How emotion affects computing a simple task: a psychological study

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Abstract

The affects of predictability of the stimuli, of induced emotions and of preparation for the task on monotone Continuous Task Performance task (CPT) which consist in typing on the keyboard) the letter preceding in alphabetical order (action, eg; L) the one appearing on the screen (stimulus: M). We varied predictability of the letter (predictable, unpredictable and alternative sequences of predictable and unpredictable stimuli), and task preparation (with and without), induced emotion (positive, neutral and negative).

Results show that the more the task was predictable, shortest was response time (RT) and smaller was the number of errors. Preparation increased response times as providing more control while emotions did not affect Rts, but error rates in interaction with predictability: negative emotions increased the amount of errors for unpredictable targets while both positive and negative emotion decreased the amount of errors. Results are discussed in terms of internal or external distribution of attention under automatic or controlled cognitive processes

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Keywords: Continuous Performance Task, Cognition, Emotions.

1 Automatic vs. controlled processes and predictability

In studies about tasks execution and about learning of how to solve tasks, there is a classical and well-known distinction between automatic and controlled processes (e.g., Vallacher & Wegner, 1987). According to Posner and Snyder (1975), the cognitive process of solving a task is automatic when it occurs without intention, when it does not cause conscious attention, when it does not interfere with another mental activity. According to Schneider and Schiffrin (1977), automatic processes and controlled processes can be seen as two stages of training, the controlled processes being those of the novice beginner and the automatic processes being those of the expert.

The distinction between controlled processes and automatic processes is found with the Norman and Shallice (1986) model of the attention that comprehends three levels of controls: (i) controls made by rigid schemas for planning that are applied through automatic processes, (ii) controls made by a hierarchy of constraints through partly automatic processes, and (iii) controls made by an attentional supervisor through consciously controlled processes that render the execution of the task more flexible.

Studies about automatic and controlled processes underlying the execution of tasks, do not stress however sufficiently the nature of the task and, dependently, the nature of the objects on which one acts for solving the task. One of the aspects of task objects that could affect the

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balance between automatic and controlled processes is, for instance, the nature of what differs between targets and distractors. As shown with the Schneider & Shiffrin (1977) studied targets and distractors category differences. In their experiment, participants that have to learn a task, with first controlled processes when consciously having to apply the rules, with cognitive load, then with automatic processes, when solving the task with no cognitive load. They found stronger performances contribution of consistent coding (when targets and distractors are of two distinct groups of objects), compared to contribution of inconsistent coding (when targets and distractors are drawn from the same group of objects). In short, acquiring automaticity for task execution (without the need for conscious guidance or Monitoring) is easier for instance when targets are some numbers and distractors some letters, than when targets are some letters or numbers and distractors are some other numbers or letters. An effect we relate to the predictability of action related to the targets. For example, a target "r" of a set of targets (r, j, k, m) that are all letters is more predicting action than the same target "r" of a set of targets (r, 5, 9, m) that are either letters or numbers. In the former, "r" is predicting the action related to the target because it is "r" *and* because it is a letter while in latter "r" is predicting the target related action only because it is "r".

Except few studies (e.g.,Schneider & Shiffrin, 1977), how much objects of the tasks participate in the learning processes of automacity, remains largely unexplored.

We reasoned as follows. First, given that a task relates to objects, performances, for both learning and automatic execution, might be affected by the nature of the objects of the task to be processed. Second, if formalizing the whole process of task execution as follows.

- Task objects are <u>external objects</u> (ext-what)

1- to be first identified as <u>internal objects</u> (int-what)

2 - known to be applied <u>rules of action</u> (int-how)

2.1 - that are to be selected and verified <u>by internal controllers</u> (int-why: inter-how on int-what)

2.2- as corresponding to action (ext-how) to be applied to external object (ext-what)

2.3- as further providing positive feed-back when (ext-what: ext-how)

Then, the whole summarized controlled process can be seen as paying attention [*what: identifying objects*], then to process according to the task at hand by rules selection [*how: applying [what]rules*], with control of action [*why: verifying [what[how on [what]]]*].

Third, acquiring automaticity could thus be seen as decreasing attention and rule selection: verification becoming directly verif-action, verified action: [*what: how*].

