and, importantly, have not even studied the area of the brain that *would* be most associated with "behavioral control" (though for the reasons already discussed, this is a problematic and unsubstantiated theory). For instance, the findings of brain activity for Disruptive Behavior Disorder adolescents reported in Kalnin et al. (2005) and Wang et al. (2002) (in unpublished and unreviewed studies) do not seem to correspond to the model that has been cited by the same group of researchers in a later study, Mathews et al. (2005). First, the pattern described in that model of aggressive and violent behavior (by Davidson et al. (2000)) depends on a brain region called orbitofrontal (and associated ventromedial prefrontal) cortex. But none of the studies reported

by Kronenberger and his colleagues looked at that area of the brain. Indeed, the 2005 study published by Kronenberger and his colleagues, Mathews et al. (2005), explicitly state that they did not have the technical ability or capability to image brain activity in the orbitofrontal cortex. Likewise, the Wang et al. (2002) study examines brain regions more closely associated with cognitive processes such as working memory and attention (e.g., Badre & Wagner, 2004; Kondo et al., 2004), rather than impulse control. The Kalnin et al. (2005) study does not explicitly identify (as would be standard in most scientific brain imaging) the brain regions that are investigated. Thus it appears that the technical limitations on the research carried out by Dr. Kronenberger's group cannot investigate the brain regions that were identified by Davidson, et al. (2000) as relevant for aggressive behavior – but which in any event are also relevant to depression (Davidson et al., 2002).

Methodological Biases In Measures of "Aggression" and "Media Exposure"

31. Another problem with the methodology used in Dr. Kronenberger's research group is how they measured "aggression." The participants are described in the studies as adolescents with Disruptive Behavior Disorder (DBD). In studies such as Mathews et al. (2005), subjects can be classified as DBD simply by breaking rules and challenging authority. Although Dr. Kronenberger's research team found that each subject had at least one incident of "aggression" in the 6 months prior to the study, the subject's aggressive behavior (which can include verbal aggression) was based solely on the report of a caregiver. In other words, there is no objective evidence of aggressive behavior in these subjects and it is entirely possible that adolescents who defy the authority of their caregiver may be reported as displaying overt aggression due to reporting bias.

32. As noted previously, the measure of violent media exposure employed by Dr. Kronenberger's team did not separate out exposure to "violent" video games from "violent" television. It is therefore not possible to draw any conclusions from research using this measure regarding the exposure to video games containing violence. A correlation in exposure among the different types of media cannot mitigate this criticism. Furthermore, it is important to note that, contrary to the guidelines of the best standards of evidence-based medicine, this measure of exposure is based solely on self-report and parent reports, which are subject to reporting biases and are not substantiated by objective measurements of actual video game exposure. The detailed nature of the

reports cannot substitute for objective measures of observed exposure; retrospective self-report measures, are subject to recall error among other biases.

Measuring "Executive Functioning"

33. In Kronenberger et al. (2005a) it is claimed that the "executive functioning" of adolescents is impaired for those with higher exposure to media violence and this has been associated with differences in patterns of brain activity in the "frontal lobes" (Mathews et al., 2005; Wang et al., 2002). The discussion of "executive functioning" is at best incomplete. The frontal lobes are, relatively speaking, large and complex neural networks. While cortical activity in parts of these regions is associated with decision-making, behavioral control, attention, and other cognitive functions, it is incorrect to treat these regions as homogeneous or undifferentiated either anatomically or with respect to their functions, as this research appears to do.

34. For example, the neurocognitive tasks used by Dr. Kronenberger's team are not directly relevant to aspects of frontal cortex activity in service of behavioral or emotional control. Mathews et al., (2005) and Kronenberger et al. (2005a) used variants of a task called the "Stroop task." This is a response-selection task in which subjects have to ignore one property of a stimulus (e.g., the word RED) and name (or press a button to classify) the color of the ink in which it is printed (e.g., green). Since reading the word (i.e., RED) and naming the color of the ink (i.e., GREEN) are both responses in terms of color names, and because reading is a highly practiced skill and ink color naming is not, the response based on the printed word interferes with naming the color. Subjects have to filter out one response and focus on the other. Other forms of the Stroop task such as the Counting Stroop (as in Mathews et al., 2005) present a possible response conflict in the number of items (to be named) and the numbers that make up the items. For example, if presented with 3333, the correct response of the number of items (i.e., 4) is in conflict with the name of the items themselves (i.e., 3).

