In the November 2006 issue of ANESTHESIOLOGY, Stonell *et al.*[1] report an elegant use of the word stem completion test to address sex differences in memory formation during anesthesia. They used the task in combination with the process dissociation procedure (PDP), which allows a closer look of the memory formed. In particular, the PDP touches upon the question whether the memory arose unconsciously ("implicit memory") or consciously ("explicit"). Rather than relying on different tests (*e.g.*, a recall questionnaire and a word stem completion task), the PDP relies on a single task that is performed under two, only marginally different, instructions. The purpose of this setup is to contrast performance on the same task when the subject tries to retrieve and use information (inclusion instruction) *versus* memory retrieval without using the information (exclusion instruction). By contrasting the two conditions, by virtue of their similarity, estimates for implicit and explicit memory can be calculated using relatively simple mathematical equations.[2] Using PDP, we reported evidence for implicit memory function during general anesthesia.[3,4]

The PDP relies on various assumptions, the least controversial of which is that tasks are comparable. Or, as the founding father of the procedure put it,[2,5] subjects must use the same "response criterion" in the inclusion and exclusion conditions if one wants to use the calculations that render the PDP so popular. Subjects should have, or rather, be enabled to have, a similar tendency to use previously presented items in both conditions. If not, the parameters that represent the two bases of memory in the various equations do not represent the same concept and, therefore, cannot be mathematically extracted.

Some evidence for equal response criteria comes from the distractor hit rate, also referred to as the "base rate," which represents the probability of responding with a study word without being previously presented with it. Some subjects, for example, will complete the stem COU__ to *couch* simply because it works, regardless of whether they heard the word during anesthesia. Base rates, in other words, establish chance performance and tell us something about response tendencies. By the same token, differences between base rates in the inclusion and exclusion condition indicate that subjects used different response criteria (which violates the PDP).

Stonell *et al.*[1] observed significantly different base rates (Kate Leslie, M.D., written communication, November 2006) but nonetheless calculated PDP estimates based on which the authors suggested that both implicit and explicit memory function contributed significantly to the memory effect observed. This conclusion is hard to reconcile with the PDP model and clinical findings so far, where either implicit or explicit uses of memory usually account for observed effects: Hit rates are either boosted in both the inclusion and exclusion conditions (indicative of implicit memory) or they are in the inclusion condition only (indicating explicit memory). Because the rates across all conditions in the work of Stonell *et al.* varied substantially, it is hard to discern what was at play in this study. From the inclusion condition, it can be derived that reliable memory was formed, but we can only guess the type of learning that may be held accountable for this effect.

A likely reason for the different base rates in the study by Stonell *et al.*[1] is the instructions given to the subjects upon stem completion testing. In our studies, we have observed comparable base rates and instruct patients in both conditions to use the word stem as an aid (cue) to recall words presented during anesthesia.[3,6–8] Memory retrieval is thus encouraged in both parts of the test. In the inclusion condition, subjects are then told to complete stems with the recalled word, whereas such words are not to be used for stem completion in the exclusion condition. In contrast, Stonell *et al.* instructed subjects in the exclusion condition to use words not heard during anesthesia. Although subtle, the distinction between their and our instructions is important to the PDP procedure and its calculations. Because Stonell *et al.* gave dissimilar instructions in the inclusion and exclusion conditions, encouraging memory in one but not in the other part of the test, the tasks are not directly comparable and the PDP assumption of equal criteria is violated. The dissimilarity may have caused subjects to complete fewer exclusion than inclusion stems and to use unusual words in the exclusion part of the test, as the authors noted in the discussion of their report, observations that are in line with the notion of different response criteria. The conclusion, therefore, that both implicit and explicit memory function are to be held accountable for the memory observed by Stonell *et al.* was inappropriately drawn, although the conclusion that memory was formed at Bispectral Index values between 50 to 55 is clearly correct.

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Statistical Approach to Word Stem Completion Test

To the Editor:—I recently read the interesting study of Stonell *et al.*[1] about the use of the word stem completion test to measure implicit and explicit memory formation during general anesthesia. I think that the word stem completion test is one of the most useful and clinically feasible models to study the implicit form of awareness in general anesthesia, and it is an important tool to validate systems for awareness prevention.

Stonell *et al.* used a word presentation counterbalancing scheme based on a previous study by Lubke *et al.*[2,3] In this scheme, two of four words lists are given to patients during surgery, after induction of anesthesia; these lists are defined as inclusion target and exclusion target, whereas the two lists not given are defined as inclusion distracter and exclusion distracter.

Postoperatively, patients are asked to complete a column of word stems (inclusion target and inclusion distracter) with the words that they remember hearing during anesthesia, and then they are asked to complete another column of word stems (exclusion target and exclusion distracter) with words they have surely not heard during surgical anesthesia.

