An inversion of the ERP old-new effect associated with recollection

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*An **online supplement** regarding the original research report "The influence of object and background color manipulations on the electrophysiological indices of recognition memory" by Ullrich K.H. Ecker, Hubert D. Zimmer & Christian Groh-Bordin of Saarland University, Germany, to appear in **Brain Research** (early 2008).*

In the original research report, a perceptual study-test manipulation was implemented in an object recognition memory task. From study to test, color was manipulated either as an intrinsic feature of the respective object, or as an extrinsic feature of the context (background). The intrinsic but not the extrinsic manipulation attenuated the midfrontal old-new effect associated with familiarity (Same > Different). Some exploratory analyses were carried out in order to investigate why in the above mentioned study there was no late parietal old-new (LPC) effect in the averaged data. These are summarized in this supplement.

Inspection of single subject data showed that the LPC null effect was due to half the participants exhibiting an inversed LPC effect (correct rejections more positive than hits) and therefore, the null effect is in fact an averaging effect. One possibility is that this is only the outcome of natural variation, i.e., overall there is no LPC effect, so there may be no mnemonically relevant processing downstream of familiarity. There are several reasons why further examination of this effect pattern seemed warranted. First, the behavioral data of the Extrinsic condition (i.e., congruency (Same-Different) effects in RT and accuracy) suggest there must be some differential processing of Same and Different items in the Extrinsic condition. Because FN400 effects are of similar magnitude in the Extrinsic Same and Different conditions, the behavioral effects do not seem to depend on relative familiarity. Second, in a task that would usually reliably elicit a standard LPC old-new effect, it is very unusual that half the subjects show an inverse effect. Third, amplitudes exceeded what one would usually ex-

pect if there was only natural variation around zero. We thus decided to establish a new post-hoc Group factor in order to compare ERPs of subjects with a standard LPC effect with those showing an inverse effect. For that purpose, Intrinsic and Extrinsic conditions were collapsed, and so were Same and Different repetitions. Subjects were then grouped according to the resulting plain old-new effects at the left-posterior ROI between 500-700 ms. This is important because subjects were grouped by collapsed overall effect size, while we were actually interested in effects differing between conditions. Exactly half the subjects showed a standard old-new effect (range was .3 to 6.3 microvolts). The other half of subjects demonstrated an inverse LPC old-new effect, with waveforms elicited by new items more positive (effect range was -.2 to -5.9 microvolts). ERP and behavioral analyses were then repeated incorporating this Group factor (Standard vs. Inverse). It is important to note that this post-hoc median split shall not imply that these were in fact two sharply separated groups; therefore, only the main outcomes of these supplementary analyses are reported here (detailed statistical analyses are available from the corresponding author).

Grand average ERPs of the two groups are depicted in Figure 1. Importantly, grouping did not affect the FN400 effect pattern described above. In both groups, the FN400 old-new effect is larger for Same vs. Different test cases in the Intrinsic but not the Extrinsic condition (see planned comparisons in Table 1).

The effect difference between the two groups obviously stems mainly from the correct rejection waveforms, which are substantially more positive in the Inverse group. Peak latency analysis revealed that correct rejection waveforms peaked later in the Inverse as compared to the Standard group (690 vs. 629 ms; $F(1,30) = 5.55$, $p < .05$), which is further evidence for two qualitatively different processes. Therefore, the time window for analysis of the Inverse group data was altered to 600-800 ms. In the Standard group, the original 500-700 ms time window was used.

