A new memory model for ad impact and scheduling

Antonio Chessa and Jaap Murre, University of Amsterdam, show how a model of memory can be used to plan and evaluate ad schedules

HOW CAN WE optimise the effectiveness of an advertising campaign? Effectiveness can be measured according to different factors: the propensity for product purchase, brand awareness, sales figures and the impact of advertising exposures through media (for example, in terms of the recall of the contents of a TV spot). A major issue among research companies, advertisers and media planners is the distribution or scheduling of advertising exposures in time, with the objective to optimise their effectiveness subject to a given budget and time window. The main question is whether advertising exposures for a brand should be concentrated in time as a 'burst' ('flight'), spread out evenly ('dripped', 'pulsed'), or distributed according to a mixture of these two strategies.

Similar problems are encountered in the psychology of learning and instruction. How should learning material be communicated? According to a 'massed' ('bursting') or 'spaced' ('dripping') schedule? The general superiority of spaced over massed learning is well established in learning psychology. A problem, however, is to determine the optimal spacing schedule for each individual campaign.

Drawing upon this parallel between psychology and advertising, this article proposes a mathematical memory model for the impact of advertising. This is structured to account for retention characteristics and scheduling possibilities. It provides the decision-maker with a viable means of determining optimal schedules for a given budget and time window over which advertising effectiveness is measured and predicted. The approach will be illustrated with impact data from the Dutch SPOT project.