Table 1. Cross-association Scheme between Tracks and Types of List Function

	Groups	IT	ET	ID	ED
Track A	Group 1	List 1	List 2	List 3	List 4
	Group 2	List 1	List 2	List 4	List 3
	Group 3	List 2	List 1	List 3	List 4
	Group 4	List 2	List 1	List 4	List 3
Track B	Group 1	List 1	List 3	List 2	List 4
	Group 2	List 1	List 3	List 4	List 2
	Group 3	List 3	List 1	List 2	List 4
	Group 4	List 3	List 1	List 4	List 2
Track C	Group 1	List 1	List 4	List 2	List 3
	Group 2	List 1	List 4	List 3	List 2
	Group 3	List 4	List 1	List 2	List 3
	Group 4	List 4	List 1	List 3	List 3
Track D	Group 1	List 2	List 3	List 1	List 4
	Group 2	List 2	List 3	List 4	List 1
	Group 3	List 3	List 2	List 1	List 4
	Group 4	List 3	List 2	List 4	List 1
Track E	Group 1	List 2	List 4	List 1	List 3
	Group 2	List 2	List 4	List 3	List 1
	Group 3	List 4	List 2	List 1	List 3
	Group 4	List 4	List 2	List 3	List 1
Track F	Group 1	List 3	List 4	List 1	List 2
	Group 2	List 3	List 4	List 2	List 1
	Group 3	List 4	List 3	List 1	List 2
	Group 4	List 4	List 3	List 2	List 1

Lists presentation counterbalancing based on the four list functions: IT (Inclusion Target), ET (Exclusion Target), ID (Inclusion Distracter), and ED (Exclusion Distracter). For each words lists track (every track is made by two lists) there are four groups. For probability calculation the total number of cross associations is 24: (number of lists – 1) ! * number of list functions.

The word list presentation scheme is composed of four groups, but in this way, other possible cross-associations between the four lists are excluded.

Statistically, by probability calculation, with four lists to choose two by two, the number of audio tracks to administer to patients is six (track A: list 1 and list 2; track B: list 1 and list 3; track C: list 1 and list 4; track D: list 2 and list 3; track E: list 2 and list 4; track F: list 3 and list 4). Then, any list can be associated with four different types of function (inclusion target, inclusion distracter, exclusion target, or exclusion distracter). In this way, the possibility number is 24 [(number of lists − 1)! * number of list functions]; the total cross-association is shown in table 1.

I would like to create an Italian task for the word stem completion test, but I do not understand how, so I would like to know why, in the word presentation counterbalancing scheme adopted by Stonell *et al.*[1] and proposed by Lubke *et al.*,[2–3] there are only four groups.

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In Reply:—We appreciate the interest of Drs. Kerssens and Falzetti in our report.[1] Our study was closely modeled on the previous work of Dr. Kerssens *et al.*,[2–4] who published the following instructions (with minor variations): "In the inclusion part, patients were asked to complete the stems, if possible, with a word presented during surgery, or, otherwise, with the first word that comes to mind. [In the exclusion part of the test], patients were asked, if possible, not to use presented words for stem completion but to use any other word they could think of."[2]

On our audio compact disks, we issued the following instructions about completing the word stems: In the inclusion part, we asked the patients to "write down a word you remember hearing during your surgery or the first word that comes to mind." In the exclusion part, we asked patients to "write down a word you did not hear during your surgery." We believe that memory would be encouraged in both conditions, because to choose a word that had not been heard during surgery, patients would need to think about which words had been heard. Nevertheless, we accept that the subtle difference between our instructions and previous instructions may have resulted in a different base rate and encourage future researchers to use the exactly comparable instructions.[2–4] Finally, as emphasized by Dr. Kerssens, although our conclusion about which type of memory may be responsible for our result is subject to debate, our conclusion that Bispectral Index values greater than 50 may be associated with memory is still correct.

Dr. Falzetti is correct that, mathematically, there are six ways of presenting two out of four lists (*i.e.*, 1 + 2, 1 + 3, 1 + 4, 2 + 3, 2 + 4, and 3 + 4). However, to use all of the lists would complicate the procedure unnecessarily, and so we followed the lead of Lubke *et al.*[2,3] and used only four of the combinations (*i.e.*, 1 + 2, 1 + 4, 2 + 3, and 3 + 4), so that we had a different set for each condition (*i.e.*, inclusion target, inclusion distracter, exclusion target, and exclusion distracter). Because we wanted all of the words to appear in each condition, we ended up with four groups. The items on each list were presented in a random order to each individual, thereby taking care of list order effects. One could make a case of counterbalancing all six combinations of lists, but that would only be necessary if the *combination* of lists is expected to have an effect (which it is not).

Therefore, we advise that if researchers wish to create their own language-specific lists, they should read the original articles on list construction,[5] create a large set of comparable words, run a pilot study in a representative and sufficiently large sample using all words, and select those items that perform uniformly (in our case, word stem completion base rates of 33%), to avoid using highly unusual or very common words in their lists.

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