

An Examination of Process Dissociation Procedure (PDP) in Sentence and Action Memory

بررسی جداسازی پردازش اطلاعات در حافظه عملی و کلامی

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چکیده

در مطالعه حاضر، از روش جداسازی پردازش اطلاعات (PDP) برای دو هدف استفاده شده است: 1. تا سهم پردازشهای خودکار و کنترل شده در تکلیف اجرای عمل (SPT) و تکلیف کلامی (VT) بطور جداگانه اندازه گیری شود؛ 2. مشخص شود که آیا دو تکلیف SPT و VT در ارتباط با اندازه پردازش خودکار با هم متفاوت هستند. در آزمایش اول، دو تکلیف اجرای عمل و کلامی در دو حالت جداگانه غیرفراگیر دستکاری شدند. در آزمایش دوم، هر دو تکلیف SPT و VT به طور همزمان در یک حالت واحد غیرفراگیر دستکاری شدند. بعلاوه در آزمایش سوم، به آزمودنیها گفته نشد این دو تکلیف را به یاد بسپارند و یا در باره آزمون حافظه آتی اطلاعی به آنها داده نشد. نتایج هر سه آزمایش نشان داد که روش PDP، بزار مناسبی برای تمایز بین دو پردازش خودکار (نهان) و کنترل شده (آشکار) نیست و برای موقعیتها یا برای مواد یادگیری گوناگون تقسیم پذیر نیست. این نتایج، با توجه به نقض دو فرض روش PDP (تغییرناپذیری در آشنایی و تغییرناپذیری در یادآوری) مورد بحث قرار گرفته اند.

واژه های کلیدی: جداسازی پردازش اطلاعات، پردازش خودکار، پردازش کنترل شده، تکلیف اجرای عمل، تکلیف کلامی، پردازش نهان، پردازش آشکار.

Abstract

The Process Dissociation Procedure (PDP) was used in the present study for two purposes: 1) to measure separately the contribution of automatic and controlled processes in subject-performed tasks (SPT) and verbal tasks (VT). 2) to explore whether SPTs and VTs differ with respect to automaticity. In Experiment 1, SPTs and VTs were manipulated in two separate exclusion conditions. In Experiment 2, both SPTs and VTs were manipulated simultaneously in one exclusion condition. Furthermore, in Experiment 3, the subjects were not told to remember SPTs and VTs and were not informed about a later memory test. The results of all three experiments, conducted on a total of 45 undergraduate students, revealed that PDP is not a suitable instrument for distinction between automatic (implicit) and controlled (explicit) processing, and not generalizable for different situations or different learning materials. The results are discussed with respect to violation of two PDP assumptions (i.e., invariance in familiarity and in recollection).

Key words: Process Dissociation Procedure (PDP), subject-performed task (SPT), verbal task (VT), automatic processing, controlled processing, implicit processing, explicit processing.

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Jacoby (1991; Jacoby, Toth, & Yonelinas, 1993; 1998) introduced a new methodological framework, called "Process Dissociation Procedure" (PDP), to estimate the differentiated contribution of automatic and intentional processes. He argued that the distinction between direct (explicit) and indirect (implicit) tests of memory (e.g., Graf & Schacter, 1985) is only task dissociation, which is fundamentally different from the process dissociation estimated by PDP.

The most important problem in distinguishing between direct and indirect tests is that there is no one-to-one mapping between indirect versus direct tests and automatic versus intentional processing. That is, sometimes there may be intentional contamination of indirect tests, and automatic processing may also influence the results on direct tests. The most important advantage of the PDP is that there is no need to use different memory tasks to estimate separately both automatic and controlled processes. In the PDP paradigm, it is assumed that memory test performance is mediated in part by conscious processes and in part by unconscious or automatic processes. The PDP measures controlled and automatic influences when both are under a single set of conditions and they affect each other. The PDP has been used in different memory tests such as YES/NO recognition (e.g., Jacoby, 1991); forced recognition (e.g., Jennings & Jacoby, 1993); and stem-cued recall (e.g., Jacoby et al., 1993).

