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BIS/BAS individual differences and the verification of conditional hypotheses

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ABSTRACT

Two experiments were carried out to examine if the tendency either to verify or to falsify conditional hypotheses has roots in BIS/BAS individual differences (Carver & White, 1994). Experiment 1 presented the participants with a game version of the Wason selection task (Wason, 1966). The hypothesis to be tested was a rule: "Whenever a card has a (certain) letter on one side it has "gain (an amount of) euros" on the other". Participants were told that the task-goal was to test if this rule was false. Letters could be accompanied either by a gain or by a loss. Of the four cards displayed, one represented a gain and another a loss. The value of gains and losses was manipulated: one card with a large gain and the other with a small loss (one task version), and vice-versa (the other version). Experiment 2 tested the hypothesis that falsification in this task is related to individual differences in BIS sensitivity, while verification is related to individual differences in BAS sensitivity. The results support this hypothesis in the light of the reinforcement sensitivity theory (Gray & McNaughton, 2000).

1. Introduction

One idea that has re-emerged in the past two decades is that behaviour is built on two distinct kinds of action tendencies: approach and avoidance (Miller & Dollard, 1941) or motives: appetitive and aversive. The rationale is that these two types of motives are the fundamental building blocks that underlie the complexity of human behaviour.

This proposal has had an important impact on personality research, mainly due to the work of Gray (1981). Gray postulates two dimensions of personality: anxiety and impulsivity. These two qualities of personality represent individual differences in the sensitivity of two neurological systems in response to relevant cues. The behavioural inhibition system (BIS), the aversive motivational system, controls the experience of anxiety in response to anxiety-relevant cues. It is sensitive to signals of punishment, non-reward and novelty and inhibits behaviour that may lead to negative outcomes. Thus, BIS activation causes inhibition of movement towards goals. BIS is responsible for the experience of negative feelings such as fear, anxiety, frustration and sadness in response to these cues.

The physiological mechanism that controls appetitive motivation is the BAS: behavioural approach system. This system is said to be sensitive to signals for reward (or non-punishment) and escape from punishment. Activity in this system causes the person to begin (or to increase) movement towards goals. BAS is responsible for the experience of positive feelings such as hope, elation and happiness. Greater BAS sensitivity should be reflected in proneness to engage in goal-directed efforts.

More recently, this proposal, now known as reinforcement sensitivity theory (henceforth, RST) has been revised (Gray & McNaughton, 2000). Particularly, relevant to our research focus in the revised version is that fear and anxiety are distinguished as caused by different systems: fear by the fight-flight-freeze system (FFFS, responsible for avoidance), and anxiety by BIS. Moreover, the revised RST attributes a central role to tendency conflicts (Corr, 2004). The BIS is activated only when there is a simultaneous activation of the BAS; that is, when there are conflicting and concurrent goals as approaching a reward vs. avoiding a punishment. The theory establishes that changes in the values of punishment and reward in conflict inputs to the BIS will affect the degree of BIS activation. Activation of BIS has the aim of assessing potential risks in order to resolve the goal conflict.

The BIS/BAS have been examined in several psychological domains: self-regulation, interpersonal relationships, group processes, psychopathology and motivation, as can be seen in the monograph of *Motivation and Emotion* (2006), *30*. The usefulness of the BIS/BAS as organizing themes for theory development has yet to be fully realized (Carver, 2006).

The aim of this paper is to examine the role of BIS/BAS in reasoning, a domain not previously examined in this light. More specifically, to check whether the tendency to select either evidence that verifies or falsifies hypothetical conditionals (referring to the consequences of taking actions) has its roots in BIS/BAS. This type of conditional is generally posed as "If you do this you attain that" and is involved in different forms of exchange such as advice, promises, offers or contracts. Verification and falsification are

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central phenomena for hypothesis-testing research. Verification has been shown to be a general bias: people tend to look for evidence that verifies a previous hypothesis (see Nickerson, 1998). However, falsification is preferred if the (hypothetical) conditional *action → result* refers to social contracts (Cosmides, 1989). Moreover, people are motivated to reject (and to falsify) threatening propositions (Dawson, Gilovich, & Regan, 2002).