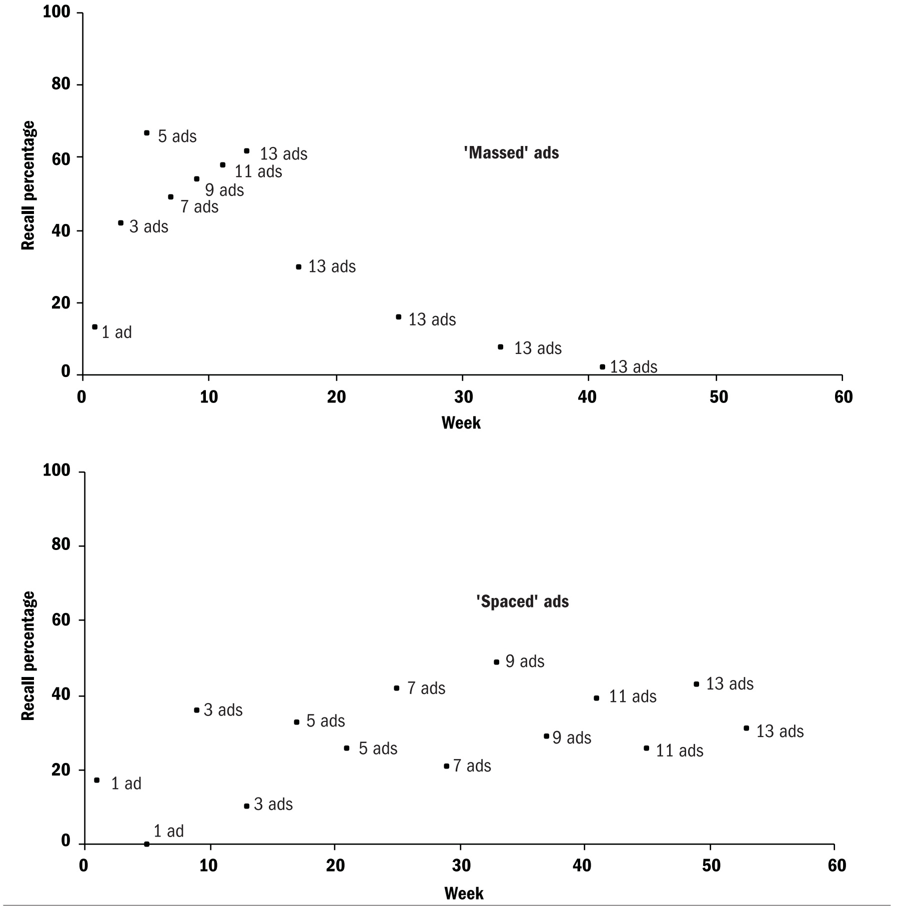
The Zielske experiment

Zielske was the first to study the effectiveness of massed and spaced advertising schedules in an experiment conducted in the 1950s. Respondents were sent printed advertisements according to two schedules: one group received ads every week ('massed'), while the second group received ads every four weeks ('spaced'). Both groups were exposed 13 times. In order to obtain data about the course of recall of the advertisement in time, both groups were subdivided into smaller groups that were interviewed in specific weeks. The interviews were organised in such a way that data about learning and forgetting between and after exposures were obtained (Exhibit 1).

The study concluded that the weekly schedule reaches a higher peak in recall but, after about 17 weeks, recall for the spaced schedule reaches and stays at a higher level. Consequently, the number

EXHIBIT 1

Recall data for advertising schedules (weekly and 4-weekly)



of 'recall-weeks', that is, the number of weeks multiplied by the weekly recall rates, is larger for the four-week schedule, which implies that the decision-maker should prefer the spaced schedule to the massed one (1).

One cannot extend these conclusions beyond the domain of the data and the experimental conditions. They hold for the specific (food) product, the advertising medium and the two exposure schedules considered. A pure data-analytical approach is unlikely to satisfy the decision-maker's needs. There may be other schedules that give a better performance, but this cannot be established from the data. A memory model for advertising impact, which takes scheduling as a variable and fits the recall data, can take these inferences a step further.

Learning models

Many models that describe the rate at which learning takes place over repeated presentations or exposures are based on Markov chains. There are different models (see (2) and (3)), but the underlying idea is the same. The level of learning of some item is supposed to belong to one of a limited number of memorised states and the transition from one state to another, which can only take place after a new presentation, is specified in terms of a matrix of probabilities. Some models account for spacing effects.

These learning models yield an expression for the recall probability as a function of the number of presentations, but they do not give a formal description of forgetting between two successive presentations. Forgetting models have been developed primarily for situations with only one presentation. There are models with an underlying theory of memory (see (2) and (4)) and rather ad hoc models selected on the basis of curve-fitting (5).

Developments in learning and forgetting have proceeded on different tracks and there have been few attempts at integrated theories of memory. However, this is necessary in order to make predictions about advertising effectiveness, because the decay of memory for a product between ad exposures must be taken into account to give reliable estimates of a schedule's effectiveness.

An impact model for ad exposures

The memory model underlying the impact of an ad exposure schedule starts with a theory of learning and forgetting an advertisement after a single exposure. An exposure gives rise to 'memory representations' that are related to one or more characteristics of the ad. These build up during an exposure (learning) and their number decreases in memory after the exposure (forgetting). The number of representations in memory determines the recall of an ad; the larger this number, the better the recall. The mathematical model is called a point process, which is probabilistic and chosen to model variations in memory that may be due to neural and psychological factors (6).

The following assumptions are made.

- The mean number of memory representations formed increases linearly with the 'intensity' of a single exposure, which is measured as a GRP.
- Each memory representation has an exponential lifetime.

This single-exposure memory model has three parameters: two are part of the linear intensity function of the GRP and the third parameter is the decay rate or mean lifetime.

From a neural and psychological point of view, memory representations in the model can be thought of as elements in a single memory store, which could represent a short-term memory or the hippocampus. Yet it is possible to have an ad with such an impact that its first exposure leads to rehearsal and subsequent consolidation of information to a slower-decaying second store. This adds two assumptions to the memory model:

- rehearsal produces a replica of the memory process in the first store, at some unknown rate
- the memory representations of the replicated process are transferred to the second store, where their consolidation rate is determined by the exponential lifetime for this store, which is larger, on average, than that in the first store.

This idea about rehearsal and consolidation to a second store can be extended to an arbitrary number of stores in the same feed-forward fashion, but here only the single-store and two-store memory models will be considered.