With reference to the dual-process theories of memory retrieval (e.g., Atkinson & Juola, 1974; Jacoby & Dallas, 1981; Mandler, 1980), conscious recollection and judgments of familiarity are considered as alternative bases for recognition memory

decisions. Recollection is referred to as a consciously controlled, intentional use of memory, and familiarity is referred to as an automatic and less effortful use of memory. According to PDP, conscious and automatic processes can act in concert to facilitate recognition, but also in opposition to each other to produce interference. For the purpose of assessing the facilitation influence, Jacoby (1991) used a standard recognition test (inclusion test), in which all previously encoded words (reading words, anagrams, and heard words) were to be called *old* and only not previously presented words were to be called *new*. For the interference influence, subjects were instructed to call only some of the previously encoded words (heard words) as *old* items and the remaining (previously read words and anagrams) in addition to not previously encoded words as *new* items. This was called an exclusion recognition test because, unlike the inclusion test, part of the previously encoded words were to be excluded from the recognition memory test. In the inclusion condition, subjects attempt to select **for** items, whereas, in the exclusion condition, they attempt to select **against** items. Recollection can be measured as the difference between the probabilities of calling a particular item *old* in the inclusion and the exclusion conditions. The following formulas were used to measure the probability of recollection in the inclusion condition: $O_i = R - F - RF$ and in the exclusion condition: $O_e = F(1 - R) = F - RF$ ($O = old$, $R = recollection$, $F = familiarity$). Thus, the probability of conscious recollection can also be defined as: $R = O_i - O_e$. The probability of responding based on familiarity can also be defined as: $F = O_e / (1 - R)$ (Jacoby, 1991; Mandler, 1980).

Jacoby (1991) compared reading words and anagrams in the inclusion and the exclusion conditions. Reading words that are relatively easy to perceive are experienced as familiar, whereas anagrams that are more attention-demanding are required conscious recollection. The read versus anagram manipulation had opposite effects in performance on inclusion and exclusion tests of recognition memory. In the inclusion test, anagrams were more likely to be called *old* than were reading words, whereas, in the exclusion test, reading words were more likely to be called *old* than were anagrams. Also, the difference between the inclusion and exclusion conditions was more pronounced for anagrams than for reading words.

In the present study, we compared subject-performed task (SPT) and verbal task (VT) by means of PDP in YES/NO recognition tests. SPTs refer to encoded enactment, whereas VTs refer to encoding without enactment (Cohen, 1981). In SPT encoding, subjects were presented with simple commands (e.g., lift the book) and were instructed to perform the action indicated by the commands. In verbal encoding, subjects receive the same commands as in the SPT encoding, but they only read the commands without performing them. The results of such experiments typically show that memory for enacted commands is higher than memory for nonenacted commands. This SPT effect has been observed in a wide variety of experimental settings (see Kormi-Nouri & Nilsson, 2001; Engelkamp & Cohen, 1991; and Nilsson, 2000 for reviews).

According to several theories, it has been suggested that the reason why SPTs are remembered better

than VTs is due to automaticity difference between these two encoding tasks. Cohen (e.g.,1983) suggested SPTs and VTs as two extreme points on a continuum of automaticity in encoding. Acquisition of SPTs is automatic and does not require memorization strategies, whereas VT encoding is attention-demanding and strategic. Bäckman and Nilsson (e.g.,1984,1985) suggested that SPT encoding is partly automatic and partly attention-demanding. They proposed that the encoding of physical features of SPTs is automatic, whereas the encoding of verbal features of SPTs is strategic. Nilsson and Bäckman (1989) also proposed that although both SPT and VT memory involve explicit processing, encoding enactment adds a unique implicit memory component to the SPTs. With the possibility in mind that SPTs and VTs differ with respect to automaticity, the objectives of the present study were: (1) to measure separately the contribution of automatic and controlled processes in both SPT and VT encoding by means of PDP, and (2) to explore whether SPTs and VTs differ with respect to automaticity.

Experiment 1

Method

Subjects: The subjects were 45 undergraduate students participating in the experiment for course credit, 15 subjects were randomly assigned to each of the three test conditions (one inclusion test and two exclusion tests).

Materials: A set of 76 commands (e.g., empty the pencil-sharpener, hide the drawing-pin) was selected as to be remembered-items. Thirty eight of these commands were encoded as SPTs, whereas the rest

were encoded as VTs. Each command consisted of one action - verb and one concrete noun. Two formats were constructed such that the commands used as SPTs in the one format were used as VTs in the other format and vice versa. A list of 152 commands (76 *old* items and 76 *new* items) was presented as a recognition memory test. For new items, different combinations of verbs and nouns were used.