Fourth, this learning process of automatic, described as [*what: how*], could be done according to both the degree of foreseeability (the possibility that *int-what* is *ext-what*) and of predictability (probability that *int-how* matches *ext-how: ext-what*).

In order to model automaticity as decreasing of attention and rules selection, we pose that an internal object as a target that can be predicted, and that fits the external object of action, *takes in charge the attention needed to be identified* by increasing its features selectivity which differently would be necessary to be processed, thus lowering the degree of attention which would have to be devoted to it if it were unpredictable. This approach, - in the line of situated action (Norman, 1993) who supports the idea of an internal and external distribution of attention/representation, and of Logan (2002) about automaticity -, allows to consider that the successful detection of a target requires the same degree of attention, either internal or external.

This is the external situation that made in one case targets to be only letters and in the other case, target to be either letters or digits. Thus, with controlled processes, "r" in the target set (r, j, k, m) or in (r, 5, 9, m) requires the same amount of internal processing: *What is this ext-object? is-it internal 'r"? If internal "r", then what are the rules to apply to external "r" ? Then, apply rules of internal "r" to external "r"*.

In opposite, with automatic processes, external "r" in (r, j, k, m) would be seen as an *internal "letter"* that matches directly *ext-how on [letters]*, in a both categorization and attentional process of learning (Tijus, 2001) that is difficult to develop for "r" in (r, 5, 9, m).

If automaticity depends on the way attention and representation (e.g. through matching internal categories) could be distributed in an internal way (a great amount of attention allocation) and in an external way (having the attentional processing being taken in charge to some extent by the situation), thus a manner of supporting the installation of automatic processes is to increase the predictibility of the objects to be processed or of the events to which the operator must face.

Continuous Task Performance (CTP) is an experimental paradigm for monotonous tasks, done in laboratories. CTO tasks share certain aspects of the tasks of vehicle driving (automobile, trains, etc). Originally, Rosvold, Mirsky, Sarason, Bransone, and Beck in 1956 designed CPT to test the attention of the people having cerebral lesions. These monotonous tasks are now widely used to study the attention processes, for instance to study executive functions all along the child cognitive development in the young (McGee, Clark, & Symons, 2000), or how incidents and accidents are processed in continuous monotonous tasks (Conners, 1994).

CTP tasks are experimental tasks of the GO/NO-GO type, for which participants see moving objects on a screen of computer, while having as trials to press on a key since a target appears, namely an object of a particular kind: symbols, drawings, etc.

Characteristics of the participant, characteristics of the task and characteristics of the situation are known to affect performances of CPT tasks. CTP tasks appear to be a right ground of experimentation to study the internal and external distribution of attention, thus automaticity, through the more or less predictability of the target. The CPC task that we use is a monotonous task of striking letters. The letter to type is the preceding letter in alphabetical order of the letter that is displayed on the computer screen. Thus, if the character displayed on the screen is “D”, letter “E” is to be typed. If there is the appearance of the letter “N”, then the striking is the letter “M”.

Now, suppose that the letters successively displayed on the screen are in alphabetical order. The next target is highly predictable. You even don’t need to process the letter on the screen, you will have to type the next alphabetical letter. This situation provides proceduralization of the task by having an action-action loop: to type the next alphabetical letter of the letter you just typed. In opposite, if letters are successively displayed on the screen at random, the next letter is unpredictable. It is necessary to await the display of the letter on the screen to know which one precedes in the alphabetical order and thus which letter to strike. Such a task cannot be automatized.

Within this framework, one sees the interest of predictability for automaticity: speed of execution by doing few errors. However, automaticity should impede the processing of an incident, i.e. here an unexpected event (or of very low probability of occurrence) that requires an unusual response.

In our task, incident was the display of a white square. Participants were informed of possible incidents of the form of a white square that is to be solved by typing “X in capital letter” to be able to continue the task of typing letters. We predicted that this resolution of incidents will be more difficult to detect and to solve in case of predictable letters than in case of unpredictable letters, since the participant must be attentive to what appears on the screen.

Note also the interest of semi-prédictable tasks, i.e. of tasks which make follow a sequence of a varied number of prédictable letters with a sequence of a varied sequence of a varied number of unprédictable letters, and so on. In this third task, there can be a preparation of the answer, effect of the predictable sequence, accompanied with a constant attention to the letters displayed on the monitor screen since a sequence of predictable letters can turn on a sequence of unpredictable letters. We used these three tasks to study internal factors that could affect performance by increasing or decreasing the allocation of attention to external objects (letters displayed on the screen): preparation and emotion.

