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Ellen Townsend [a] , Alexa Spence [a b] & Sarah Knowles [c]
[a] School of Psychology , University of Nottingham , Nottingham , UK
[b] Horizon Digital Economy Research, University of Nottingham , Nottingham , UK
[c] Centre for Primary Care , Institute of Population Health, University of Manchester , Manchester , UK
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Investigating the operation of the affect heuristic: is it an associative construct?

Ellen Townsend[a]*, Alexa Spence[a,b] and Sarah Knowles[c]

[a]*School of Psychology, University of Nottingham, Nottingham, UK;* [b]*Horizon Digital Economy Research, University of Nottingham, Nottingham, UK;* [c]*Centre for Primary Care, Institute of Population Health, University of Manchester, Manchester, UK*

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Affect is of central importance in risk perception and risky decision-making, and the affect heuristic is a very influential construct developed in relation to this. We examined whether this heuristic operates at an associative level of processing as, despite much theorising, empirical evidence on this issue is lacking. We compared affective heuristic task performance with performance on established implicit association tasks. Participants ($n = 151$) completed explicit attitude and risk measures, and five experimental tasks (three Go/No-Go Association Tasks (GNAT), a priming task and a time-pressured affect heuristic task). A modified 'risk-benefit' GNAT provided a speeded analogue of the affect heuristic task which was equivalent to the evaluative GNAT in terms of response mode and cognitive effort. Affect heuristic task performance was not associated with implicit task performance. The evaluative GNAT did not correlate with the risk-benefit GNAT (speeded affect heuristic task). However, affect heuristic task performance was strongly associated with, and significantly predicted by, explicit affective attitude and explicit risk measures suggesting that this heuristic may primarily reflect deliberative rather than associative processing. Findings contradict the (much cited) notion that this important psychological construct operates at an associative level. However, the conclusions that can be drawn from this study are limited by the implicit attitude measures used here. In future research, it would be desirable to use different measures of implicit associations, e.g. the Single-Category Implicit Association task, to further interrogate the processes operating within the affect heuristic.

Keywords: affect heuristic; implicit measures; Go/No-Go Association task; associative processing; explicit attitudes

Introduction

When we make a risk-related judgement or decision, which psychological processes guide our responses? How do we decide if nuclear power, genetically modified food or smoking cigarettes is risky, beneficial or both? The role of affect has frequently been theorised to be influential in such judgements and decisions. Indeed, many studies demonstrate that affect is a strong driver of responses to risky issues and decisions (Lerner and Keltner 2000, 2001; Slovic et al. 2004, 2007; Blanchette and Richards 2010). In particular, it has been argued that perceptions of risks and

*Corresponding author. Email: ellen.townsend@nottingham.ac.uk

benefits are driven by feelings (Alhakami and Slovic 1994). Whilst in reality, risk and benefits tend to be positively correlated (the more risky something is, the more beneficial it is), risk and benefit seem to be negatively correlated in people's minds (less risky issues are perceived to be more beneficial and vice versa). The affect heuristic has been proposed to account for this discrepancy – where underlying feelings of goodness or badness associated with a stimulus (e.g. nuclear power) are used to evaluate it as risky (bad) or beneficial (good). Here, mental images of stimuli are hypothesised to be tagged to a greater or lesser degree with these feelings in an 'affect pool' which is consulted when risk–benefit judgements are required (Alhakami and Slovic 1994).

In his Nobel Prize lecture, Daniel Kahenman noted that 'The idea of an *affect heuristic* (Slovic et al. 2002) is probably the most important development in the study of judgment heuristics in the last decades' (Kahenman 2002, 470). Indeed, the concept of the affect heuristic has been influential and used to explain a wide variety of results including the relationship between risk and affect in regard to wood smoke pollution (Hine et al. 2007) and sources of radiation, including nuclear power (Peters, Burraston, and Mertz 2004). However, to date, the way in which the affect heuristic operates remains unclear. In particular, despite many *theoretical* accounts of the operation of this heuristic (Slovic et al. 2004, 2007), there are currently no studies that have *empirically* tested whether it operates at an associative level of processing, which represents a serious gap in understanding. Having said this, a number of studies have examined the role of associative processes in risk perception and risk communication (e.g. Siegrist, Keller, and Cousins 2006; Spence and Townsend 2006, 2007; Visschers et al. 2007, 2012). Moreover, recent research has examined the associative processes that underlie the role of affect in risk perception (Dohle, Keller, and Siegrist 2010). Hence, whilst there is some evidence that associative processes are important in risk perception, we investigated whether these processes also underlie the operation of the affect heuristic specifically as this has not been investigated before explicitly.

