Journal of Scientific Exploration, Vol. 28, No. 3, pp. 437–452, 2014 0892-3310/14

RESEARCH ARTICLE

Anomalous 'Retrocausal' Effects on Performance in a Go/NoGo Task

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Submitted 3/6/2014, Accepted 8/1/2014, Published 9/30/2014

Abstract—Retroactive effects were investigated in the context of a Go/NoGo task. Performance differences between rational and intuitive thinkers also were investigated. Participants were presented with a shape and instructed to either respond or not respond, depending on the shape. In the first Go/NoGo task, the subject had to respond to two shapes that were randomly chosen out of four shapes. In the second Go/NoGo task, participants only had to respond to one shape. This shape was randomly chosen from the two that were used as Go-signals in the first Go/NoGo task. In accordance with the growing literature on retroactive influences on cognition and emotions, where future events seem to have an anomalous, retroactive influence on responses and behavior in the present, we predicted that the second Go/NoGo task would have a practice effect on performance during the first task. We also predicted that this effect would be stronger for subjects classified as "intuitive thinkers" based on the Human Information Processing questionnaire. These predictions were confirmed. During the first Go/NoGo task, the subjects responded ~2% faster to the (target) shape—which they also had to react to during the second task—than to the (control) shape they only had to respond to during the first task ($t = 2.59$, $df = 66$, $p = 0.024$). Subjects with an intuitive thinking style were totally responsible for the whole effect ("intuitive" thinkers alone: $t = 3.41$, $df = 34$, $p < 0.001$). Explorations of the HIP-questionnaire subscales suggest that the relation between anomalous performance and Human Information Processing style is mostly caused by a factor we label as "rigidity." We also discuss how "Questionable Research Practices" could have contributed to the current results.

Introduction

Retroactive Influences

Recently, there have been multiple studies on retroactive influences on cognition, where future events seem to have an anomalous, retroactive influence on responses made in the present (Bem 2011). One example of this that has received quite some attention in the last decades is presentiment:

Multiple studies have shown that certain measures of arousal (galvanic skin response, heart rate, etc.) can show an increase a short time before the actual onset of a random arousing stimulus (e.g., Bierman & Radin 1997, Bierman & Scholte 2002, Mossbridge, Tressoldi, & Utts 2012). Such results suggest that information concerning a stimulus can actually go back in time (from milliseconds to seconds), although it might be more precise to say that the present apparently is dependent on the past and, to a much smaller degree, on unknown future conditions. Another example of this same phenomenon is retroactive priming, where primes shown after the target stimulus have an effect on the response latency for that stimulus (e.g., de Boer & Bierman 2006, Bem 2011).

A further example of this phenomenon that shows said anomalous retroactive effects even earlier (multiple minutes back in time) is retroactive practice or learning (e.g., Franklin & Schooler 2011a, 2011b). Simply put, it is conventional practice turned around. Studying for an exam is a good example: Normally, studying before an exam influences one's performance during that subsequent exam. According to the theory of retroactive influences, it would theoretically be possible to influence one's performance on an exam by studying for it after it has taken place.

Some of the above-mentioned studies will now be described in more detail. Bem (2011) did a study, consisting of nine separate experiments, on precognition and premonition, with two examples of a more general phenomenon: the retroactive, anomalous influence of a future event on a person's current responses. All but one of these experiments yielded significant results, supporting these retroactive effects. One of these experiments, for example, was a reversed priming experiment: Participants judged pictures as being either pleasant or unpleasant. After being shown a picture, instead of before as in a regular priming experiment, a congruent or incongruent word would quickly be shown. Participants responded significantly faster in congruent trials than in incongruent trials.

It should be mentioned that this study has attracted strong criticism. A good example of such criticism is from Wagenmakers, Wetzels, Borsboom, and van der Maas (2011), who call upon Bayesian statistics in an attempt to weaken Bem's results. The points they and others have raised are either incorrect or applicable to statistics in experimental psychology in general. An issue that has hardly been raised in the discussion of Bem's and similar anomalous results is whether the use of Questionable Research Practices can account for these results. A number of meta-analytic results in the field of experimental parapsychology show consistent and significant effects (often larger than 6-sigma). Small effects induced by questionable research practices in individual studies, however, can of course build up to large meta-analytic effects. Recent simulations of so-called Ganzfeld telepathy experiments show that about 40% of the reported meta-analytic effect-size can be accounted for by these practices (Bierman & Bijl 2014, in preparation).