The models have been adapted to situations in which advertisements are exposed several times. The simplest extension is to assume that each individual exposure gives rise to the same memory process as the first exposure. This implies that the multiple-exposure memory model superimposes identical memory processes, which are shifted with respect to each other according to the times of exposure. The number of parameters is therefore the same as for the single-exposure models. The complexity of the memory model increases when spacing effects are included. This is accounted for by introducing assumptions about attention as a function of inter-exposure lag or by refining the consolidation process when there are two memory stores (7).

The impact of an ad exposure schedule is defined in the model as the probability that at any time since the first exposure there is at least one memory representation available (one store may be empty in the two-store model). Recall probability functions are derived in (6) and (7) and will not be given here. Exhibit 2 shows a fit of the two-store memory model to the Zielske data. Statistical goodness-of-fit tests indicate that a two-store model with spacing effects fits the data well. The model fits the data simultaneously – the values of the parameters are the same for both schedules.

The fits show the typical 'saw-toothed' behaviour of the model, with impact peaks at each new exposure and decay between exposures. The parameters tell us that the expected impact of the first exposure is 29%, that 40% of the content of the first (short-term) store is lost every week and 4% is lost in the second, slower-decaying store, while 10% of the information in the first store is rehearsed. The expected number of recall-weeks for the two schedules can now be calculated exactly, which confirms the superiority of the spaced schedule by a factor of approximately 1.5 (against a factor 2 obtained by extrapolating data from Simon (1)).

Application to SPOT data

The satisfactory fit of this model with Zielske's data invites us to explore further. An opportunity was offered by the extensive data from a project carried out

EXHIBIT 2

Old vs new laydowns: efficiency change

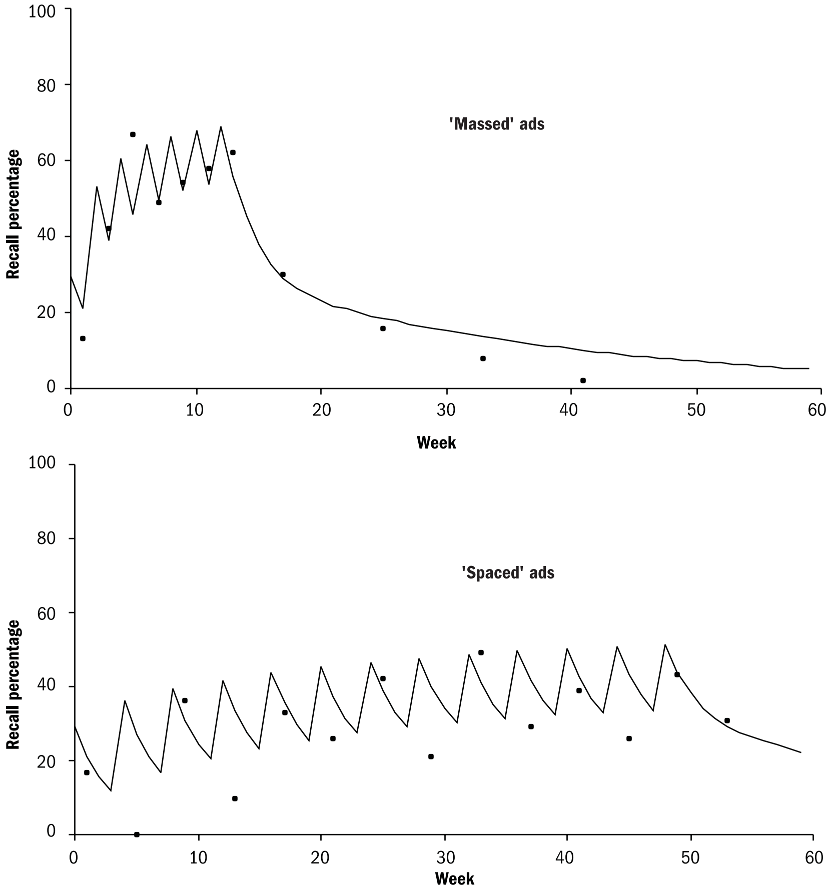
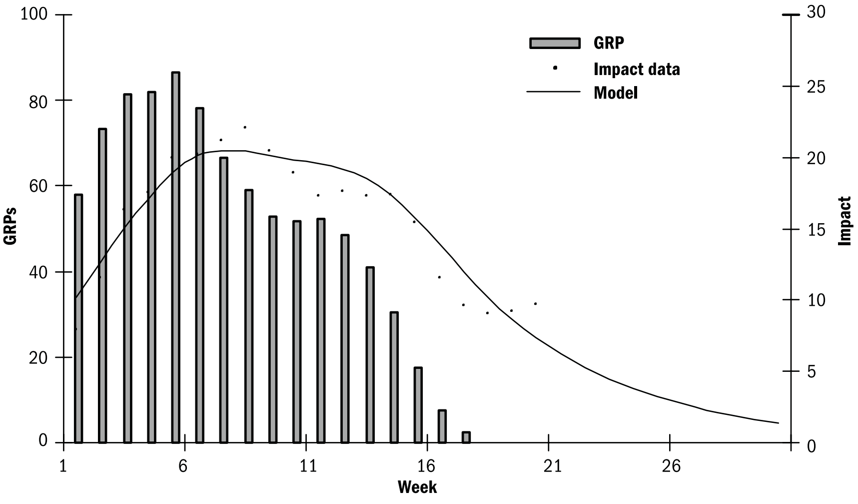