2 Emotion and distribution of attention

As described above, our experimentation is based on the perception-action loop: a letter is displayed on the screen and the participant types the preceding letter in the alphabet. A simple model is that participants 1. capture the shape displayed on the screen, 2. encode this shape for recognition and identification starting from knowledge in long-term Memory (LTM), 3. find in LTM which letter is preceding I the alphabet, and 4. Press the corresponding key with the keyboard.

As steps 1, 2 and 3 are common know-how and knowledge of the participants, the performance and the training will depend on phase 4: to find and type on the key corresponding to the identified letter. This simple model does not take into account the sequential structure of the letters which appear on the screen and which can intervene in the perception-action loop. This model does not consider for example that the repetition of the same letter on the screen can make it possible to reduce the loop perception-action loop, making useless phases 2 and 3 by giving the same response to the same shape. Same strategy applies if the letters are displayed in the alphabetical order: the letters to be typed are in the alphabetical order.

Our assumption is that the perception-action loop proceeds in a different way according to the situation, namely "how much objects of the situation are predictable". Such predictable situations can be designed in laboratory by varying conditions of stimuli presentation. In our experimentation, we varied the order of presentation of the letters on the screen: a condition named "unpredictable" in which the order of presentation of the letters is at random, a condition named "predictable" in which the letters are displayed in the alphabetical order and a condition named "semi-predictable" in which, for 15 to 20 trials, the letters are displayed either in a random way, or in the alphabetical order.

With the unpredictable condition, steps 1, 2, 3 and 4 should be done. With training, expertise brings a shorter time duration of the striking of the letter all along the learning of Keyboard (location of the keyboard keys).

With the predictable condition, novice participant starts proceeding at beginning in the same way that the participants of the unpredictable condition. With training, participants note that the letter to be typed is the one that follows in the alphabetical order the letter just typed. There is not need to process the shape displayed on the screen (except checking from time to time): typing on the keyboard the key of the next letter in alphabetical order can solve the task. The action-perception loop is thus transformed into an action-action loop.

With the semi-predictable condition, the participant who wants to get profit of the action-action loop must however be vigilant on the predictable-unpredictable passage, which means switching from a controlled mode to an automatic mode, or vice-versa, as soon as possible. This mode might allows better performances that the unpredictable mode by having partly the benefit of sequence of predictable letters. In addition, having to pay attention of switching sequences of predictable-unpredictable letters displayed on the screen, incidents (the display of square, instead of a letter) should be faster detected than with the predictable condition. The unpredictable condition should favor incidents detection and their solution compared to semi-predictable condition. We also varied the preparation to the task that enhances controlled processes and induction of emotions (Positive, Negative, Neutral) among participants, and we reasoned that the fact to be mentally prepared to the task (be careful, remember now what you will have to do) should increase control, having no effects on automaticity.

Similarly, we reasoned that emotions should affect controlled processes when the letters are unpredictable: positive emotions (thinking before the task to a positive event) should reduce errors by enhancing confidence while negative event should provide decrease confidence and increase cognitive load by thinking to the negative event.

3 Experimentation

3.1 Participants

Participants were ninety students of the Paris 8 University. They were recruited according to the criterion "text editing with one or two fingers, looking for keys at the keyboard".

3.2 Materials

The experiment was computer driven using the software Frida (S. Poitrenaud) for collecting data protocols files of participants running the experiment. Each file is written experimental condition, anonymous identifier of the participant, current session, the ordered set of 100 trials and for each trial, the letter displayed on the screen, the successive key(s) that were pressed as response and for each key pres, response time in 1/60 of second.

The task was a CPT task for which response must be given for each trial. For each trial, on the screen of the computer a capital letter appears. The task is to press on the keyboard the key of the preceding letter in the alphabet, in capital letter. If the letter that appears was "A", "Z" key is to be activated. If the key pressed on the keyboard is the one of the letter that precedes in the alphabet the letter displayed the screen, then the letter on the screen disappears and another appears for the next trial, and so on for 100 trials.