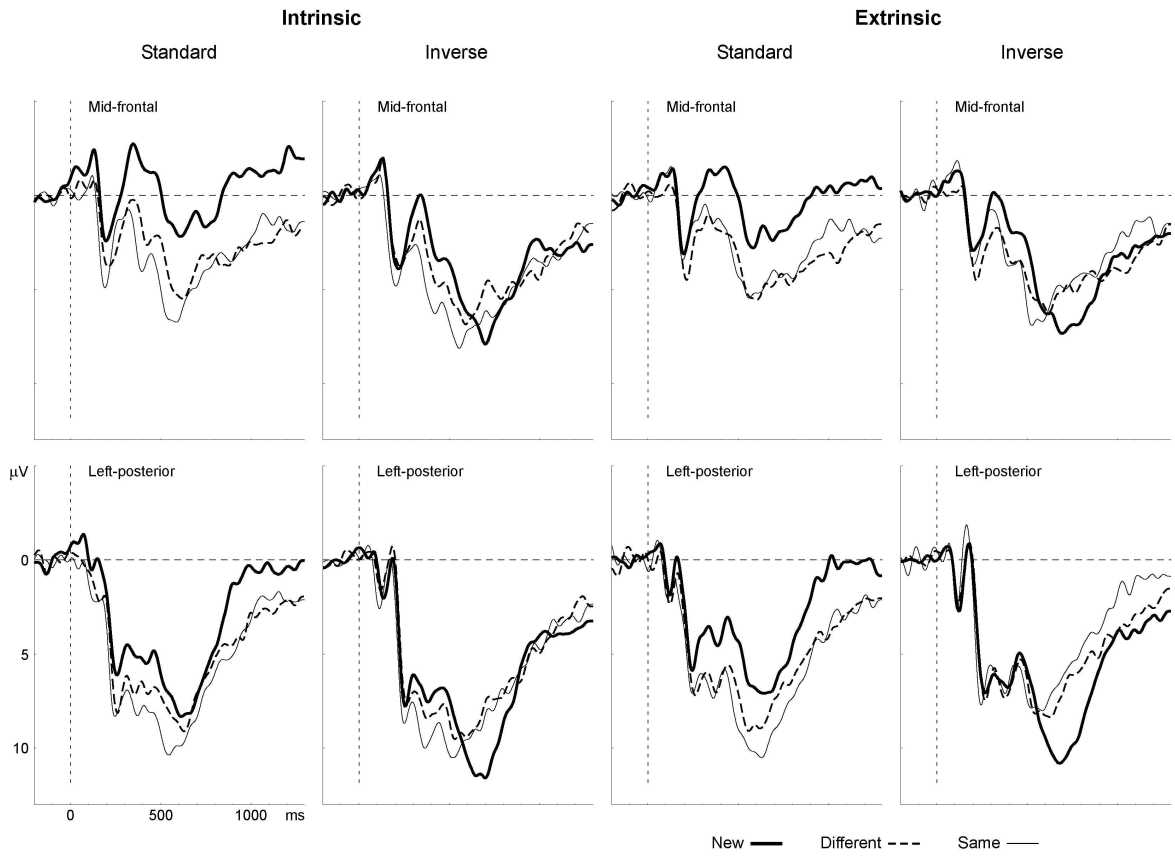

Figure 1. Grand average ERP data from Intrinsic and Extrinsic conditions after grouping according to shape of parietal old-new effect (Standard and Inverse groups) at mid-frontal and left-posterior ROIs (see main text for details).

In the Intrinsic case, the LPC effect seemed to be larger for Same vs. Different repetitions in the Standard group, while there was no difference in the Inverse group; the respective interaction contrast of Congruency (Same vs. Different) and Group (Standard vs. Inverse) was not significant ($F < 1$). In the Extrinsic case, however, the LPC effect was larger for Same vs. Different repetitions in both the Standard and the Inverse case. That is, the old-new effect was accentuated in the Same condition in both groups, even though this implies that the Same waveform was the most negative in one and the most positive in the other group. Thus, the interaction contrast of Congruency (Same vs. Different) and Group was significant ($F(1,30) = 4.77$, $p < .05$). (see planned comparisons in Table 2).

