# Keep It Simple Stimuli: Brain-Vetted Elements of Movie Trailers Predict Opening Weekend Ticket Sales

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## ABSTRACT

We propose a novel method to predict movie ticket sales based on the stimulus complexity of the associated advertisements (i.e. movie trailers). We identify characteristics of movie trailers (e.g. semantic and visual clarity) that promote neural similarity (i.e. Cross-Brain-Correlation) among moviegoers at a commercial theater and foreshadow commercial success.

## INTRODUCTION

The film industry has enticed consumers with movie trailers for over a century. When the first movie trailer debuted in 1913, it was heralded as "an entirely new and unique stunt" (Hoefling 2010). Now ubiquitous and highly competitive, movie trailers are the products of substantial investment. A single movie trailer can take six months to produce and Hollywood spends over $3 billion per year on cinematic advertising (Faughnder 2015). Putting that into perspective, annual movie trailer production costs more than buying a movie ticket for every person in the United States (average ticket price is $8.70, IMDb.com, Inc., Seattle, Washington; US population is 323 million, US Census Bureau).

Given the film industry's high upfront advertising costs, there is substantial interest in advance predictions of the commercial success of movies. Researchers have identified potential early indicators of financial outcomes such as aspects of a movie's script or whether the movie is a sequel (Eliashberg et al. 2006). In particular, Eliashberg et al. report that sequels tend to outperform stand-alone movies in ticket sales and that advertising for sequels is more efficient since moviegoers have prior knowledge of the base story. Additionally, there has been a rapid increase in scholarly attention to the effects of individual cast members on film revenue. A star actor's participation in a film is often interpreted as implicit endorsement of the project, and endorsements by popular figures have been broadly successful in advertising campaigns (Choi et al. 2005). Specifically, a star actor garners an average of $3 million in additional ticket sales for a film, but often the compensation paid to these actors cancels out the marginal increase in theatrical revenues to the film studio (Elberse 2007). Eliashberg et al. also cites the rising cost of talent (especially for sequels) as a factor that complicates revenue predictions.

High revenue movies, by definition, attract a wide audience, which suggests that the corresponding movie trailers were broadly appealing to the moviegoer population. Qualitatively, members of a captivated audience behave similarly: laughing, flinching, or gasping at the same time, looking in the same direction, and maintaining an attentive physical posture. Recent research has identified neural underpinnings for such behavioral resemblances; neuroscientists have discovered that brains act similarly while processing certain stimuli, such as memorable movies, television shows, advertisements, and stories (Hasson et al. 2004, Furman et al. 2007, Hasson et al. 2008ab, Avidan et al. 2009, Regev et al. 2013, Barnett et al. 2015). These results suggest that measuring neural similarity is a promising technique to distill aspects of stimuli that contribute to collective appeal and action.

In this work, we offer a neuroscientific lens to characterize basic elements of successful movie trailers. We use portable electroencephalography (EEG) systems to record the neural activity of moviegoers at a commercial movie theater, and then we compute neural similarity throughout each of the trailers (Study 1: EEG Field Study). We hypothesize that movie trailers that promote relative neural similarity will be more memorable (i.e., higher recall rates) as measured in a survey immediately following the movie. In this survey, we also confirm the supremacy of trailers by asking moviegoers which factors influence their decision-making process; the majority of moviegoers use trailers to decide which movie to watch.

After movies are released, there are countless factors that influence moviegoer purchase decisions, including online user reviews, recommendations, popular excitement, and critical acclaim. However, before the movies are released, most of the aforementioned factors are unavailable (by definition) to moviegoers; therefore, trailers are even more important regarding purchase decisions of opening weekend movie tickets. Therefore, we measure the commercial success of a trailer as its corresponding movie's opening weekend domestic ticket sales. Thus, we additionally hypothesize that neural similarity during movie trailers will correlate with their respective opening weekend box office performances.

In Study 2 (Characterization of Stimuli), we dissect quantifiable stimulus attributes of movie trailers. We hypothesize that numerous measures of complexity will be negatively correlated with neural similarity; conversely, simpler advertisements have more uniform effects across multiple brains. We investigate standard measures of semantic complexity, such as the number of words, sentences, questions, and unique speakers per unit of time (Flesch 1948, Kincaid et al. 1975). Additionally, we measure the proportion of speaking time versus non-speaking. We also study visual complexity, which we assess as the average entropy (i.e., statistical randomness) of each frame of the movie trailer; low-entropy images are relatively uniform in intensity whereas high-entropy images have many bright areas and dark areas (see example in Figure 1). Accordingly, high-entropy images often have many focal points for visual attention (Itti et al. 2005). In turn, we hypothesize that these stimulus characteristics will correlate with neural engagement and will subsequently influence opening weekend ticket sales.