How could BIS/BAS affect reasoning in the ambit of searching for evidence to test hypothetical conditionals? One possible way is by biasing individuals towards selecting either evidence for falsifying or verifying *action → result* conditionals. Take the example of advice; someone tells you that by investing in the shares of company C, you gain money. This comment constitutes a hypothetical *action → result* conditional (*If someone invests in the shares of company C then he/she gains money*) and it could be in your interest to find evidence to check this hypothesis. As aforementioned, the BAS is sensitive to signals for reward, and so causes approach towards behaviour that may lead to rewarding outcomes. There could be signals of a reward following the action of investing. For example, you are informed that the company is trustworthy in a growing economic sector. In that case, BAS leads you to attempt to check the sequence *action → reward*. That is, to verify the *action → result* conditional by being sensitive to (or actively looking for) evidence of: (a) Persons who have invested in shares of company C (Have they gained money?); and (b) persons who have gained money (Have they invested in company C?).

Conversely, the BIS is sensitive to signals of punishment (or non-reward), and so causes inhibition towards behaviour that may lead to negative outcomes. There could be signals of punishment following the action of investing; for example, you are informed that the company is untrustworthy. In this case, BIS leads you to try to check the sequence *action → punishment*. That is, to falsify the *action → result* conditional by being sensitive to evidence of: (a) Persons who have invested in shares of company C (Have they lost money?); and (b) Persons who have lost money (Have they invested in shares of company C?).

The bias towards verification (in contrast to the greater difficulty of falsification) has received several explanations. From a cognitive perspective, Evans (1989) attributed this to the facility to represent positive instances of a certain proposition in contrast to the alternative negative ones. From a motivational perspective, Dawson et al. (2002) made the proposal that people tend to accept (and so to verify) agreeable or neutral propositions, while they are motivated to reject (and so to falsify) disagreeable and threatening propositions. From the BIS/BAS perspective, the occurrence of verification versus falsification depends on the reward and punishment involved in accepting the proposition. As previously shown, the conditional proposition: *If someone invests in the shares of company C then he/she gains money* would be verified if the probability (and value) of the reward ("gaining money") is high. In contrast, it would be falsified if what is high is the alternative punishment ("losing money"). In contrast to the motivational and cognitive approaches, neither the agreeability of the proposition nor the cognitive scenario has changed when verification or falsification occur.

The Wason selection task (Wason, 1966) is a useful tool in research of the cognitive processes involved in verifying/falsifying conditional rules or hypotheses by checking partial evidence either in epistemic (Evans, 1998) or social contexts (Cosmides, 1989).

The original task is a paper-and-pencil problem that invites subjects to check whether a hypothetical conditional rule of the type "if p then q" is true or false as follows (see Fig. 1).

The usual selection, about 45% of the time, is that of cards "A" (the "p" card) and "4" (the "q" card), which is a confirmatory selection (see Nickerson, 1998). The falsifying selection of turning over

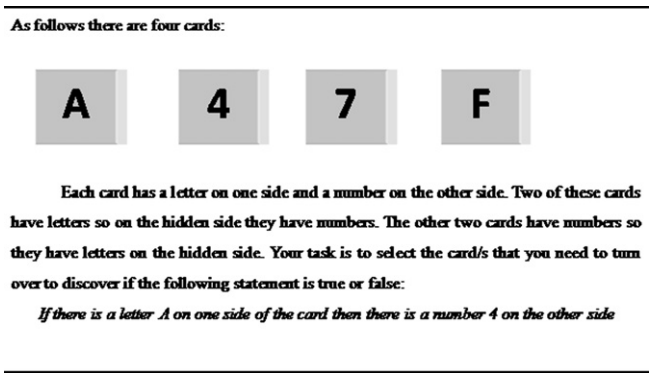

Fig. 1. The original Wason selection task.

card "A" (the "p" card: to see if it has a seven on the other side) and card "seven" (the "not-q" card: to see if it has an A on the other side) is infrequent (less than 10%).