35. It is important to note that "response conflict" in the context of a Stroop task only means that there are two possible responses (e.g., in Color Word Stroop, the word RED and the ink color green) and only one is correct (i.e., the ink color green). It does not imply "conflict" as in conflict between people, and response selection, in this situation has nothing to do with behavioral

regulation or control. In addition, Kronenberger et al. (2005) used a vigilance task called the continuous performance task (CPT). These tasks do not involve impulse control or self-control.

36. The Wang et al. (2002) study, which looked at fMRI results of adolescents who watched a filmed clip of video game play, is not published and does not (as a PowerPoint presentation) provide sufficient data to support its conclusions. It does appear, however, that the Wang et al. (2002) study examined brain activity without any kind of "executive function" task. Thus, the changes in frontal lobe activity reported cannot be interpreted specifically about executive functioning within this task. The comparison of observing a James Bond game (but not playing the game) and a car racing game is more akin to watching a movie than to an actual task that specifically requires explicit decisions and responses.

37. Group differences of the type used in all the studies reported by Dr. Kronenberger's team cannot serve as the basis for drawing any causal conclusions about the relationship between media exposure and executive functioning. Two groups such as DBD and Control subjects may differ in a number of ways that they are not matched on, and these differences may be responsible for any measured differences in performance on a test. Moreover, assignment to the groups is not done by the standards of evidence-based medicine, making it impossible to draw any strong conclusions regarding these differences.

38. For example, Kronenberger et al. (2005) report that the DBD and Control subjects were matched on IQ. However, there are many cognitive functions that can vary among individuals that do not specifically correlate with IQ. Among other things, it is possible that there are working memory differences between the groups such that Controls have greater working memory ability. Working memory refers to the ability to hold information in mind while using it for some purpose (e.g., Baddeley, 1986). Or there may be differences in reading ability between the groups, or math ability, or some other cognitive skill or function that has not been assessed. If so, the difference between these groups in performance of a task such as Stroop may be entirely due to these uncontrolled differences, rather than the claimed difference of aggressive or disruptive behavior.

39. Similarly, two groups that differ in reports of exposure to violent media could differ for a number of reasons beyond this exposure, which could be similar to the DBD vs. Control group

difference. For example, DBD kids may not read as much as Control kids, and kids with high exposure to media with violent content may read less than those with low exposure to media with violent content because this content is more exciting (Anderson & Dill, 2000). In the Wang et al. (2002) study comparing a James Bond "violent" video game and a "non-violent" car racing game, control subjects appear to have rated the James Bond game more exciting, interesting, fun, and requiring attention than car racing (although this difference may not be significant and the scales have been manipulated so the difference in the numbers is not readily visually apparent). Therefore, ratings of violent media exposure might be predicted by reading ability and interest, such that poor readers play more video games that are fun, exciting, and interesting (and have violent content) that than good readers who spend more time reading. And poor readers might show more Stroop interference than good readers (cf. Johnson et al., 2003). There is no way to draw any conclusion from this study regarding the causal role of violent media exposure and certainly there is no basis for concluding anything regarding the effects of exposure to video game violence (because the researchers did not differentiate between television and video game violence).

Two Additional Research Reports

40. A recent study reported by Weber et al. (2006) is the first study in which participants actually play a violent video game during fMRI neuroimaging. However, the report is published in *Media Psychology*, a non-peer-reviewed journal, and gives very little technical information about the data analyses or the basic methods of the study. It is important to note, however, that the results reported by Weber et al. are not consistent with the previous findings reported by Dr. Kronenberger's group. The Weber study only reports neural activity from three cortical regions—two parts of the anterior cingulate (dorsal and rostral portions) and the amygdala The decreased amygdala activation and the interpretation of the rostral anterior cingulate activation is inconsistent with the Davidson et al. (2002) model used by Dr. Kronenberger's research team and the results for the amygdala and dorsal anterior cingulate directly contradict the findings of Kalnin et al. (2005). Although Weber et al. argue for a causal relationship between violent video game playing and the patterns of brain responses reported, there is no evidence of causality. First, neuroimaging measurements are simply correlational measures (see Uttal, 2001). Second, the authors have only carried out cross-

correlational analyses of the relationships among three different brain areas. These can certainly show that there are reliable associations but cannot rule out other factors from playing a causal role.

41. A second study by Bartholow et al. (2006) makes extremely strong, but unsupported, claims that exposure to violent video games results in a neural deficit in processing violent images that leads to aggressive behavior. In this study, participants with more or less experience playing violent video games were shown a series of pictures, some violent and some not. Brain electrical activity was measured using scalp electrodes, focusing on the "P300 component." One of the components of brain electrical activity occurs 300 msec after a stimulus and typically is thought to reflect the recognition of the stimulus. This measurement is known as the "P300 component." In the Bartholow et al. study, the P300 was smaller with regard to violent images for participants with more experience playing violent video games, but was not reliably different for neutral or non-violent but negative images. There is no specific or unique psychological interpretation of this difference, nor is there any specific or unique behavioral prediction that follows from this. The neural mechanisms underlying the size of the P300 response are not understood. Thus one cannot draw any strong conclusion from this finding.