Lastly, we propose a linear model to predict the commercial success of a movie based on its trailer. Our model incorporates previously studied indicators (i.e., whether the movie is a sequel) along with the semantic and visual complexity of its advertisement. We seek to demonstrate that stimulus attributes that facilitate neural processing can, themselves, be applied towards predicting theatrical revenues.

# METHODS

## Study 1: EEG Field Experiment

### *Subjects and Procedure*

Fifty-nine subjects watched trailers and movies while undergoing EEG recordings at a commercial theater that we partnered with for the study (AMC Theatres, Northbrook, Illinois; NYSE: AMC). Subjects were given free admission to a movie of their choice that they had not previously seen from a list of the theater's regular showtimes. Subjects were also offered free soft drinks and popcorn before the movie, but were not allowed to consume these concessions while undergoing the EEG recordings to avoid interfering with the neural measurements. Subjects were fitted with an electrode cap with a circumference of either 54cm or 58cm depending on head size and comfort with the cap's tightness. While the subjects were wearing the caps, a washable conductive gel was placed with a syringe at each electrode site on the subjects' scalps. For each showtime in our study (n = 44), we collected data from multiple subjects seated next to each other at a preferred row dedicated for the study. All subjects were native English speakers with normal hearing who provided informed consent. Additionally, we explained the experiment to other moviegoers and theater staff (not participants) in the vicinity to avoid interruptions.

### *EEG Data Acquisition*

Subjects' neural data were collected using 32-channel EEG systems (Brain Products GmbH, Gilching, Germany) at a rate of 250 samples per second. Each electrode connection was verified to be functioning properly (i.e., detecting electrical activity from the scalp) before starting the recording. Neural data were acquired from diverse brain regions; the 32 EEG electrode sites were distributed across the entire scalp according to the actiCAP 64Ch Standard-2 (green holders) montage (Brain Products GmbH, Gilching, Germany).

### *Free Recall and Survey Data*

Immediately following the movie, subjects were asked to participate in a survey about the content that they viewed (e.g., movie plot recall, movie trailer recall), their general movie preferences (e.g., favorite genre), and factors that influence their movie selection (e.g., user reviews, scores, recommendation from friends, spontaneous decision at theater, viewing trailers).

### *Cross-Brain-Correlation Computation*

We computed moment-to-moment synchrony in EEG data across subjects experiencing the same audiovisual stimuli, which we deem Cross-Brain-Correlation (CBC). At each electrode site, we measured neural activity over time as the power (dB) of alpha oscillations (also known as Berger's wave; cf., Berger 1929) in the recorded EEG data, which are commonly associated with attention to visual stimuli (Klimesch 2012, Dmochowski et al. 2014). To do this, we performed a Short-Time Fourier Transform (STFT) of the raw EEG signal at each timestep, filtered the resulting Power Spectral Density (PSD) matrix, and multiplied the common logarithm (base 10) of the PSD matrix by 10; we then assembled a time series of activity at the given electrode site that was then correlated with the stimulus-matched time series of activity at the corresponding site for each subject. At each timestep, we averaged the correlations at a given electrode site for every pair of subjects. Finally, we averaged across the 32 electrode sites to arrive at a single value of neural similarity at each timestep, thus producing the CBC time series. The CBC values were normalized to range from zero (minimum) to one (maximum) for ease of comparison. Additionally, as a control for eye blinks and muscle movements, which primarily affected the front two electrode sites on the forehead (Fp1 and Fp2), we repeated our CBC computations without those channels and found that these differences were negligible with respect to all of our findings.

***Stimuli.*** Across all 44 trials, subjects viewed 5.84 ± 1.26 trailers (*mean ± standard deviation*) prior to their selected movie. Subjects' movie selections corresponded with 13 trailers presented more than once and subsequently recalled by more than one subject. These trailers represented movies that ultimately earned over $1.25 billion in domestic ticket sales. Trailers were consistent in length (136 ± 20 seconds), but diverse across other dimensions of visual and semantic complexity. Five of these trailers corresponded with sequels while the other eight advertised movies were stand-alone original stories.