Contrast	df	F	p
Intrinsic condition – Standard group			
New – Same	1,30	43.08	< .0001
New – Different	1,30	21.25	< .0001
Same – Different	1,30	5.92	.0211
Extrinsic condition – Standard group			
New – Same	1,30	28.88	< .0001
New – Different	1,30	37.67	< .0001
Same – Different	1,30	< 1	
Intrinsic condition – Inverted group			
New – Same	1,30	14.52	.0006
New – Different	1,30	3.59	.07
Same – Different	1,30	5.39	.0272
Extrinsic condition – Inverted group			
New – Same	1,30	6.96	.0131
New – Different	1,30	7.76	.0091
Same – Different	1,30	< 1	

Table 1. Planned comparisons concerning Intrinsic and Extrinsic conditions in the Standard and Inverse groups at the mid-frontal ROI in time window 1.

Groups did not differ with respect to demographic characteristics, and reanalyis of accuracy data yielded no enlightening results. Yet, in RT reanalysis, the Group factor had a significant influence on the congruency effect reported above, that is, the difference between correct Same and Different responses was larger in the Standard group compared to the Inverse group (181 ms vs. 107 ms; $F(1,30) = 5.43$, $p < .05$; see Figure 2).

Notably, even the grouping of subjects into two groups according to the shape of their later parietal old-new effect (Standard vs. Inverse, see below) did not alter the FN400 effect pattern. Thus, independent of subsequent processing, extrinsic information does not affect familiarity calculation. This indicates that it is indeed the Intrinsic/Extrinsic factor that moderates perceptual specificity in familiarity and not task strategy, for instance. Also, the stability of the FN400 pattern despite dramatically differing subsequent processing speaks strongly in favor of dual-process models of recognition memory (cf. Ecker et al., in press; Yonelinas, 2002).

Contrast	df	F	p
Intrinsic condition – Standard group			
New – Same	1,30	4.41	.0442
New – Different	1,30	1.04	> .1
Same – Different	1,30	1.07	> .1
Extrinsic condition – Standard group			
New – Same	1,30	22.56	< .0001
New – Different	1,30	10.77	.0026
Same – Different	1,30	4.21	.0491
Intrinsic condition – Inverse group			
New – Same	1,30	7.49	.0103
New – Different	1,30	9.67	.0041
Same – Different	1,30	< 1	
Extrinsic condition – Inverse group			
New – Same	1,30	19.06	.0001
New – Different	1,30	15.16	.0005
Same – Different	1,30	1.08	> .1

Table 2. Planned comparisons concerning Intrinsic and Extrinsic conditions in the Standard and Inverse groups at the left-posterior ROI in time window 2.