In studies such as those mentioned above, where anomalous retroactive influences are tested, it is essential that the future condition that is supposed to "influence the past" is chosen randomly. If that condition is not met, then normal inferential processes about the future might have caused the current performance in the present. In studies such as those mentioned above (and in the current experiment as well), the selection of the future condition is generally based upon the outcome of an electronic or software-based random number generator. Franklin & Schooler (2011a, 2011b), however, conducted multiple experiments (yet to be published) where they used the above-mentioned retroactive practice effect to predict real world events (in this case, the spin of a roulette wheel). To do this, they used a setup similar to the one used in the current experiment: During two subsequent Go/NoGo tasks, subjects were asked to respond to a stimulus that appeared on the screen. During the first Go/NoGo task, subjects pressed a button for two shapes (the Go-shapes) randomly selected from four. For the two other (NoGo) shapes, subjects had to withhold a response. During the second Go/NoGo task, subjects only had to react to one of these two Go-shapes from the first task. This shape is also referred to as the target-shape. The choice of target-shape was determined by the spin of a roulette wheel.

If their response during the first task was quicker for Go-shape A than for Go-shape B, the experimenters assumed that shape A would be the one chosen by the random decision of the roulette wheel (to be used again as the target-shape during the second Go/NoGo task). In this manner, they were able to infer the future outcome of the roulette wheel just by looking at the results during the first Go/NoGo task. Their results were a bit less straightforward than a superior performance during the first task for the shape exercised during the second task. During the final experiment, they achieved a success rate of 57% ($N = 111$, $p = 0.062$) in predicting these roulette outcomes.

The Consciousness Induced Restoration of Time Symmetry model (CIRTS) (Bierman 2010) is based upon the fact that time-symmetry is intrinsic in almost all formalisms of theoretical physics. Apparently, this symmetry has been broken for most physical systems. It is assumed that under specific information processing conditions, this symmetry is partly restored. In that case, one would expect correlations that appear to be retrocausal. The particular context that restores symmetry is that information is processed by a multi-particle system like our brains. This also introduces the single parameter that can account for individual differences, namely the coherence of the brain. It is argued that intuitive participants have a more global and spontaneous type of information-processing than more rational (serial-thinking) participants, and therefore CIRTS would predict a larger retrocausal effect for "intuitive" participants.

The current study was designed to replicate the anomalous retroactive practice effects reported by Franklin & Schooler (2011a, 2011b).[1]

Research Question

We investigated whether future practice can affect performance in the present. We compared this effect for intuitive and rational thinkers, expecting the effect to be larger for the former.

Hypotheses

We used the same design as the Go/NoGo experiment by Franklin and Schooler described above, with the exception that we didn't use a roulette wheel as a randomizing device, but rather the built-in random function of "Visual Basic." This study must therefore be treated as a confirmatory experiment.

- Hypothesis I: The second Go/NoGo task will have a training effect on performance in terms of response times during the first Go/NoGo task. More specifically, assuming the two Go-shapes in the first task are "A" and "B," and assuming that the Go-shape in the second task is "A" (aka the target-shape), we predict that subjects will respond faster to A than to B during the first task (and vice-versa for subjects who have to respond to target-shape B in the second task).

- Hypothesis II: Subjects with an intuitive thinking style will show a larger retrocausal effect than subjects with a rational thinking style.

Method

Subjects

In total, 69 people (35 female; 34 male) with a mean age of 20.8 (ranging from 18 to 64, with a standard deviation of 8.3) completed the experiment. The number of participants chosen was based on a power analysis based on the effect size found in Franklin and Schooler's (2011a, 2011b) experiments. This power analysis resulted in 64 participants. We ended up testing five more for reasons that had to do with the way subjects were selected in a school environment (so no optional stopping was used). The subject pool consisted of some first-year psychology students participating for credit as a mandatory part of the curriculum at the University of Amsterdam, and, for the most part, students from a local high school in Alkmaar who were in their last year before entering university. This was because of the low availability of participants at the university.

Procedure and Materials

The study was approved under number 2011-BC-2019 by the Faculty Ethics Review Board. After arriving at the test room, participants were asked to read an informational brochure informing them about the nature of the experiment. Before taking part in the experiment, each participant provided written consent.