EXHIBIT 3

Moderate learning and forgetting brand (1-store model)



in 1997–1998 by SPOT, the Foundation for Promotion and Optimisation of Television Advertising in The Netherlands. A total of 43 campaigns were tracked for about half a year, giving data on the advertising's effectiveness. The data came from 50 interviews per brand per week. Estimates were derived for three effectiveness measures: brand awareness, propensity to purchase and advertising impact. The data give indications about the behaviour of these measures as a function of GRPs per week.

Only impact is considered for the application of our model; its relationship with the other measures will be studied in future research. We found that the single-store memory model for multiple exposures fits in most cases when applying statistical tests specifically developed for these goodness-of-fit problems (8). The single-store and two-store memory models were fitted and tested in 41 cases. The single-store model is accepted in 36 cases, while in 5 a two-store model is needed.

Exhibit 3 shows a fit of the single-store model to impact data for one campaign. In this case, the GRPs lead to an initial impact of about 10% and a forgetting rate of 15% per week of memory representations stored concerning the ad. Extrapolations on the basis of the fitted model were made until week 30; Exhibit 3 shows the implications of the model parameters for impact after the campaign. Exhibit 4 shows a fit of the single-store model to another impact data set. The product advertised in this case is a well-known brand. Its initial impact is among the highest in the tracking study. However, the forgetting rate is about 12% per week, showing that the product needs long-run advertising to maintain impact.

Optimisation of scheduling

The models give the advertiser a means to predict future impact for any time window and also to calculate the expected impact for different GRP values per week. In practice, one can fix a time window and a GRP budget to expend over this window in advance, and find out which distribution of GRPs yields the highest impact over the time window for the given budget. To do this, one needs to find suitable parameters for scheduling. An exponential function with one parameter is sufficient to describe both bursting and dripping, and combinations of these two schemes.

We have reflected this in the model fitted in Exhibit 4 to find out whether other schedules give improved impact. The optimal schedule

EXHIBIT 4

High learning, moderate forgetting brand (1-store model)