## Study 2: Characterization of Stimuli

### *Movie Trailer Transcription and Coding*

We manually transcribed each trailer in order to perform programmatic text analysis. We used standard word processing applications to count sentences and words. We also manually coded each trailer to determine the proportion of speaking time (i.e., character dialogue or narration) relative to the entire video clip. Additionally, we manually counted the number of questions and the number of unique speakers for each trailer with one exception (an advertisement for a nature documentary did not lend itself to these two measures).

### *Visual Complexity Computation*

We programmatically measured the entropy (i.e., statistical randomness) of the intensity image. For a uniformly intense image (meaning every pixel has equal brightness), entropy is zero; conversely, an image of random pixel intensities (e.g., "snow" displayed on analog televisions when no signal is received) is maximally entropic (normalized to 1). Next, we computed the average entropy across all frames for each trailer, which corresponds to its overall level of visual complexity (i.e., disorder).

### *Supplemental Stimuli*

We extended our data by adding the trailers corresponding to the ten all-time highest grossing movies according to the Internet Movie Database (IMDb.com, Inc., Seattle, Washington), seven of which were sequels. We repeated the same steps to characterize the stimuli (manual transcription and coding, programmatic word counts and visual complexity computations). Accordingly, the combined dataset in this study consists of 23 movie trailers (12 sequels and 11 stand-alone original stories).

# RESULTS

In Study 1 (EEG Field Experiment), we found that viewing trailers was the single most important factor influencing movie selection: 33 subjects (55.9%) reported deciding which movie to watch based, in whole or in part, on viewing trailers. Out of the remaining 26 subjects (44.1%), subjects were approximately split between deciding based on user reviews, recommendations, and other factors (e.g., showtime). Subjects' preferred genre had a mild effect on the use of trailers: 50.0% of those that prefer action, 54.5% of those that prefer comedy, and 61.1% of those that prefer drama reported making purchase decisions based on trailers.

Subjects' average Cross-Brain-Correlation (CBC) values throughout each movie trailer were highly correlated ($r = .66$, $p = .01$) with their associated levels of recall following the movie, which is consistent with previously documented links between neural similarity and memory (Furman et al. 2007, Hasson et al. 2008a, Barnett et al. 2015). Furthermore, movie trailer CBC was highly correlated

($r = .51$, $p = .08$) with the corresponding opening weekend domestic ticket sales. However, the CBC-sales relationship was weaker ($r = .22$, $p = .45$) for later weeks of distribution presumably as other influential factors besides trailer viewing (e.g., user reviews, recommendations) became available.

In Study 2 (Characterization of Stimuli), we observed that CBC was negatively correlated with numerous measures of stimulus complexity. (In other words, simpler movie trailers tend to generate higher CBC). For example, a movie trailer's proportion of speaking time, which relates to the amount of speech processing undertaken by audience brains, has a strong negative correlation ($r = -.78$, $p < .01$) with CBC. Similarly, CBC was negatively correlated with words per minute ($r = -.77$, $p < .01$), sentences per minute ($r = -.67$, $p = .01$), questions per minute ($r = -.58$, $p = .05$), and unique speakers per minute ($r = -.61$, $p = .04$). Visual complexity (average entropy per frame; see Methods) also had a strong negative correlation with CBC ($r = -.72$, $p < .01$).

Next, we used the aforementioned stimulus characteristics that correlated strongly with neural similarity to predict opening weekend ticket sales for all 23 movies in our extended trailer dataset. Collectively, these movies comprised $1.96 billion in opening weekend sales; however, there was wide variation in the opening weekend success of each movie, which ranged from $113,301 (*Bad Words*) to $247,966,675 (*Star Wars: The Force Awakens*; all-time highest grossing opening weekend performance). On average, a movie in our data set earned $85.10 ± $78.68 million in its opening weekend.

The proportion of speaking time was again the most influential stimulus characteristic; proportion of speaking time had a strong negative correlation ($r = -.67$, $p < .001$) with opening weekend ticket sales. Words per minute, speakers per minute, and questions per minute each had correlations of approximately -.60 ($p < .01$), while sentences per minute had a slightly weaker, but still statistically significant, relationship with opening weekend performance ($r = -.44$, $p = .04$). Likewise, visual complexity had a strong negative correlation with opening weekend sales ($r = -.62$, $p < .01$). Additionally, all of these characteristics were negatively correlated with ticket sales in later weeks, although these relationships were consistently weaker (see Table 1 for all correlation values).