It has been demonstrated that verification and falsification strategies in this task are induced by the type of content, the task context and instructions (see Evans, 1998). However, as far as we know, the role of BIS/BAS has not been examined.

Here we adapt the Wason selection task and directly focus on examining the role of BIS/BAS in orientating individuals towards either the falsification or verification of contextual and hypothetical *action → result* conditionals.

2. Study 1

We presented the participants with a game version of the Selection task elaborated by the authors. The hypothesis to be checked was a rule: "Whenever a card has a (certain) letter on one side it has "gain (an amount of) euros" on the other". Letters could be accompanied either by a gain or by a loss. Of the four cards displayed, one represented a gain and the other a loss. The value of gains and losses was manipulated: one card with a large gain and the other with a small loss in one task version, and vice-versa, one card with a small gain and the other with a large loss, in the other version. Participants were told that the task-goal was to check in a free-cost test whether the rule was false in order to avoid the loss (see Appendix A).

As aforementioned, the revised RST attributes a central role to tendency conflicts. Here there is a conflict between attaining a reward (the gain) and avoiding a punishment (the loss). According to Corr (2002), the conflict between the reward and punishment is resolved by the decision mechanism depending on which input to this mechanism is stronger. Therefore, activation of BAS would predominate when a great reward is involved. Conversely, activation of BIS would predominate if a great punishment (in contrast to a small reward) is involved. Therefore, our predictions were that participants will tend to verify the conditional rule in the condition "large gain/ small loss" and solve the task by concluding that the rule is false if it is not true. In this task version, BAS would lead subjects to check the sequence *action → reward* (the large gain), that is, to check if the letter A is followed by the gain and the gain card is preceded by the letter A. In contrast, we predict that subjects will tend to falsify the rule in the condition "small gain/large loss" and solve the task by directly considering if the rule is false. In this version, BIS leads subjects to check the sequence *action → punishment* (the large loss), that is, to check if the letter A is followed by the loss and the loss card is preceded by the letter A.

2.1. Method

2.1.1. Participants

One hundred twenty-seven students from the University of La Laguna participated in this experiment in exchange for course credit. Their ages ranged from 18 to 27. Thirty-seven were male.

2.1.2. Design and procedure

The design had one between-subject factor, the gain/loss value displayed in the cards with two conditions: Large gain/small loss and small gain/large loss. Two dependent variables were used. One was "Loss card selection", the result of adding the following selections: letter A and the loss card, letter Y and the loss card, and the loss card alone. The other was "Gain card selection", the result of adding the selections: letter A and the gain card, letter Y and the gain card, and the gain card alone.

Seventy subjects were assigned to the "small gain/large loss" and 57 subjects to the "large gain/small loss" conditions. The two task versions were randomly given out to the students during regular class without a time limit in a quiet environment. The proportion of male participants was similar in the conditions.

2.2. Results

As expected, participants selected the gain card (49%) more than the loss card (26%) significantly in the condition large gain/small loss, χ^2 (1) = 6.32, $p < .05$. In contrast, the gain and loss cards were equally selected in the condition small gain/large loss (42%).

If we consider the gain card selection, there was no significant effect between the large gain/small loss (49%) and the small gain/large loss (42%) conditions, χ^2 (1) = 0.63, $p > .20$. In the case of the loss card selection, participants selected the loss card more in the condition small gain/large loss (42%) than in the condition large gain/small loss (26%), in a marginally significant way, χ^2 (1) = 3.39, $p < .10$.