Procedure: Each subject was presented with commands written on cards, which were shown one at the time, at a rate of 6 secs per item in addition to 3 secs for inter-stimulus interval. They were informed that commands would sometimes be presented as SPTs (the experimenter uttered "action" before those commands) and that their task was to perform the action indicated by the commands. Real objects were used in SPTs; each object was handed over to the subject at presentation of the command and was hidden immediately after the presentation. Subjects were told that other commands would be presented as VTs (the experimenter uttered "sentence" before those commands) and that their task was to read those commands aloud. No object was used in VTs. The subjects were presented with two practice examples of SPTs and VTs before the presentation of the study list. The subjects were instructed to remember both SPTs and VTs for an unspecified memory test.

After a 10-min interpolated task of learning and recalling a list of 28 paired words, subjects were given one of three recognition tests: one inclusion and two exclusion tests. In the inclusion test condition, subjects were instructed to call an item *old* if the item was previously presented as a SPT or VT. In exclusion test 1, subjects were instructed to call an

item *old* only if it was earlier encoded as a VT. SPTs and not previously presented distractors were to be called *new*. In exclusion test 2, subjects were instructed to call an item *old* only if it was earlier encoded as a SPT. VTs and not previously presented distractors were to be called *new*.

Results and Discussion

Table 1 results show regular enactment effects within the inclusion test and between the two exclusion tests. In the exclusion tests, false recognition of SPTs was higher than false recognition of VTs, although these performances were not high enough to make any conclusion with respect to difference between automatic processes in SPTs and VTs.

Table 1

<u>Test condition</u>	<u>SPT</u>	<u>VT</u>	<u>NEW</u>
Inclusion	.87	.66	.12
Exclusion 1	.04	.68	.03
Exclusion 2	.90	.01	.13

A one-way ANOVA for the inclusion data and a two-way ANOVA for the exclusion data show the standard SPT effect both in the inclusion test (within - subjects comparison) (.21) and in the exclusion test (between-subjects comparison) (.22) ($p < .001$), where SPTs and VTs were to be named as *old* items. The two-way ANOVA, 2 (type of test instruction: Exclusion 1 vs. Exclusion 2) x 3 (type of item: SPT/VT/NEW), also revealed that the mistaken recognition of SPTs in Exclusion 1 was larger than the mistaken recognition of VTs in Exclusion 2, $F(1,28) = 9.19$, $MSe = 1.31$, $P < .01$, although it should

be noted that the performances were at floor level (.04 vs. .01). Using the PDP's formulas, the probability of recollection for SPTs and VTs were estimated to be .83 and .65 respectively. The estimated probability of calling a command *old* on the basis of its familiarity was .24 for SPTs and .03 for VTs. The false recognition of *new* items was larger in Exclusion 2 than in Exclusion 1, $F(1,28) = 17.23$, $MSe = 23.41$, $P < .001$, when subjects were to exclude SPT, in comparison with VT, they were much less likely to recognize false *new* items as *old* items.

The PDP assumes that memory test performance is mediated in part by conscious processes and in part by unconscious or automatic processes. The PDP measures controlled and automatic influences when both are under a single set of conditions and they affect each other. The main implication of the results in Experiment 1 was that we failed to measure separately the contribution of automatic processes. In fact, the performances of SPTs and VTs in the two exclusion tests are at floor level and they do not allow us to claim for any contribution of automaticity at all. Furthermore, the lower false alarm in Exclusion 1 shows that subjects used familiarity differentially in this condition, compared to Exclusion 2 and the inclusion condition.

Experiment 2

In Experiment 1, we manipulated SPTs and VTs in two separate exclusion conditions, whereas, in the Jacoby study (1991), anagrams and reading words were excluded simultaneously in a single exclusion condition. This might be the reason that we were not

able to measure automaticity as Jacoby was. To make the method similar to that used in the Jacoby study, in addition to SPTs and VTs, subjects were instructed to learn another type of item (VTO). In VTOs, the instruction was similar to VTs, except that the subjects were shown the objects indicated in the commands but were not allowed to touch the objects. VTOs were used as base line control in the inclusion and exclusion conditions, whereas SPTs and VTs were compared as variables of interest with respect to the contribution of automatic and controlled processing.

Method

Subjects: The subjects were 36 students from the same pool as used in Experiment 1. They were randomly divided into two test conditions (inclusion vs. exclusion).