42. In addition, participants in the Bartholow study played a competitive game in which they presented a noise to their competitor whenever the participant won a round. Although Anderson and Bushman (2001) have called the adjustment of the noise an aggressive behavior, in my opinion there is no evidence that noise adjustment is anything more than a competitive behavior. In their 2005 study, Bartholow et al. showed that participants with more experience playing violent video games also presented longer or louder noises (there is no clear report of how much longer or louder the noise was). Since the P300 has no specific relationship to aggressive behavior or self control (it is a measure of perceptual categorization), and the competitive game behavior is not specifically aggressive, there is no evidence in this study about the effects of violent video game exposure on anything related to aggressive behavior or neurological deficits.

Evidence that Video Games Improve Cognitive Function

43. It is interesting to note that another set of researchers, Green and Bavelier (2003), showed that extensive experience playing games with violent content such as *Grand Theft Auto 3*,

Half-Life, and *Halo* produce substantial *improvements* in cognitive function in visual attention tasks that involve selection and control of processing. Moreover, this paper showed that these improvement are specifically obtained as a result of experience with video games with violent content and not for video games without violent content. Green and Bavelier gave non-game playing subjects experience playing either *Medal of Honor: Allied Assault*, which has "violent" content, or Tetris, which has no violent content but engages eye-hand coordination and interest. Subjects trained on the first-person shooter game showed significant improvements in visual information processing and attentional control compared to subjects trained on the non-violent puzzle game. The researchers do not attribute these benefits to the violence but to the way these games engage the player. (The Green and Bavelier (2003) study is one of the few studies that selected subjects based on specific video game experience to examine using performance tests the psychological consequences of this experience, and then tested the conclusion by specifically providing that experience to novices and administering the same tests.) It is extremely important to note that these improvements in behavior would likely be accompanied by reductions in fMRI measures of brain activity in the DLPFC and ACC since these areas are involved in attention (LaBerge, 1995). Indeed, Poldrack et al. (2005) found just such reductions in cortical activity after attentional training.

Conclusion

44. In summary, there is no evidence any of the research on neuroimaging or brain electrical activity that playing violent video games produces any kind of neurological deficit. Nor do these neuroimaging studies show that playing violent video games reduces neural activity in the frontal lobes of game players. Furthermore, there is no evidence that playing violent video games has a negative effect on executive function or self control.

45. The California State Legislature's "finding" that minors who play video games with violent content are more likely (1) to engage in violence or aggression, (2) to experience feelings of aggression, and (3) to experience a reduction in brain activity in the frontal lobes is not supported by the existing research. As noted previously, there is no strong scientific evidence supporting the first two of these assertions that playing video games with violent content causes aggressive behavior and thoughts. And as I have explained above, the research put forth to support the third proposition is

seriously flawed. However, even if the third contention were correct, given all the qualifications and concerns already raised previously, it is not clear that it has any significance regarding the first two claims. Reductions in frontal lobe activity, as reported in the research reviewed here, are not in areas that have been most closely identified with problems of behavior or aggression control, namely orbitofrontal or ventromedial cortex. Instead, the areas that are demonstrated to show reductions, dorsolateral prefrontal cortex and anterior cingulate, are areas of the brain more closely associated with attention. The assumption that such reductions reflect deficits in brain function is not warranted, given that extensive experience with video games leads to improvements in attentional function and that studies that examine brain activity following improvements in attention function reveal reductions in these areas.

References

Adleman, N. E., Menon, V., Blasey, C. M., White, C. D., Warsofsky, I. S., Glover, G. H., & Reiss, A. L. (2002). A developmental fMRI study of the Stroop color-word task. *Neuroimage*, *16*, 61-75.

Anderson, C. A., & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: A meta-analytic review of the scientific literature. *Psychological Science*, *12*, 353-359.

Anderson, C. A., & Dill, K. E. (2000). Video games and aggressive thoughts, feelings, and behavior in the laboratory and in life. *Journal of Personality and Social Psychology*, *78*, 774-790.

Baddeley, A. D. (1986). *Working memory*. New York: Oxford University Press.

Badre, D., & Wagner, A. D. (2004). Selection, integration, and conflict monitoring; assessing the nature and generality of prefrontal cognitive control mechanisms. *Neuron, 41,*473-497.