It was relevant that participants who selected the "gain card" tended to justify their decision as aimed either at confirming or not the rule; for example: "I selected the cards A and 100 € gain because on the other side of the card A you can find either 100 € gain or 1 € loss. Likewise, on the other side of the card 100 € gain you can find the letter A or another letter." In contrast, participants who selected the loss card tended to justify their decision as aimed at directly falsifying the rule; for example... "I selected card A because I have to know if on the other side of this card there is a 100 € loss, and card 100 € loss because if the letter A is on the other side, I will not play, I'll pass."

These results give some support to our main predictions. Participants tended to verify the conditional rule by selecting the gain card if there was a large gain. Conversely, participants tended to falsify the conditional rule by selecting the loss card if there was a large loss in contrast to a small gain.

However, the absence of more robust statistical effects in the type of selection made in the two experimental conditions suggests that there could have been an influence of individual variability. Participants could have differed in their sensitivities to reward (gain) and to punishment (loss), and this variability could have weakened the experimental effects. The aim of Experiment 2 was to examine the role of individual differences in BIS/BAS sensitivities in the card selection.

3. Study 2

The revised RST establishes that changes in the values of punishment and reward in conflict inputs to the BIS will affect the degree of BIS activation. Moreover, both reward and punishment sensitivities will determine whether a conflict is detected and to what extent (Corr, 2004). Thus, we predicted that high BAS subjects will tend to verify the conditional rule by selecting the gain card in the condition "large gain/small loss". As they will be sensitive to the greater value of reward, they will tend not to detect the conflict and will check the sequence letter A → gain card, that is, the sequence *action → reward*. In contrast, high BIS subjects will tend to falsify the conditional rule by selecting the loss card in the condition "small gain/large loss". As they will be sensitive to the greater value of punishment, they will tend to detect the conflict and will check the sequence letter A → loss card, that is, *action → punishment*.

Also relevant to our research is to examine whether punishment and reward sensitivities act as separable or joint subsystems, as the precise pattern of personality effects is hypothesised to depend upon this (Corr, 2002). If they act as separable, BIS facilitates BIS-mediating conducts and BAS facilitates BAS-mediating conducts and mutual inhibition occurs. In contrast, if they act as joint subsystems, antagonism could be expected with BIS impairing BAS mediated behaviour, and BAS impairing BIS mediated behaviour. Situations that contain mixed reward and punishment cues are hypothesised to facilitate joint subsystem activity. As there are mixed cues of reward and punishment in the game task, we adopt the joint subsystem hypothesis. This predicts that appetitive (verifying) responses in the game task should be highest in individuals high in BAS but low in BIS. Conversely, aversive (falsifying) responses should be highest in individuals high in BIS but low in BAS.

3.1. Method

3.1.1. Participants

One hundred thirty-nine students from the University of La Laguna. Ages ranged from 18 to 29. Thirty-nine were males.

3.1.2. Measures

BIS/BAS. There are different BIS/BAS measures (Carver & White, 1994; Caseras, Ávila, & Torrubia, 2003). We use the Carver and White scales that have been reported as useful in several studies (see Carver, 2006). The scales are a 20-item, four-point Likert-type measure composed of the following four subscales: BIS, with items that reflect concern and fear about the possibility of a bad occurrence, or sensitivity to occurrence, BAS-reward responsiveness (BAS-RR) items reflect responsiveness to reward, BAS-drive (BAS-D) relates to the tendency to act quickly and strongly in pursuit of appetitive goals, and BAS-fun seeking (BAS-FS) refers to the tendency to seek out new potentially rewarding experiences. Respondents are asked to rate the extent of their agreement, from 1 (*strongly disagree*) to 4 (*strongly agree*). Internal consistencies of the scales ranged from good to excellent, and test–retest reliability, convergent and divergent as well as factorial validity were satisfactory in the studies of Carver and White. Further research has confirmed their standard as BIS/BAS measures (Carver, 2006; Caseras, Ávila, & Torrubia, 2003). In the current study, the sample had alpha values BIS: .81, BAS-RR: .88, BAS-D: .52 and BAS-FS: .57. These values are all acceptable, especially those of BIS and BAS-RR.