When the activated key did not match the preceding letter, the displayed letter was turn in white in a black square (inverse-video), lasting 1 second to indicate that the response letter was incorrect. The participant must then type again a letter. Delivery of the next trial, with another letter, was done only after activation of the correct letter key.

Lastly, an incident randomly appears ranging between the 51th and the 100th trial. This incident is the following: at the location of the letter on the screen, a white square with a black edge is displayed. In order to make it disappear, it is necessary to type "X" in capital letter and the task continues. Participants were informed of this possible incident and how to solve it.

The display of letters was declined in three different conditions (Predictable, Semi-predictable and unpredictable). With the predictable condition, the 100 letters successively displayed on the screen were in the alphabetical order. With the semi-predictable condition, the letters were either displayed in alphabetical order or at random for a succession of a number of trials that varies from 15 and 20. With the unpredictable condition, the letters were successively displayed at random.

3.3 Procedure

In turn, each of 90 participants was affected in one of the 18 groups corresponding to experimental conditions obtained by the crossing from predictability of the target (predictable, semi-predictable, unpredictable), of the preparation (with preparation, without preparation), and of mood (positive mood, negative mood, without mood).

Participants agreed to run 3 experimental sessions of 3 sets of 100 trials. They were instructed "*to type on the keyboard in capital letter the letter which precedes the letters displayed on the screen, as soon as possible, but without making mistakes. If a white square appears, then it is necessary to type X in capital letter*". For preparation, participants were asked to think first about being mentally prepared the task they will have to perform for about 60 seconds. For inducing positive (or negative) emotions, they were told to think for about 60 seconds about a positive (or negative) event that occurs recently in their daily live. For without preparation or neutral emotion, they were told to think about their coming in the laboratory for about 60 seconds or how they will go home. All the participants were familiarized with the task at the beginning of the first session with 10 trials.

Thus, each participant was given 900 trials: 3 sessions of 3 sets of 100 tests, at a rate of a session per week. The experimental design is the following: $S_5<C_3*P_2*H_3>*SES_3*SET_3*T_{100}$, where S represents the 5 participants per group, C represents the 3 modes of displaying letters (predictable, semi-predictable, unpredictable), P represents the 2 preparation modes (with or without), H represents the 3 induced emotions (positive, negative, without), SES represents the 3 successive session (1st, 2nd, 3rd), SET represents the 3 successive Sets in each session (1st, 2nd, 3rd), and T represents the one hundred trials. Experimental design for incidents analysis is $S_5<C_3*P_2*H_3>*I_9$ where I represents the incident that was occurring in each of the 9 sessions

4 Results

Remain that, after being familiarized with the task, each of the 90 participants solve nine hundred trials into three sessions of three sets of 100 trials. For each trial, they must type in capital letter on the keyboard the letter that precedes in the alphabet the letter that is displayed in capital letter on the screen.

4.1 Effects of training

The task was a learning task since we observe an increasing performance all along the 9 successive sets: errors rate of pressing the wrong key lessened, although in a non-significant way, as well as reaction times (RT) to press the correct key (F(8,576)=74 ; p<.001).

There was also a learning of solving the incident since the errors rate of pressing other keys than “X” decreased to a significant degree all along the nine sessions, from 2,3 errors on average within the first session to 1,4 errors within the ninth session (F (8,576) =1,9; p<, 0001).

The RT to solve the incident decreased to a significant degree all along the nine successive sessions, from 5 to 1.68 seconds from the first to the ninth session (F (8,576) =15,03; p<, 0001).

4.2 Effects of predictability

There was a strong effect of predictability. On average, there were more typing errors for unpredictable targets (1.9 errors on average per participant by session), that for semi-predictable (1.5 errors) or predictable (1.2 errors) targets. This difference is significant (F (2,72) =3,9; p=.02).

The RTs were higher when the target was unpredictable (2.2 seconds on average per target), lower when the target was semi-predictable (1.8 seconds) and lower when the target was predictable (1 second). This difference is significant (F (2,72) =79,51; p<, 0001).

In addition, there was a significant effect of predictability on the evolution of errors rates (F (16, 576) =1,72; p= .03) and on RTs through sets (F (16, 576) =74,05; P< .0001). Thus, more the task was predictable, less there are errors and shorter was the time to press the correct key.