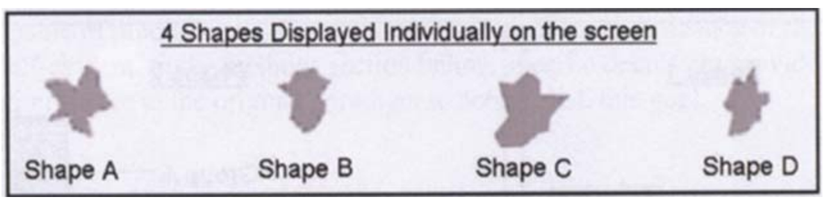

Figure 1. The four shapes used in the Go/NoGo tasks.

They were then introduced to the tasks and the shapes that were used during the two Go/NoGo tasks (see the shapes in Figure 1), and informed that they were free to quit the experiment at any time. The experiment consisted of three phases.

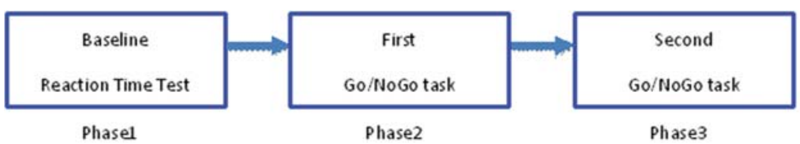

Figure 2. Flow chart of the experiment's several phases.

In the first phase, preceding the two Go/NoGo tasks (phase 2 and phase 3), subjects performed an initial baseline reaction time task (see Figure 2). They were asked to respond to an "X" appearing center-screen on a computer at random intervals, ranging from 1,000 to 3,000 milliseconds during 20 trials, by pressing the "Enter" button on the keyboard. The mean baseline reaction time measured in this way for each participant was later used to "normalize" the experimental response times, thereby reducing the inherent inter-subject variability due purely to differences in physiologically driven motor responses.

After this, subjects were given the first Go/NoGo task (phase 2), with the instruction to simply do the best they could. The task was made up as follows (see Figure 2): Participants were, in each of the 64 trials, randomly shown one of four predetermined shapes on a computer screen at random inter-stimulus intervals uniformly distributed from 1,500 to 3,500 milliseconds. The screen size of the shape was 3.5 cm × 3.5 cm on a 30.8 cm × 23-cm computer screen with a resolution of 1024 × 768 pixels.

Participants were asked to press the Enter button if a Go shape appeared on the screen. In the first Go/NoGo task, there were two Go shapes. For instance, the participants were asked to respond when either shape A or shape B appeared on the screen, and to not respond to the two others (shapes C and D). Note that for each participant, the assignment of which shapes to respond to was random. This was important in order to avoid effects caused by intrinsic recognition of the shapes. After the first Go/NoGo task, they entered a second Go/NoGo task. In this task, participants had to respond to only one of the four shapes. The shape they had to respond to during the second Go/NoGo task was randomly chosen from the two they had to respond to during the first (i.e. in this example shape A *or* B).

The shape subjects had to respond to during *both* Go/NoGo tasks will be referred to as the "target-shape" for that specific participant. The shape to which the participants only had to respond to during the first Go/NoGo task, and therefore didn't get further training on in the second Go/NoGo task, will be referred to as the "control-shape."

The program used during the experiment was written with Visual Basic programming language using Real Studio 2011, version 4.3. It can be downloaded from: https://www.dropbox.com/s/akv3k5p2ihwidlv/GNG.rb

Finally, using the HIP-questionnaire (Human Information Processing) (Taggart & Valenzi 1990), subjects' tendency toward rational or intuitive reasoning was assessed. This was done after the actual Go/NoGo tasks to avoid the effect of this questionnaire (and the resulting reflection on one's thinking style) on subjects' natural style and their resulting performance. Subjects were given statements concerning their thinking style. They rated how much the statement applies to them, from "always" to "never" on a 6-point Likert-scale. An example of such a statement is, "When solving problems I prefer to use proven methods over trusting my first intuitive impressions."

Dependent Variables

The dependent variables that we used in the analyses have been operationalized as follows.