3.1.3. Design and procedure

The same as in Experiment 1, 70 participants in the "small gain/large loss" and 69 participants in the "large gain/small loss" conditions. Their scores in BIS/BAS scales were taken from a battery previously passed.

3.2. Results

3.2.1. BIS/BAS prediction of the type of selection

We carried out linear multiple regression analyses in each condition with BIS/BAS scales as predictive variables and type of selection as the criterion. To enable this analysis, we assigned value 1 to the gain card selection and −1 to the loss card selection. So positive beta values indicate the relation of a given scale to verifying the rule (selecting the gain card) and negative values indicate the relation of the scale to falsifying the rule (selecting the loss card). Participants who did not select either of these cards were removed from the analysis (11%). In addition, we decomposed the BIS scale. As aforementioned, anxiety and fear are different emotions in the revised RST. There is some empirical evidence that supports this functional distinction (see Perkins, Kemp, & Corr, 2007). The BIS scale was differentiated by two subscales: BIS-fear composed of the two fear items of the original scale and BIS-anxiety scale by the other BIS-items. We adopt this procedure following Corr and McNaughton (2008).

In order to carry out the regression analysis we firstly force the BIS and BAS scale (the result of adding the scores of the three BAS-subscales), and subsequently we introduce the BAS and BIS subscales stepwise.

In the large gain/small loss condition, the BIS/BAS scales predict 16% of the variance. The model of regression was significant, $F(2,57) = 5.53$, $p = 0.006$. The BAS scale was the only significant predictor (Table 1). In accordance with our predictions, individuals with high BAS tended to select the gain card (the reward) and so to verify the rule in this condition. By stepwise, only the BAS-reward responsiveness was significant and predicted 13% of the variance. The model of regression was significant, $F(1,58) = 8.49$, $p = 0.005$. In a discriminative way, the BAS-RR was the strongest predictor of the gain card (reward) selection.

In the small gain/large loss condition, the BIS/BAS scales predicted 8% of the variance. The model of regression was marginally significant, $F(2,61) = 2.65$, $p = 0.07$. Only the influence of BIS-scale was significant (Table 1). In accordance with our predictions, high BIS individuals tended to select the loss card (the punishment). By stepwise, only the BIS-fear subscale was significant (Table 1) and predicted 22% of the variance. The model of regression was significant, $F(1,62) = 17.21$, $p = 0.000$. It is worthy of note that BIS-fear predicted a lot more the conduct of selecting the loss card (punishment) than the whole BIS-scale (and so the BIS-anxiety).

Table 1
Multiple linear regression values of the predictive variables

BIS/BAS scales	β	t	p	R^2 (%)
Large gain/small loss				
BAS	0.366	2.96	0.004	16
BIS	−0.114	−0.93	0.358	
By stepwise:				13
BAS-reward responsiveness	0.358	2.91	0.005	
Excluded:				
BAS-drive	0.130	1.03	0.307	
BAS-fun	0.242	1.99	0.052	
BIS-fear	−0.190	−1.56	0.120	
BIS-anxiety	−0.173	−1.40	0.170	
Small gain/large loss				
BAS	0.108	0.680	0.499	08
BIS	−0.338	−2.140	0.037	
By stepwise:				22
BIS-fear	−0.466	−4.15	0.000	
Excluded:				
BAS-drive	0.140	1.24	0.157	
BAS-fun	−0.054	−0.477	0.635	
BAS-reward responsiveness	−0.110	−0.090	0.930	
BIS-anxiety	0.092	0.700	0.487	

3.2.2. Joint or separable BIS/BAS subsystems?

We carried out several analyses of variance with the type of selection as dependent variable. One way ANOVA with (median-split) BIS (3.14) and BAS (3.07) as the between-subject factors was carried out. The main effect of BAS was marginally significant, $F(3,120) = 3.44$, $p = 0.06$ while the main effect of BIS was significant, $F(3,120) = 8.00$, $p = 0.005$. The effect of BIS∗BAS interaction was not significant, $p < .20$.