Materials and procedure: A set of 90 commands was selected as to-be-remembered- items: 30 items for each of SPT, VT and VTO encoding. They were presented in a mixed order. Three formats were constructed such that commands could be equally presented as SPTs, VTs, and VTOs. A 30-item vocabulary test, a 53-item Stroop test, and a 14-item anagram test were used as interpolated tasks (15 mins) between study list and test. A list of 180 commands (90 *old* items and 90 *new* items) was presented as a recognition memory test. In the inclusion test, subjects were instructed to call an item *old* if the item was earlier presented as SPT, VT, or VTO. In the exclusion test, subjects were instructed to call an item *old* only if it was earlier presented as VTO; the subjects were told to call SPTs and VTs

(along with real *new* items) as *new* items.

Result and Discussion

Results in Table 2 show only regular enactment effect in the inclusion test but not in the exclusion test, reflecting that there is no difference between automatic processes in SPTs and VTs.

Table 2

<u>Test condition</u>	<u>SPT</u>	<u>VT</u>	<u>VTO</u>	<u>NEW</u>
Inclusion	.87	.54	.66	.11
Exclusion	.02	.06	.60	.06

A one-way ANOVA conducted for the inclusion data showed that SPTs were recognized better than VTOs, which, in turn, were recognized better than VTs, $F(2,34) = 41.20, MSe = 10.96, P < .001$. A 2 (test condition: inclusion vs. exclusion) \times 2 (type of item: SPT vs. VT) ANOVA was performed to compare the contribution of recollection and familiarity processing in SPTs and VTs. The Test \times Item interaction was significant, $F(1,34)=73.87, MSe=7.45, P<.001$. However, a simple effect comparison revealed that the SPT -VT difference was only significant in the inclusion test but not in the exclusion test ($p > .20$). Using PDP formulas, the probability of recollection for SPTs and VTs were estimated to be .85 and .48 respectively. The estimated probability of calling a command *old* on the basis of its familiarity was .13 for SPTs and .12 for VTs. As in Experiment 1, the performances for SPTs and VTs were at floor level in the exclusion test and we are therefore unable to draw any conclusion for the contribution of automatic processing in memory test.

Another analysis was performed to examine the effect of test instruction on subjects' ability to discriminate between VTOs and *new* items. It was revealed that recognition was larger in the inclusion test than in the exclusion test, $F(1,34) = 11.45, MSe = 14.95, P < .01$, and VTOs were recognized more likely as *old* items than were *new* items, $F(1,34)=75.86, MSe=28.86, P < .001$. A simple effect comparison showed that *new* items were recognized more incorrectly in the inclusion test than in the exclusion test, $F(1,34) = 6.74, MSe = 26.37, P < .05$, whereas, for VTOs, there was no difference between the two test conditions ($p > .20$). These results indicate that subjects used different criteria in the inclusion and exclusion conditions.

Experiment 3

In Experiments 1 and 2, the subjects were told to remember SPTs and VTs and were informed about a later memory test, although the nature of test was unspecified. On the other hand, Jacoby (1991) did not mention to the subjects about any memory test for anagrams and reading words. In fact, subjects were led to believe that the processing speed of anagrams and reading words was measured. As was suggested by Jacoby (1998), test instructions are important to satisfy assumptions underlying the estimation procedure. Thus, the difference between the Jacoby study (1991) and the present study might be the reason for a low performance of SPTs and VTs in the exclusion condition, and the different incorrect alarm rate in the inclusion and exclusion conditions. Experiment 3 was therefore designed to solve these problems. An attempt was made to use a PDP method closely

similar to the one used in the Jacoby (1991) study.

Method

Subjects: Thirty six students from the same pool as used in Experiments 1 and 2 were randomly assigned to two test conditions (inclusion vs. exclusion).