"Normalized" Response Times

From the data of the initial simple reaction time task, mean "baseline" reaction times were calculated for each subject. In addition, mean reaction times were calculated for each Go shape during the two Go/NoGo tasks per subject (two during the first task and one during the second task). We normalized these reaction times by dividing a participants' reaction time on a shape by their mean baseline reaction time measurement. In order to remove individual differences caused purely by differences in physiological motor responses, we divided the raw response times by the mean response time of each individual on the simple motor reaction (baseline) task. This, of course, is different from normalization by converting individual scores to z-scores. In the latter procedure, individual differences pertaining to the increased complexity of the Go/NoGo task compared with a simple task also are removed. We wanted to keep that particular aspect of the individual differences in our equations. Error rates were also calculated per task per subject. Averaged normalized response times were calculated using only the correct responses.

Intuition Score and Categorization

For the HIP scores, the three scores related to a rational thinking style were added per subject. The same was done for the three scores related to an intuitive style, resulting in two scores for each subject: one signifying the amount of rational thinking (R = rational score), and one the amount of intuitive thinking (I = intuitive score). The intuitive scores were subsequently divided by the rational scores, resulting in a thinking style-score "IR," which varyied between 1.5 and 0.7; the first indicating a very intuitive thinking style, the latter a very rational one. Subjects were categorized as "intuitive" if their IR was larger than the median, and as "rational" if their IR was smaller.

Results

Subjects and Data

The data of one subject had to be disregarded because the number of errors was so large that it was clear the subject hadn't understood the instructions. For one subject, there was data-loss caused by computer failure. The analyses, therefore, were performed for the remaining 67 subjects.

Hypothesis I: Retrocausal Training Effect

To test our prediction that the second Go/NoGo task (phase 3) would have

TABLE 1

Baseline Reaction Times in msec and Normalized Reaction Times on Target and Control Shapes for Rational and Intuitive Thinkers for the First Go/NoGo Task

	Baseline (msec)			Target-shape			Control-shape			Diff (t)
Group	Mean RT	N	Std. Dev.	Mean Normalized	N	Std. Dev.	Mean Normalized	N	Std. Dev.	
Intuitive thinkers	354.46	35	31.98	1.73	35	0.23	1.80	35	0.25	3.4 **
Rational thinkers	353.35	32	29.25	1.79	32	0.2	1.79	32	0.22	0.3 (ns)
Totals	**353.9**	**67**	**30.48**	**1.75**	**67**	**0.21**	**1.795**	**67**	**0.23**	**2.59***

* = p < 0.02, ** = p < 0.01.

a training effect on performance during the first Go/NoGo task (phase 2), the reaction times to both Go-shapes during the first Go/NoGo task (the target-shape and control-shape) were compared with each other to inspect whether the future Go/NoGo task in phase 3 had a retroactive practice effect on the first task. The normalized reaction times were always larger than one because the normalization factor was obtained in a simpler reaction time task in phase 1 of the experiment. A paired samples t-test was performed comparing the normalized reaction times of the control-shape and target-shape during the first Go/NoGo task. Reaction times to the target-shape proved significantly lower than reaction times to the control-shape (t = 2.59, df = 66, p = .012 one-tailed, Cohen's effect size d = 0.22), suggesting a retroactive practice effect of the second Go/NoGo task on the first (see Table 1). Data are available at: https://www.dropbox.com/s/j44lvj0c561o5in/Main%20datafile.sav (SPSS datafile).

Hypothesis II: Individual Differences

To test whether this effect was more pronounced for subjects with an intuitive thinking style, we performed a one-way ANOVA with thinking style as a between-subject factor, comparing the difference in normalized reaction times between the target-shape and control-shape during the first Go/NoGo task for rational and intuitive thinkers. A main effect for thinking style was found ($F_{(1, 66}$ = 4,477, p = 0.038). We also repeated the paired samples t-tests comparing normalized response time for target-shape and control-shape for intuitive and rational thinkers separately. Only the intuitive group showed a significant difference in the expected direction (t = 3.41, df = 34, p = 0.001, one-tailed, Cohen's effect size d = 0.40). When the same paired samples t-tests were performed using the raw reaction times (instead of the "normalized" responses), the same pattern emerged. Only the intuitive group showed a significant difference (t = 3.43, df = 34, p = 0.002).

Exploration of the HIP

The Human Information Processing questionnaire has 30 items, resulting in 6 subscales, called rat1, rat2, rat3, int1, int2, and int3. The authors of the HIP labeled these subscales "Logic," "Planning," and "Rituals" for rat1, rat2, and rat3, respectively, and "Insight," "Vision," and "Sensing" for int1, int2, and int3, respectively.