Bartholow, B. D., Bushman, B. J., & Sestir, M. J. (2006), Chronic violent video game exposure and desensitization to violence: Behavioral and event-related brain potential data. *Journal of Experimental Social Psychology,* to appear.

Bucher, H. C., Guyatt, G. H., Cook, D. J., Holbrook, A., & McAlister, F. A. (1999). Users' guides to the medical literature: XIX. Applying clinical trial results. A. How to use an article measuring the effect of an intervention on surrogate end points. Evidence-Based Medicine Working Group. *JAMA*, *282*, 771-778.

Cacioppo, J. T., & Nusbaum, H. C. (2003). Component processes underlying choice. *Proceedings of the National Academy of Sciences*, *100*, 3016-3017.

Cacioppo, J. T., Berntson, G. G., Lorig, T. S., Norris, C. J., Rickett, E., & Nusbaum, H. (2003). Just because you're imaging the brain doesn't mean you can stop using your head: A primer and set of first principles. *Journal of Personality & Social Psychology*, *85*, 650-661.

Davidson, R. J., Pizzagalli, D., Nitschke, J. B., & Putnam, K. M. (2002). Depression: Perspectives from affective neuroscience. *Annual Review of Psychology, 53,* 545-574.

Davidson, R.J., Putnam, K.M. & Larson, C.L. (2000). Dysfunction in the neural circuitry of emotion regulation-A possible prelude to violence. *Science*, 289 591-594.

Dezel, E., Habib, R., Rotte, M., Guderian, S., Tulving, E., & Heinze, H. Human hippocampal and parahippocampal activity during visual associative recognition memory for spatial and nonspatial stimulus configurations. *Journal of Neuroscience*, *23*, 9439-9444.

Farrer, C. & Frith, C. D. (2002). Experiencing oneself vs another person as being the cause of an action: the neural correlates of the experience of agency. *NeuroImage*, *15*, 596-603.

Fenn, K. M., Nusbaum, H. C., & Margoliash, D. (2003). Consolidation during sleep of perceptual learning of spoken language. *Nature*, *425*, 614-616.

Francis, A. L., & Nusbaum, H. C. (2002). Selective attention and the acquisition of new phonetic categories. *Journal of Experimental Psychology: Human Perception and Performance*, *28*, 349-366.

Fujii, T., Okuda, J., Tsukiura, T., Ohtake, H., Miura, R., Fukatsu, R., Suzuki, K., Kawashima, R., Itoh, M., Fukuda, H., & Yamadori, A. (2002). The role of the basal forebrain in episodic memory retrieval: a positron emission tomography study. *NeuroImage*, *15*, 501-508.

Fukui, H., Murai, T., Fukuyama, H., Hayashi, T., & Hanakawa T. (2003). Functional activity related to risk anticipation during performance of the Iowa Gambling Task. *Neuroimage. 24*, 253-259.

Goldin-Meadow, S., Nusbaum, H. C., Kelly, S., & Wagner, S. (2001). Explaining math: Gesturing can lighten the load. *Psychological Science*, *12*, 516-522.

Green, C.S. & Bavelier, D. (2003). Action video game modifies visual attention. *Nature, 423*, 534-537.

Hadjikhani, N., & de Gelder, B. (2003). Seeing fearful body expressions activates the fusiform cortex and amygdala. *Current Biology, 13*, 2201-2205.

Haxby, J. V., Gobbini, M. I., Furey, M. L., Ishai, A., Schouten, J. L., & Pietrini, P. (2001). Distributed and overlapping representations of faces and objects in ventral temporal cortex. *Science*, *293*, 2425-2490.

Johnson, W., Bouchard, T. J., Segal, N. L., Keyes, M., & Samuels, J. (2003). The Stroop Color-Word Test: Genetic and environmental influences; Reading, mental ability, and personality correlates. *Journal of Educational Psychology*, *95,*58-9565.

Kalnin, A. J., Wang, Y., Kronenverger, W. G., Mosier, K. M., Li, T. Q., Dunn, D. W., & Mathews, V. P. (2005). Effects of media violence in adolescents with disruptive behavior disorder: Emotional Stroop fMRI study. Paper presented at the 11th Annual Meeting of the Organization for Human Brain Mapping, Toronto, Ontario.

Kanwisher, N., McDermott, J., & Chun, M. (1997) The Fusiform Face Area: A Module in Human Extrastriate Cortex Specialized for the Perception of Faces. *Journal of Neuroscience*. **17** 4302-4311.