Materials and Procedure: The materials and procedure were the same as for Experiment 2 except for some changes. Like the Jacoby (1991) study, in Phase 1, only SPTs (30 enacted commands) and VTs (30 reading commands) were mixed and presented and no mention was made of a test of memory to be given later. Subjects were led to believe that the experiment was related to attention; how they can attend two successive tasks (SPTs and VTs), the number of error made by subjects in performing SPTs and reading VTs. In fact, no error was recorded. To make SPTs and VTs as similar as possible, real objects were not used in SPTs and subjects were instructed to perform the actions with imaginary objects. After the presentation of SPTs and VTs, the 30-item vocabulary test used in Experiments 1 and 2 was given. In Phase 2, 30 heard commands were presented: The commands were aurally presented by means of a tape recorder at a 6-s rate. Subjects were instructed to repeat each command aloud and to remember them for a subsequent test of recognition memory. Again, like Experiment 2, SPTs, VTs (reading commands), and heard commands were interchanged across subjects. After the presentation of heard commands, two interpolated tasks were used: (1) to write down as many capital cities as possible within a period of 5 mins. (2) to solve 14 anagrams used in Experiment 2. At the end, the subjects were given one of two test

conditions. In the inclusion test condition, subjects were to call an item *old* if the item was previously SPT, VT or a heard command. In the exclusion test condition, subjects were to call an item *old* if it was earlier heard, and call the rest of the items *new*.

Results and Discussion

The results shown in Table 3 reveal a regular enactment effect in the inclusion test, but no difference between aurally presented items (heard items) and visually presented items (reading items). In the exclusion test, incorrect recognition of VTs was higher than incorrect recognition of SPTs.

Table 3

<u>Test condition</u>	<u>SPT</u>	<u>VT</u>	<u>Heard</u>	<u>NEW</u>
Inclusion	.86	.59	.62	.14
Exclusion	.04	.21	.63	.07

A one-way ANOVA conducted for the inclusion data shows that type of encoding was significant, $F(2,34) = 33.35$, $MSe = 10.96$, $P < .001$. Pairwise comparisons (Tukey) revealed that SPTs were recognized better than VTs and heard items, but there was no difference between VTs (reading commands) and heard commands. A two test condition (inclusion vs. exclusion) x 2 type of encoding (SPT vs. VT) ANOVA was performed to compare the contribution of recollection and familiarity processing in SPTs and VTs. The Test x Item interaction was significant, $F(1,34) = 64.46$, $MSe = 12.62$, $P < .001$. In the inclusion test, SPTs were more likely to be called *old* than were VTs (reading items). In the exclusion test, VTs were more likely to be called *old* than were

SPTs. Using PDP formulas, the probability of recollection for SPTs and VTs were estimated to be .82 and .38 respectively. The estimated probability of calling a command *old* on the basis of its familiarity was .22 for SPTs and .34 for VTs. As in Experiment 1, the level of performance in the exclusion test was low for SPTs (.04), but, unlike Experiment 2, it was increased for VTs (.21). Another analysis was performed to examine the effect of test instruction on subjects' ability to discriminate between heard and *new* items. It was revealed that the difference between the inclusion test and the exclusion test was marginally significant, $F(1,34)=3.31$, $MSe = 43.72$, $P = .08$, and heard items were recognized more likely as *old* items than were *new* items, $F(1,34) = 51.53$, $MSe = 30.07$, $P < .001$. The Test x Item interaction was significant, $F(1,34) = 5.79$, $MSe = 30.07$, $P < .05$. *New* items were recognized more incorrectly in the inclusion test than in the exclusion test, whereas, for heard items, there was no difference between the two test conditions. As in Experiment 2, Experiment 3 results indicate that subjects used different criteria in the inclusion and exclusion conditions.

General Discussion

In the PDP, it is assumed that memory- test-performance is mediated in part by conscious processes and in part by unconscious or automatic processes. More specifically, it is believed that recognition-memory-tests tap a mixture of consciously controlled recollection and automatic familiarity (Jacoby, 1991). The PDP was therefore designed to assess controlled and automatic processes separately

when both are operating under a single set of conditions. In the present study, we examined the PDP with new memory tasks: commands were encoded with enactment (SPTs) and without enactment (VTs). The purpose of this manipulation was (1) to measure separately the contribution of automatic and controlled processes for SPTs and VTs, as was measured for anagrams and reading words in the Jacoby (1991) study, and (2) to explore whether SPTs and VTs were different with respect to automatic processing.