The formal test of our hypothesis (that intuitive subjects would show the anomalous training effect more than rational subjects) was tested using the compound measure IR = (int1 + int2 + int3)/(rat1 + rat2 + rat3). The IR scores were normally distributed (Kolmogorov-Smirnov: 0.073, df = 67, p = 0.20). The correlation between psi effect and global intuition score (IR) was a marginal R = 0.20 (p < 0.052, one-tailed).

In this section, we explore which of the subscales that go into IR contributed most to this effect. First, we performed regular and partial correlational analyses using each subscale separately while controlling for all others to predict the performance of the subjects. The correlation data are given in Table 2.

The rat3 component "Rituals" correlates most strongly with the psi score (R = −0.36, N = 67, p = 0.002). In spite of the label "rituals," the subjects scoring high on this attribute do not engage in spiritual traditions, but rather stick to rules and procedures. It could be argued that "rituals" here implies a lack of spontaneity and creativity. We prefer to label this scale "rigidity."

It can further be observed from Table 2 that some of the subscales show strong correlations among themselves. Therefore, we also calculated partial correlations where we controlled for all the remaining subscales. The partial correlation of psi score and "rigidity" happens to be near-identical to the regular correlation (Rpartial (rat2, psi) = −0.37, N = 67. P = 0.003). The other rational subscores also had a negative partial correlation with the psi scores, though not as strong as rat3. (R (rat1, psi) = −0.23; R (rat2, psi) = −0.16)

TABLE 2

Regular and Partial Correlations between Psi Performance and Subscales of the HIP, Controlled for All Other Subscales, and Regular Correlations between the Subscales Themselves

	Psi score[1]		Rat1	Rat2	Rat3	Int1	Int2	Int3
	Regular	Partial	Regular	Regular	Regular	Regular	Regular	Regular
Rat1: Logic	−0.17	−0.23*	1					
Rat2: Planning	− 0.02	−0.16	+ 0.37**	1				
Rat3: Rituals	− 0.36**	− 0.37 **	+ 0.05	− 0.33 *	1			
Int1: Insight	− 0.01	−0.02	- 0.33**	− 0.38 **	− 0.11	1		
Int2: Vision	− 0.13	−0.20	− 0.42**	− 0.46**	+ 0.13	+ 0.47**	1	
Int3: Sensing	+ 0.12	+0.15	+ 0.1	+ 0.25	+ 0.06	− 0.38**	− 0.01	1

[1] Psi score = Normalized reaction time control-shape − normalized reaction time target-shape.
* p < 0.05, ** p < 0.01.

From the partial correlations of the int-scales with psi performance, only int2 (vision) was marginally significant (Rpartial (int2, psi) = −0.2, p < 0.06), but surprisingly this was in the negative direction. The int2 factor is labeled "vision," and most items seem to measure some aspect of creativity. As we mentioned before, the rat3-subscale, which we re-labeled "rigidity," can be interpreted as representing a lack of creativity. However, there is a minor positive correlation between rat3 and int2 (R (int2, rat3) = 0.13, n.s.). This is what we would expect for two subscales, both correlating in the same direction with psi performance. However, one subscale, rat3, measures "rigidity," and the other, int2, measures "aspects of creativity." One would expect these to have a negative correlation. It is unclear why both subscales that appear to measure opposing personality aspects both correlate in the same direction with psi performance. It should be remarked that neither of the int scales have a significant contribution to psi performance, so we shouldn't take the apparent paradox too seriously. Basically, the only aspect that really counts is "'lack of rigidity," rather than the amount of intuitive processing, as it is measured by the int-subscales. This cautious conclusion fits with findings in the literature that psi performance correlates positively with the "openness factor" in the Neo Personality Inventory (Zingrone, Alvarado, & Dalton 1999). If we forget about the int subscales and use only

TABLE 3

Frequencies of the Different Shapes with Mean Normalized Response Times

Go Shape	Mean Response Time as Target	Mean Response Time as Control	Mean Response Time	Frequency as Target	Frequency as Control
1	1,778	1,786	1,783	16	22
2	1,772	1,883	1,834	15	19
3	1,756	1,712	1,736	19	15
4	1,765	1,814	1,785	18	12
Total	1,767	1,802	1,785	68	68

the ratio scales, the correlation of psi performance with Rat = rat1 + rat2 + rat3 is −0. 32, (N = 67, p = 0.004 one-tailed).