For solving incidents, there was no significant difference: 1.9, 1.6 and 1.8 errors and 2.3, 2.3 and 2.1 seconds for unpredictable, semi-predictable and predictable, respectively.

4.3 Effects of preparation

There was an effect of preparation on RT for typing the right key : there was no significant difference in error rate (1.48vs. 1.54) but in RTs (1.56 vs. 1.74; F(1,72)= 4,5 ; p= 0.3) with or without preparation respectively. Thus preparation increase control and is time consuming. Difference between the RTs of the first and the ninth session with preparation (4.9 seconds) is higher than without preparation (1.87 seconds), (F (8,576) =3,49; p=.0006).

4.4 Effects of emotion

There was no direct effects of emotions on typing the right key. Differences in errors rate (1.5, 1.6 and 1.5 errors) and in RTs (1.6, 1.7 and 1.7 seconds) respectively for positive, neutral and negative emotions were not significant.

There was no direct effects of emotions on solving the incident: 1.6, 2 and 1.9 errors and 2.2, 2.3 and 2.2 seconds, on average per session, for positive, neutral and negative emotions respectively.

4.5 Interaction of emotion and predictability

As seen in table 1, there was in fact strong effect of emotion in interaction with predictability. For unpredictable targets, negative emotions increased errors rate of 1 second (2.8 instead of 1.8 errors for neutral), while positive emotions decreased error rates. For predictable targets, both positive and negative emotions reduced errors rate. Finally, note that emotions did not affect RTs.

Table 1: Errors rate (table 1) and Reaction Times (table 2) in seconds for pressing the key and Reaction Time (table 3) for solving the incident.

		Emotion				
	preparation	positive	neutral	negative		
unpredictable	*without*	1,8	1,8	2,8	*2,1*	*1,9*
	with	1,4	1,9	1,6	*1,6*	
		1,6	*1,9*	*2,2*		
semi-predictable	*without*	1,2	1,0	1,8	*1,3*	*1,5*
	with	1,5	2,1	1,8	*1,8*	
		1,3	*1,5*	*1,8*		
predictable	*without*	0,9	1,6	0,9	*1,1*	*1,2*
	with	1,3	1,3	1,0	*1,2*	
		1,1	*1,5*	*0,9*		
		1,3	*1,6*	*1,6*		

		Emotion				
	preparation	positive	neutral	negative		
unpredictable	*without*	2,0	2,2	2,2	*2,1*	*2,2*
	with	2,3	2,2	2,2	*2,2*	
		2,2	*2,2*	*2,2*		
semi-predictable	*without*	1,7	1,5	1,7	*1,6*	*1,8*
	with	1,7	2,3	1,9	*2,0*	
		1,7	*1,9*	*1,8*		
predictable	*without*	0,8	0,9	1,0	*0,9*	*1,0*
	with	1,1	1,0	0,9	*1,0*	
		1,0	*1,0*	*1,0*		
		1,6	*1,7*	*1,7*		

		Emotion				
	preparation	positive	neutral	negative		
unpredictable	*without*	3,0	2,0	2,3	*2,4*	*2,3*
	with	1,7	1,7	3,0	*2,1*	
		2,4	*1,9*	*2,7*		
semi-predictable	*without*	2,2	1,7	1,8	*1,9*	*2,3*
	with	2,4	4,0	1,8	*2,7*	
		2,3	*2,9*	*1,8*		
predictable	*without*	1,4	1,8	1,8	*1,7*	*2,1*
	with	2,4	2,8	2,4	*2,5*	
		1,9	*2,3*	*2,1*		
		2,2	*2,3*	*2,2*		

5 Discussion and conclusion

Preparation to a task is on the cognitive side with planning and anticipation while emotions is on the affective side with judgments and feelings about objects. The main results of our study are that Preparation affected RTs and Emotions affected errors rate.

Time to process a task and errors rate are often seen as balancing outputs of the cognitive system. Reducing times is increasing errors. Paying attention of not doing errors is time consuming. However, dissociation between time to process a task and the making of errors should reveal deep functions of the processing system.

Thus, our study advocate for a model in which emotions affect attentional processes while preparation affects planning processes and mainly controlled processes. Thus emotion might affect learning by impeding the passage from controlled to automatic processes.

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