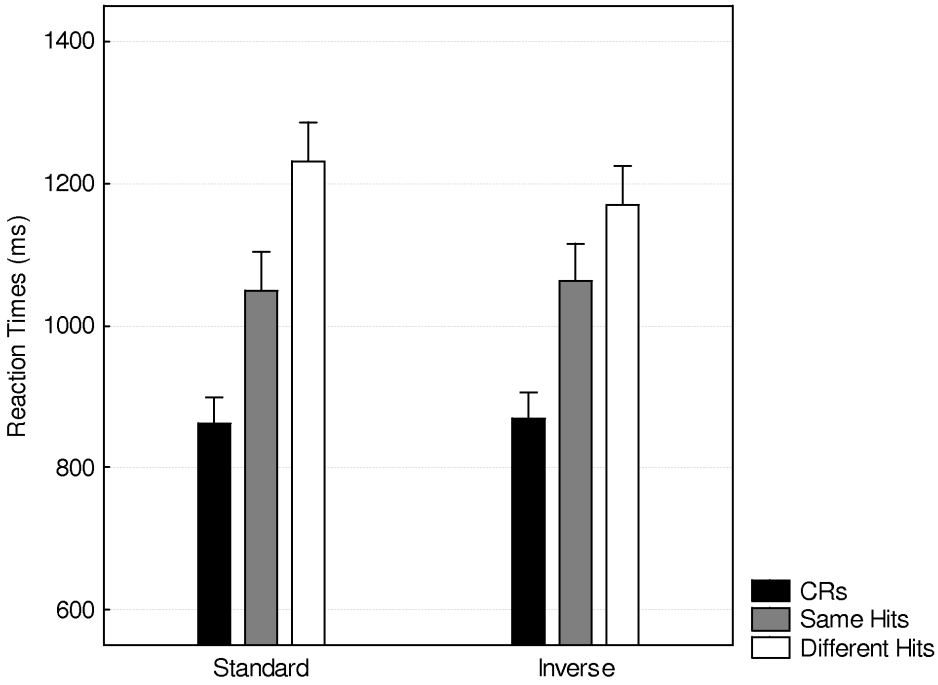

Figure 2. Mean response times for Standard and Inverse groups. CRs denotes correct rejections of new items. Vertical bars denote standard errors of the mean.

There are a some studies in the literature reporting inversed old-new effects. Cycowicz et al. (2001) found an inversed old-new effect in a somewhat later time window (800-1200 ms) in a source memory paradigm. The effect had a parieto-occipital focus, so the authors suggested it may reflect sensory reinstatement of the study image in visual cortex. This late posterior negativity (LPN) has been associated with continued and extended integration processing (Johansson and Mecklinger, 2003). Yet, given the latency difference as compared to the current effect, we do not consider this a likely interpretation of present results. Perhaps more relevant, Nessler et al. (2004) reported an inversed LPC effect in a false memory paradigm. As in the present case, the effect was based on a positive shift of correct rejection waveforms and peaked around 700 ms. In their task, subjects studied a list of words taken from 10 categories. At test they were to accept studied words as old and to reject both new items from different, novel categories and lures (i.e., new words from the study phase categories). They argued that their subjects may have focused on novel semantic information in order to reject new items from novel categories. Similarly, Azimian-Faridani and Wilding (2006) reported a positive shift of correct rejection waveforms at posterior sites around 700 ms, when they manipulated response criterion. Both studies suggested that the positive shift may have been due to target-like processing of new items affecting target-P300 amplitude and thus reducing (Azimian-Faridani and Wilding) or inverting (Nessler et al.) the standard old-new LPC effect. Thus, some subjects in the present case could have used a similar strategy and the difference between groups could reflect a difference in processing strategy.

If this is true, following Nessler et al. (2004), subjects of the Standard group should have focussed more on the appraisal of old items and the discrimination of old Same and Different items based on sensory processing, whereas subjects of the Inverse group should have focussed more on the rejection of new items, perhaps in the sense of a "recall to reject" or "exhaustive search" strategy (Rotello and Heit, 1999, 2000; Yonelinas et al., 2005). As a consequence, subjects showing a standard LPC effect should show stronger congruency effects (i.e., larger Same-Different differences). In the post-grouping ERP data, while both Same and Different conditions in the Extrinsic condition yielded significant old-new effects (in both Standard and Inverse groups), the Same effect was reliably larger in the Standard group (and there was a respective trend in the Inverse group resulting in a significant interaction con-

trast). In the Intrinsic condition, on the other hand, only the Same old-new effect was reliable in the Standard group at all, and there was no difference in the Inverse group between Same and Different. Compatibly, in the behavioral data, it became evident that effects of the feature manipulation were more pronounced in the group showing a standard LPC effect. This pattern of results is in line with an interpretation in terms of different strategies across subjects. However, since this speculative conclusion rests on post-hoc analyses, further research, for instance manipulating task strategy via instructions, should aim to clarify this.

Furthermore, the congruency effects in the 500-800 ms period can be seen as evidence for feature integration in post-familiarity (recollective) processing. In line with our initial predictions, these effects were pronounced in the Extrinsic condition, suggesting a higher need for feature integration in the Extrinsic condition as compared to the Intrinsic condition, in which feature binding already impacted on familiarity signal calculation, as expected.

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