It is evident from Fig. 2 that appetitive responses towards selecting the gain card were highest in individuals high in BAS but low in BIS (third column). Conversely, aversive responses towards selecting the loss card were highest in individuals high in BIS but low in BAS (second column). This difference (0.765) was significant, $t(52) = 3.19$, $p = 0.002$.

We now examine if influence of BIS/BAS personality traits changes as a function of the values of reward and punishment involved in the experimental conditions. It is evident from the

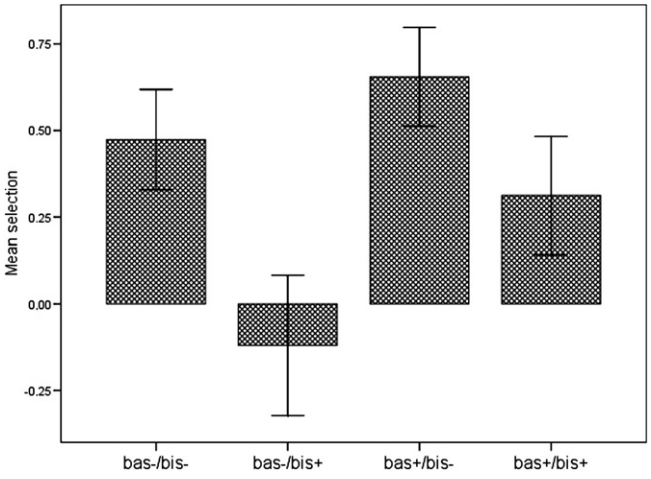

Fig. 2. Mean type of selection for (median-split) low (−) and high (+) BIS and BAS groups (bars = standard error of the mean).

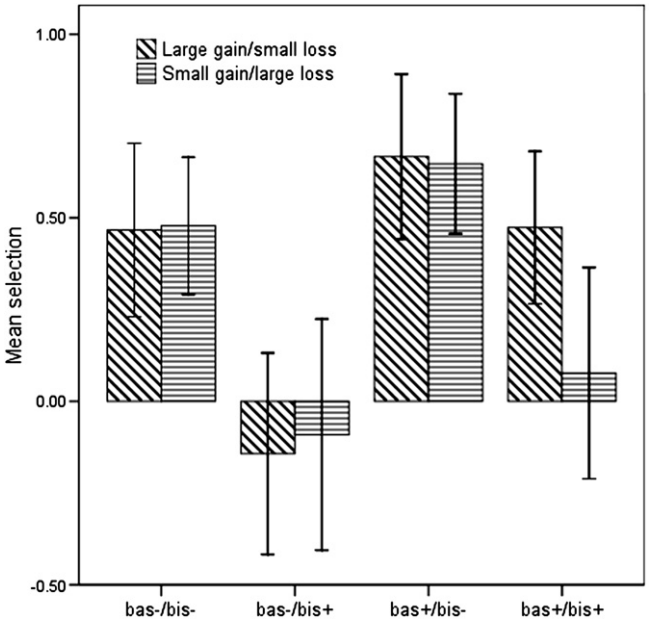

Fig. 3. Mean type of selection for (median-split) low (−) and high (+) BIS and BAS groups in large gain/small loss and the small gain/large loss conditions (bars = standard error of the mean).

contrast in Fig. 3 that only the group BAS(+)/BIS(+) has visibly changed among the two conditions.

In this group there are more appetitive responses (gain card selection) in the large gain/small loss condition (47%) than in small gain/large loss condition (8%), although this difference did not reach significance, $p = 0.26$.