Alternative Explanations for the "Retrocausal" Effect

As stated in the Introduction, in experiments of this kind, where a future condition is claimed to have a "retrocausal" influence on present behavior, it is mandatory to ensure these future conditions are properly randomized with replacement so that it is impossible to infer the future condition. For instance, in so-called presentiment research, the claim is that the actual physiological behavior of a participant is dependent on a future (randomly selected neutral or emotional) stimulus. However, in the current experiment, the relevant future condition (what shape will be the target-shape) is only determined once. Even if the randomization is weak, the participant isn't able to infer anything that could be used in the next trial.

However, the alternative explanation of conscious or non-conscious learning of the randomization is replaced in the current experiment by another potential explanation. Actually, this explanation occurs because the choice of target-shape from the possible four shapes is random and not counterbalanced. This may result in an over- or under-representation of a specific target-shape in the whole experiment. If and only if the participants have biases in response times for specific target-shapes (for instance, if it is intrinsically easier to respond to a specific shape, and that shape is over-represented as a target), we can expect that overall, participants will show faster response times for the target-shapes. In Table 3, the mean response times for the different shapes are given in the relevant column.

To check whether the four shapes used in the Go/NoGo tasks were actually equally difficult to remember and respond to, a one-way ANOVA comparing the different shapes was performed with these normalized reaction times. There were no significant differences in response times for each of the four shapes (when the shape was the target, $F_{3,66} = 0.28$, $p = 0.99$), nor when the shapes were the controls ($F_{3,66} = 1.512$, $p = 0.22$).

Of greater importance for this potential alternative explanation is checking if the frequency distribution for the Go shapes significantly deviates from a random distribution. This does not appear to be the case: chi-square = 0.588, df = 3, n.s. for the target-shape frequency distribution, and chi-2 = 3.41, df = 3, n.s. for the distribution of control-shapes.

To assess whether the actual non-significant deviations from the perfect distribution could have produced an artificial differential response time effect between target-shapes and control-shapes, we ran a simulated t-test for each subject using the shapes that were actually used in his/her experiment, while using the subject's average response times for those shapes.

This simulation resulted in a small artificial effect; the mean normalized target-shape response time was 1.782 and the mean normalized control-shape response time was 1.785 ($t = 1.07$, $df = 66$, $p = 0.22$, one-tailed). The difference was only 0.005, while in the actual experiment, the differential effect was about 10 times larger. These results show that the artificial effect, due to deviations in the frequency distribution of shapes and their respective mean normalized response times, is able to explain only 0.15% of the total 2% effect. The fact that the difference in reaction times between the control- and target-shapes was only found for intuitive thinkers further renders this alternative explanation, based upon different difficulties and different frequencies, unlikely.

Discussion

The prediction that the second Go/NoGo task (phase 3 of the experiment) would have a training effect on performance during the first Go/NoGo task (phase 2), and that this effect would be more pronounced for subjects with an intuitive thinking style, was supported by the results. During the first Go/NoGo task, intuitive subjects reacted significantly faster to the target-shape than to the control-shape. The only difference between the target- and control-shape was that the target-shape would be trained in the future (second Go/NoGo task), while the control-shape wouldn't. Rational subjects did not show this difference at all. This suggests that for subjects with an intuitive thinking style, the second Go/NoGo task had a retroactive practice effect on their performance during the first Go/NoGo task. When this difference was compared for the entire subject pool, it was still significant, with an effect size *d* of 0.25, which is comparable to what Franklin & Schooler (2011a, 2011b) found in their experiments. Potential alternative (normal) explanations for this anomalous finding were excluded. However, given the impact that has been reported of Questionable Research Practices on psychological research findings, we will discuss this issue separately. The potential role of Questionable Research Practices has been simulated for the meta-analytic database of Ganzfeld-telepathy experiments, and from those simulations a conclusion was reached that these practices, if they indeed are used, might be able to account for at least a fraction of the anomalous results (Bierman & Bijl, in preparation).

Questionable Research Practices and Pre-Registration

The current experiment was described in detail before starting the experiment. This proposal was submitted in part to the ethics committee to obtain permission and, in full, to an independent staff member who had the obligation to check if the final product (report and presentation) corresponded with the plan. This can be seen as equivalent to a formal pre-registration. Practically, it is intended to prevent post hoc selections without explicitly mentioning that such is an exploration. For instance, in the current experiment, we did not plan to do an analysis on the HIP-subscores, and this was reported in the section "explorations."