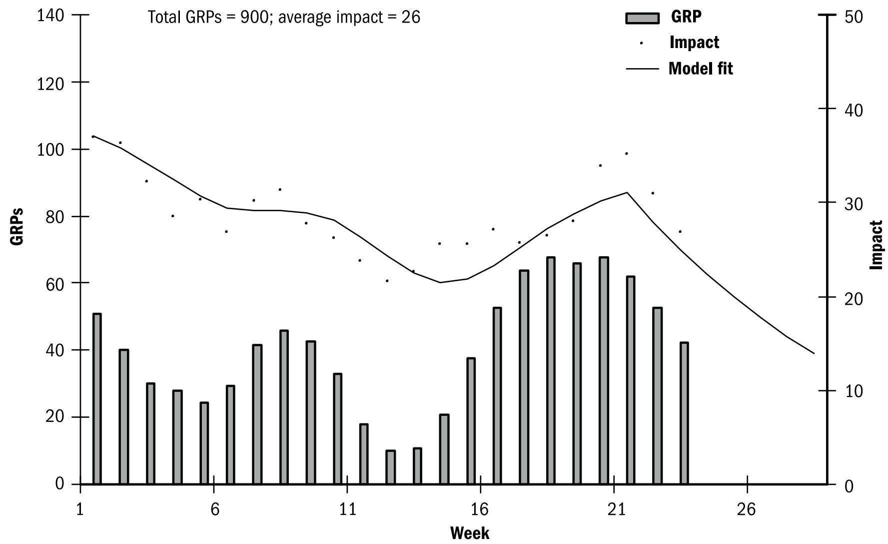
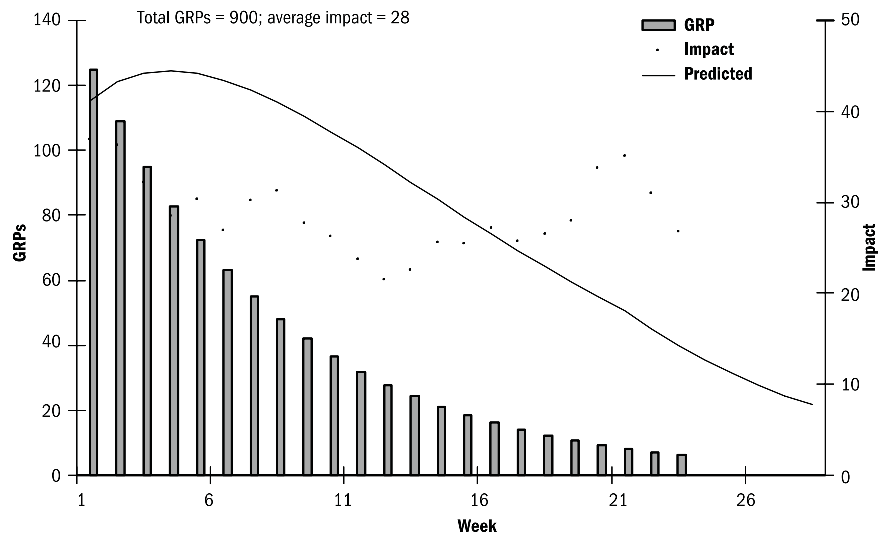


EXHIBIT 5

High learning, moderate forgetting brand – 'ideal'schedule



is shown in Exhibit 5 and improves the average impact by 7–8% for the same time window and budget as in Exhibit 4.

Conclusion

Our model was developed as a generalisation of a neurological model of memory disorders (9), but can be applied without modification to advertising. It is possible to optimise an ad campaign's effectiveness by using a mathematical model of memory, in which advertising variables like impact and GRP are integrated with psychological and neurobiological parameters regarding learning and forgetting.

The models proposed fit both the Zielske and SPOT data. In the latter case, single-store models with two or three parameters fit the data well, while the Zielske data showed a more complicated recall behaviour in time, for which a four-parameter model is needed that accounts for spacing effects. The number of memory stores and the parameter values in a model that fits the data also indicate the position of an advertised brand. These model factors enable us to classify brands in terms of the extent to which they are established and the potential of new brands and launches to gain a respectable market share. ■

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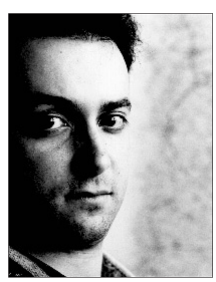

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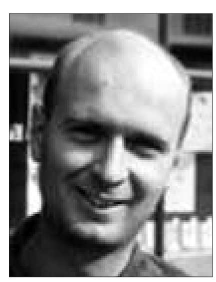

Jaap Murre *(PhD) has a research group at the University of Amsterdam investigating learning, memory and their biological basis. Prior to this he was a scientist at the Medical Research Council in Cambridge.*