The results of the present study revealed that PDP is not a suitable instrument for differentiating the contribution of automatic and controlled processes for SPTs and VTs. Of all three experiments, the performance levels of SPTs and VTs (with an exception in Experiment 3) in the exclusion test were at floor level such that it might lead us to totally rule out the involvement of automatic processing in SPTs and VTs. However, this conclusion is incorrect because it is especially at odds with the PDP assumption that memory test performance (especially recognition test) is mixedly mediated in part by conscious processes and in part by unconscious or automatic processes (Jacoby, 1991). It also differs with the view in SPT literature that assumes more involvement of automatic processing for SPTs than for VTs (Cohen, 1983; Bäckman and Nilsson, 1984, 1985; Nilsson and Bäckman, 1989). Furthermore, using PDP, we cannot draw a clear conclusion with respect to differential automatic processing for SPTs and VTs. In Experiment 1, with the use of PDP formulas, the probability estimation of automatic familiarity was more pronounced for SPTs (.24) than for VTs(.03). In

Experiment 2, there was no difference between SPTs and VTs with respect to the estimation of automatic familiarity (SPT = .13, VT = .12). In Experiment 3, compared to Experiment 1, the results were reversed: The probability estimation of automatic familiarity was more pronounced for VTs (.34) than for SPTs (.22).

The PDP requires two assumptions (Toth, Reingold, & Jacoby, 1995): (1) invariance in familiarity, and (2) invariance in recollection. The first assumption is that the probability of responding *old* to an item on the basis of its familiarity is the same in the inclusion and exclusion test conditions. The second assumption is that the probability of recollection is the same in the two test conditions. As was discussed by Graf and Komatsu (1994), the results of the present study show that both of these assumptions are violated. The familiarity assumption can be assessed through false alarm rates (Graf and Komatsu, 1994; Toth et al., 1995; Jacoby, 1998). Different false alarm rates reflect that subjects use familiarity differentially in the inclusion and exclusion test. In all three experiments of the present study, false alarm rates were different in the two test conditions (they were larger for the inclusion tests than for the exclusion tests). This indicates that the subjects did not use the same criterion for familiarity-based judgments in the two test conditions.

With respect to the recollection assumption, as noted by Jacoby (1991) and Toth et al. (1995), there is generally no independent measure of recollection. As was discussed by Graf and Komatsu (1994), the problem for this assumption is that subjects might use different criteria to make a correct *old* decision in the

inclusion and exclusion conditions. In the exclusion condition, subjects require a source decision in addition to an *old/new* decision for each item. For instance, in the exclusion condition of Experiment 3, the subjects had to decide whether a recollected item belonged to the first set of items (SPTs and VTs) or to the second set of items (heard commands). By contrast, in the inclusion condition, it was not important whether the items belonged to the first or to the second set and the subjects had to make the *old/new* decision only for each command. Consistent with this argument, all subjects participating in the exclusion condition of Experiment 3 reported (at the end of experiment) that they had more difficulty to discriminate between VTs and heard items, compared to the discrimination between SPTs and heard items. This was because both reading items and heard items were verbal (without enactment), and the modality difference for the presentation of these items (aural vs. visual) had no effect on their performances; there was equal performance for reading items (.59) and heard items (.62) in the inclusion condition. That is, the similarity between reading and heard items should have provided the problem of source decision for these items. This also explains the increase of the level of performance for VTs in the exclusion test of Experiment 3, compared to Experiments 1 and 2. It has been discussed that memory for source information (required in the exclusion condition) is influenced by other factors than memory for target information (required in the inclusion condition) (e.g., Shimura & Squire, 1991; McIntyre & Craik, 1987; Gopnik & Graf, 1988).

As was mentioned by Jacoby (1991), the problem

with the recollection assumption might be that subjects are more likely to engage in recollection in the exclusion condition than in the inclusion condition. To test this notion, we analyzed the level of confidence for heard items and *new* items in the two test conditions of Experiment 3. It should be noted that in the recognition tests, for each item, there was a 3-scale confidence rating (sure, unsure, guessing). The results showed that, for heard items which were correctly recognized as *old* items, the subjects were more confident in the exclusion condition (.77) than in the inclusion condition (.62). On the other hand, for *new* items which were falsely recognized as *old* items, the subjects were more confident in the inclusion condition (.37) than in the exclusion condition (.21). That is, in the exclusion condition, the subjects were more confident about the correct responses, whereas, in the inclusion condition, they were more confident about the errors. There is research showing that confidence and accuracy are related and subjects are cognizant of this relation (Murdock & Dufty, 1972; Robinson & Johnson, 1996). Thus, these results suggest that subjects are differently involved in recollection in the two test conditions.

In sum, the results of the present study show that PDP is neither suitable for the distinction between automatic (implicit) and controlled (explicit) processing, nor generalizable for different situations or for different learning materials.

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