We asked an independent researcher, who is responsible for checking pre-registrations at the KPU-registry (http://www.koestler-parapsychology.psy.ed.ac.uk/TrialRegistry.html), to compare our research plan with the current intended publication as if it were a pre-registration, assuming we did adhere to the original plan. He pointed out that the original research plan did not explicitly state that the main hypothesis (retroactive training) was a confirmatory hypothesis. That could have given us a post hoc option to declare the study as exploratory, which would have given us the freedom to try out several different analyses of the main hypothesis. More importantly, the normalization procedure of reaction times was not specified. It is obvious that such an omission leaves the door open for various data transformations and adjustments, such as outlier corrections. The compound variable that determines the processing style of the participants from the sub-scores of the HIP was also not specified. He concluded that there still were too many ambiguities that offered degrees of freedom that could have been exploited post hoc. Although we didn't actually use this freedom, the current results should be taken in light of these shortcomings. The normalization procedure we eventually used is logical in terms of having scores that are around 1. We therefore concluded that pre-registration is a good practice only when followed up by an independent comparison of the pre-registration with the final publication. Pre-registration with a public, openly accessible registry is already standard practice in medical and pharmaceutical research. It should be mentioned that in the 1980s the *European Journal of Parapsychology* required researchers to pre-register their experiments and the acceptance of a publication was solely dependent on the quality of the pre-registration, and not on the results. On the other hand, some of the more prolific researchers in parapsychology, and perhaps psychology in general, were for some time opposed to preregistration, claiming it would prevent "discovery." All pre-registration does, however, is prevent post hoc exploration of data from being presented as planned analyses. As several authors on pre-registration stress, it is very important in this respect to make a clear distinction between exploratory and confirmatory research (KPU 2014, and forum discussions on OpenScienceFramework.com), and there is nothing against the exploration of data obtained in a pre-registered experiment.

Subscales of the HIP

Looking at the exploratory results of the analysis of the HIP-questionnaire subscales, psi performance would appear to correlate negatively with rational thinking. The expected positive correlation with intuitive thinking could not be confirmed. These exploratory results seem to suggest that a too-rigid method of information processing hampers the psi effect significantly, while an intuitive method has a much smaller positive effect. Further research is needed to unravel the relation between intuition and psi performance. These rather confusing results with regard to HIP subscales should be considered in light of more recent work on thinking styles. The REI (Rational–Experiential Inventory) (Pacini & Epstein 1999), for instance, which in some sense attempts to measure the same rational-versus-intuitive processing styles differences, shows correlations with some of the Big Five factors. On one hand, the rational component correlates with "Openness." "Openness" has been shown in other psi research to correlate with higher psi scores (Zingrone, Alvarado, & Dalton 1999). On the other hand, an experiential thinking style was correlated with the Big Five factor "Extraversion." Extraversion has also been shown in psi research to correlate positively with psi performance (Eysenck 1967). With such complicated results, it appears that we must fundamentally rethink the relation between psi and personality. In light of the theoretical background of the current experiment, it would have been preferable to directly measure the brain-processes that could be seen as an operationalization of "coherence" in the

CIRTS model, rather than linking the yet ill-defined concept of "coherence" with an intuitive processing style, as measured by the HIP.

Conclusion

The results of the present experiment are consistent with other experimental data suggesting the presence of anomalous correlations between present behavior and future random conditions. Interestingly, there is a growing attention in fundamental physics to "retro-causality," often expressed in the form that the present is basically a "handshake" between present and future conditions (where the contribution of future conditions in most contexts are negligible) (Aharonov, Cohen, Grossman, & Elitzur 2013). Although rather rudimentary efforts have been published to integrate these findings in a psychological and physical model, it is clear that more breakthroughs in both physics and psychology are needed before we can begin to truly test and comprehend the workings behind these anomalous findings.

Acknowledgements

We thank Jim Kennedy for comparing the original research plan with the final article in order to check for potential differences that could indicate Questionable Research Practices.

Notes

[1] This study was a part of a master's thesis by the second author (see Bijl 2012), where the effect of speed-vs.-accuracy instructions on a Go/NoGo task performance for participants with a rational or intuitive thinking style were investigated.

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