These measures of stimulus complexity can be used in concert to produce even stronger predictions of opening weekend ticket sales. To demonstrate this point, we present a simple linear model that incorporates both semantic complexity and visual complexity. Additionally, given the prior literature suggesting that sequels outperform stand-alone movies (cf., Eliashberg et al. 2006), we incorporate whether or not a movie is a sequel. Therefore, we determined model coefficients via linear regression with three variables: (i) proportion of speaking time, (ii) visual complexity (entropy), and (iii) a sequel indicator variable (one if the movie a sequel; zero otherwise). Furthermore, since ticket sales cannot be negative, our prediction equals the greater of zero and the result of the following expression (coefficients rounded; units in $ millions):

$$267 - (142 \times \textit{Proportion of Speaking Time}) - (241 \times \textit{Visual Complexity}) + (82 \times \textit{Sequel})$$

Despite the model's simplicity, its predictions are highly correlated with actual opening weekend ticket sales ($r = .89$, $p < .001$; see Figure 1 for illustration). Moreover, the model is particularly diagnostic regarding whether or not an opening weekend will exceed $90 million (the optimal binary threshold value). Nine of the 23 trailers were assigned predicted opening weekend sales in excess of $90 million, and all of those movies indeed earned over $90 million in their opening weekends; conversely, none of the other 14 movies earned over $90 million in their opening weekends. Therefore, although limited to our dataset of 23 movies, our "$90 million test" has 100% sensitivity (0% false negatives) and 100% specificity (0% false positives). (see Figure 1)

## DISCUSSION

The collective results of both studies offer numerous insights into the elements of movie trailers that engage brains and ultimately promote ticket sales. Measures of complexity throughout movie trailers consistently opposed both neural similarity and the commercial success of the corresponding movies. Therefore, the film industry should heed time-honored minimalistic design principles (cf., US Navy's "keep it simple, stupid") in order to maximize impact to the brains and wallets of moviegoers.

Nonetheless, our work has substantial limitations and many opportunities for refinement. For example, we average neural activity across all 32 electrodes in our computations of neural similarity; however, we believe that a subset of brain regions could produce more precise, modality-specific measures (e.g., the most posterior electrode sites correspond with visual processing areas). Relatedly, our predictive model is not meant to suggest that the perfect movie trailer has no speaking and no visual complexity; our model assumes that trailers will conform to the same overall style and communicate key information about the upcoming movie in an orderly manner.

The specific format and distribution of movie trailers also makes it difficult to generalize our conclusions to other areas of advertising, but our studies provide an experimental paradigm by which the techniques discussed herein can be tested. Our approach may be applicable in other areas of cinematography; perhaps optimizing stimulus attributes can help make the feature films themselves (i.e., not just their advertisements) more engaging. Outside of entertainment, fields such as education (i.e., to minimize classroom distractions) and politics (i.e., streamlining persuasive arguments)

**Table 1: Movie Trailer Stimulus Complexity is Negatively Correlated with Neural Similarity and Ticket Sales.** Descriptive measures of each stimulus characteristic are presented in the table; as indicated by the high standard deviations, trailers varied significantly along these dimensions. The table also displays correlations of each characteristic with CBC, with opening weekend ticket sales, and with later week sales (*, **, and *** represent p-values less than .05, .01, and .001, respectively).

| | | Correlations | | |
|---|---|---|---|---|
| **Stimulus Characteristic** | **Mean ± Standard Deviation** | **Neural Similarity (CBC)** | **Opening Weekend Sales** | **Later Sales** |
| Proportion of Speaking Time | 35.77% ± 18.93% | -.78** | -.67*** | -.33 |
| Words/Minute | 81.13 ± 37.56 | -.77** | -.63** | -.26 |
| Sentences/Minute | 14.16 ± 8.08 | -.67* | -.44* | -.24 |
| Speakers/Minute | 2.72± 1.18 | -.61 | -.61 ** | -.37 |
| Questions/Minute | 2.04 ± 1.74 | -.59* | -.59** | -.43* |
| Visual Complexity (Entropy) | .71±.17 | -.72** | -.62** | -.48* |