Kondo, H., Osaka, N., & Osaka, M. (2004). Cooperation of the anterior cingulate cortex and dorsolateral prefrontal cortex for attention shifting. *Neuroimage. 23*, 670-679.

Kronenberger, W. G., Mathews, V. P., Dunn, D. W., Wang, Y., Wood, E.A., Giauque, A. L., Larsen, J.J., Rembusch, M. E., Lowe, M. J., & Li, T. (2005a). Media violence exposure and executive functioning in aggressive and control adolescents. *Journal of Clinical Psychology*, *6,* 725-737.

Kronenberger, W.G., Mathews, V.P., Dunn, D.W., Wang, Y., Wood, E.A., Larsen, J.J., Rembusch, M.E., Lowe, M.J., Giauque, A.L., & Lurito, J.T. (2005b). Media violence exposure in aggressive and control adolescents: Differences in self- and parent-reported exposure to violence on television and in video games. *Aggressive Behavior*, *31*, 201-216.

LaBerge, D. (1995). *Attentional processing: The brain's art of mindfulness.* Cambridge, MA: Harvard University Press.

Maddock, R. J., Garrett, A. S., & Buonocore, M. H. (2003). Posterior cingulate cortex activation by emotional words: fMRI evidence from a valence decision task. *Human Brain Mapping*, *18*, 30-41.

Mathews, V. P., Kronenberger, W. G., Wang, Y., Lurito, J. T., Loew, M. J., & Dunn, D. W. (2005). Media violence exposure and frontal lobe activation measured by fMRI in aggressive and non-aggressive adolescents. *Journal of Computer Assisted Tomography*, *29*, 287-292.

Poldrack, R.A., Sabb, F., Foerde, K., Tom, S., Asarnow, R., Bookheimer, S., & Knowlton, B.J. (2005). The neural correlates of automaticity during motor skill learning. *Journal of Neuroscience*, *25*, 5356-5364.

Phillips, M. L., Young, A. W., Senior, C., Brammer, M., Andrew, C., Calder, A J., Bullmore, E. T., Perrett, D. I., Rowland, D., Williams, S. C. R., & Gray, J. A., & David, A. S. (1997). A specific neural substrate for perceiving facial expressions of disgust. *Nature, 389*, 495-498.

Pollmann, S., Lepsien, J., Hugdahl, K., & von Cramon, D. Y. (2004). Auditory target detection in dichotic listening involves the orbitofrontal and hippocampal paralimbic belts. *Cerebral Cortex, 14,* 903-913.

Posner, M.I. (2003). Imaging a science of mind. *Trends in Cognitive Sciences*, *7*, 450-453.

Potenza, M. N., Leung, H., Blumberg, H., Peterson, B. S., Fulbright, R. K., Lacadie, C. M., Skudlarski, P. & Gore, J. C. (2003). An fMRI Stroop task study of ventromedial prefrontal cortical function in pathological gamblers. *American Journal of Psychiatry*, *160*, 1990-1994.

Reuter-Lorenz, P.A. (2002). New visions of the aging mind and brain. *Trends in Cognitive Sciences, 6*, 394-400,

Skipper, J. I., Nusbaum, H. C., & Small, S. L. (2005). Listening to Talking Faces: Motor Cortical Activation During Speech Perception. *NeuroImage*, 25, 76-89.

Small, S. L., & Nusbaum, H. C. (2004). On the neurobiological investigation of language understanding in context. *Brain & Language*, *89*, 300-311.

Uttal, W. R. (2001). The new phrenology: the limits of localizing cognitive processes in the brain. Cambridge, MA: MIT Press.

Wang, Y., Mathews, V. P. Lurito, J. T., Lowe, M. J., Dzemidzic, M., Phillips, M. D., Kronenberger, W., & Dunn, D. (2002). Effects of violent media exposure by adolescents with Disruptive Behavior Disorder as compared to control subjects: fMRI activation patterns in frontal lobe. Paper presented at the 88th Annual Meeting of the Radiological Society of North America, Chicago, IL.

Weber, R., Ritterfeld, U., & Mathiak, K. (2006). Does playing violent video games induce aggression? Empirical evidence of a functional magnetic resonance imaging study. *Media Psychology*, *8*, 39–60.

Wong, P. C. M., Nusbaum, H. C., & Small, S. L. (2004). Neural bases of talker normalization. *Journal of Cognitive Neuroscience*, *16*, 1173-1184.

///

///

///

///

///

///

///

///

///

///

///

///

///

///

I declare under the penalty of perjury that the foregoing is true and correct.

Dated this 27th day of March,

Howard C. Nusbaum