4. General discussion

In accordance with RST predictions, our results have shown that changes in the values of reward and punishment in interaction with individual variability in sensitivity to reward and punishment induced either verification or falsification in the game task. Also relevant, the greater percentage of appetitive (verifying) responses – selecting the gain – was given by individuals high in BAS but low in BIS. Conversely, the greater percentage of aversive (falsifying) responses – selecting the loss – was given by individuals high in BIS but low in BAS. In addition, our results have indicated that when the value of the loss (punishment) is high, BIS inhibits impulsivity towards selecting the gain card (reward) in high BAS participants. This pattern of results supports the joint subsystems hypothesis (Corr, 2002).

Our results also indicate that the functional distinction between anxiety and fear is appropriate to examine the role of individual differences in punishment sensitivity in selection behaviour. In our game task there was an approach–avoidance conflict of attaining the reward (the gain) and avoiding the punishment (the loss). In this context, participants high in fearfulness to potential punishment will experience the task in the small gain/large loss condition as the origin of an approach–avoidance conflict, and motivated by BIS, will tend to inspect the loss card (the risk of loss). In contrast, participants low in fearfulness (in the pursuit of a reward) will tend to ignore punishment, and to minimize this conflict. As a result, BIS is not triggered and BAS would lead them to select the gain card (reward).

In this light, we consider that further research is necessary to examine the role of fearfulness in individual differences in reward and punishment sensitivities in the light of the revised RST. More generally, a more precise definition and measurement of the psychological structure of these sensitivities is needed (see Caseras et al., 2003).

Overall, our results uphold the relevance of the revised RST (Gray & McNaughton, 2000) in the examination of individual differences in reward/punishment sensitivities in reasoning, particularly in the process of verification/falsification of hypothetical *action → result* conditionals. Also relevant is the fact that our results support in human behaviour several RST proposals that have been previously tested in animal research. In this context, they make a contribution to the research program aimed at showing the usefulness of BIS/BAS systems as organizing themes for theory development. Reward and punishment sensitivities could constitute a bridge between disparate psychological ambits such as motivation and personality on the one hand and reasoning and decision-making about actions in social contexts, on the other. Our research has also combined experimental and correlational methodologies. The relevance of relating these for the progress of scientific psychology was pointed out by Cronbach (1957) decades ago.

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Appendix A

Suppose that you go to a casino. When you go in, you find a new card game. The game is about turning up cards to check certain rules. The cards have letters on one side, and a result on the other side: either 1 € [100 €] gain or 100 € [1 €] loss.

Below, there are four cards the same as those displayed in the game:

CARD DISPLAY

As you can see, two cards show the letter side (and the result side is hidden) and two cards show the result side (and the letter side is hidden). The rule that you have to check on this occasion is: *Whenever a card has a letter A on one side, then the card has "1 € gain"* [100 €] *on the other side.* As you can imagine, the card with the letter A could have on the other side either "*1* € [100 €] *gain*" or "*100* € [1 €] *Loss*". Therefore, if the rule is true then you will gain 1 € [100 €], and if it is false you will lose 1 € [100 €]. Let us suppose that before the game starts (and before you gain or lose money), you are given the opportunity to carry out a previous test. Logically, this test has to evaluate whether this rule: *Whenever a card has a letter A on one side then the card has "1 € gain"* [100 €] *on the other side* is FALSE. The cards displayed above are to carry out this test. Once the test has been carried out, the game will start with the display of similar cards. If you check that the rule is false, then you can "pass" when it's your turn and so avoid losing 100 € [1€].

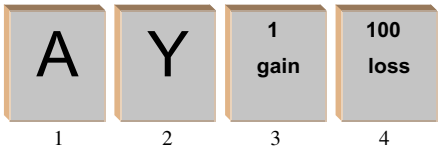
To do the test you have to indicate those two cards you definitely need to turn over to evaluate that the rule is false.

I'll turn over the cards:

Explain briefly the reasons for your selection:

A.1. Card display

A.1.1. Small gain/large loss version



A.1.2. Large gain/small loss version

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