*,**, and *** represent p-values less than .05, .01, and .001 respectively

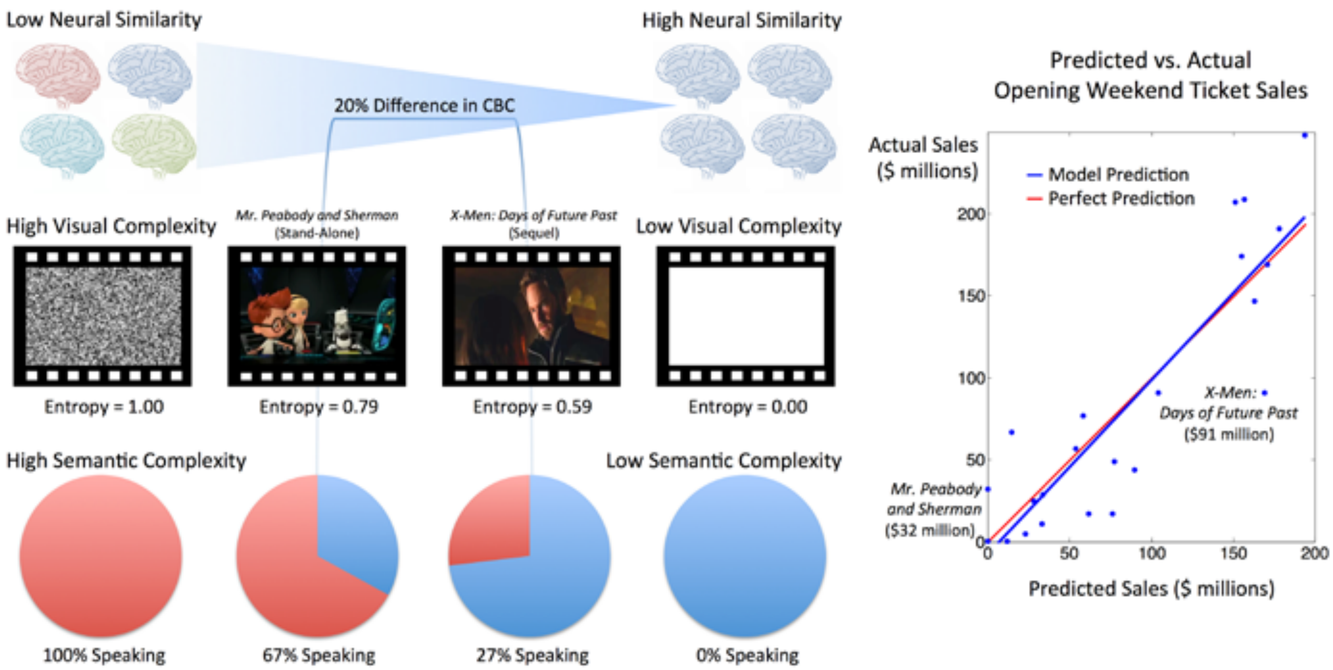


**Figure 1: Movie Trailers with Less Visual and Semantic Complexity Generate Higher Neural Similarity and Ticket Sales.** The left portion of the figure presents sample data from two trailers: *Mr. Peabody and Sherman* and *X-Men: Days of Future Past*. The latter achieved 20% higher CBC and 184% higher opening weekend ticket sales than the former. These sample images were selected because they each had entropy values within 2% of the average entropy throughout their respective trailers; therefore, these images illustrate the difference in visual complexity between the two trailers. For comparison, an image with maximal entropy (normalized to 1) is displayed on the left and a blank screen (zero entropy) is displayed on the right. The pie charts below indicate the proportion of speaking time (red) versus non-speaking time (blue). The graph on the right plots the predicted versus actual opening weekend ticket sales for each trailer. The predictions were calculated according to the aforementioned linear model. The blue line depicts the best-fit regression of the model predictions, which nearly matches the red line that depicts the hypothetical perfect prediction (i.e., predicted sales always equal actual sales)

could similarly benefit from a bottom-up approach to improving their respective stimuli.

In particular, movie trailers are incredibly rich stimuli and our work merely addresses their most basic characteristics. Other factors including content familiarity, music, cinematographic style, story comprehensibility, sequencing of narrative events, stimulus dynamics, actor popularity, harmony of elements, and artistic novelty are more challenging to measure, but may offer even greater predictive power with respect to neural and commercial outcomes. The commercial success of a given movie may also be affected by external factors such as the competitive landscape (i.e., what alternatives moviegoers face at a particular time) and seasonal variation in movie theater attendance. Increasing content exposure time (i.e., by advertising for a longer period of time or by repeating messages) has been an effective advertising strategy across industries (Campbell et al. 2003), so advertising expenditure would be another variable to control for in future work.

Our results show that, with all other artistic and commercial qualities being equal, movie trailers that minimize extraneous complexity have more consistent positive effects on the minds and future purchases of moviegoers. Thus, reverse engineering advertising content with a neuroscientific lens is a promising avenue for continued study.

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