The affect heuristic has been characterised as an associative process (akin to those described in dual-process models of associative processes (Spence and Townsend 2008), because the strength of the inverse risk–benefit correlation increases under time pressure (thereby reducing capacity to engage in deliberative processing and increasing the reliance on associative processes) (Finucane et al. 2000). Associative evaluations can be defined as 'automatic affective reactions resulting from the particular associations that are activated automatically when one encounters a relevant stimulus' (Gawronski and Bodenhausen 2006, 693). In the present study, we examined whether the affect heuristic is driven by associative processes by comparing performance on the affect heuristic task with performance on implicit association tasks which are widely accepted measures of the associative or automatic level of processing (Gawronski and Bodenhausen 2006).

It has been suggested that using implicit measures is necessary to examine if 'preconscious' or associative processes are involved in risk perception as theorised within the affect heuristic model (Hine et al. 2007; Spence and Townsend 2008). Indeed, the strong similarities between the affect heuristic and implicit attitudes have been noted recently (Marks, O'Neill, and Hine 2008; Spence and Townsend 2008). Implicit association tasks measure spontaneous, associative responses to stimuli, typically examining the ease and speed of participant responses when target stimuli are paired in some way with the attributes 'positive' and 'negative' (Spence

2005). Similarly, the time-pressured affect heuristic task (TPAH) measures risk and benefit judgements arising from spontaneous evaluations of the 'goodness' or 'badness' of a stimulus (Finucane et al. 2000). Therefore, it can be predicted that an implicit task measuring the associative evaluation of a stimulus (as positive or negative) should predict judgements on the TPAH as these are hypothesised to be driven by positive (good) or negative (bad) evaluations. Alternatively, it is possible that because specific risk–benefit judgements are made in the TPAH task, the implicit associations driving this heuristic may be specifically risk-related in nature, rather than valenced (good–bad). Both these possibilities were tested in the present study in that we used a Go/No-Go Association Task (GNAT) with the usual good–bad evaluations and compared performance on this task to a GNAT that had been modified to measure risk–benefit evaluations. Another reason for including a risk–benefit GNAT is that this task is essentially a 'speeded' implicit version of the original TPAH task which makes it equivalent to the evaluative GNAT in terms of cognitive effort and response mode and thus the comparison of these more reliable.

The main implicit association tasks that now dominate the field are the implicit association test (IAT) (Greenwald, McGhee, and Schwartz 1998) and its more recent cousins such as the GNAT (Nosek and Banaji 2001) and affective priming tasks (Fazio 2001). These tasks have been shown to be the most consistent performers in terms of reliability and validity (Spence 2005). In the present study, we compared performance on the TPAH task to performance on GNAT tasks and a priming task. The GNAT solves a major problem associated with the IAT which is that the IAT only examines evaluations of an issue (e.g. flowers) in the context of another issue (e.g. insects), whereas the GNAT is able to evaluate a single issue in isolation. This is important as it is often unclear what the opposing category should be in an IAT. This limitation has been highlighted by researchers investigating implicit associations related to risk-issues who suggest the GNAT to be a suitable alternative (Siegrist, Keller, and Cousins 2006). Previous research suggests that the comparison of at least two types of associative implicit tasks is desirable as each task may measure slightly different associative processes (Fazio and Olson 2003; Spence 2005). Hence, in the present study, we also included a priming task in addition to the GNATs.

Aims

(1) The main aim of the present study was to determine whether the affect heuristic operates at an associative level of processing. If the processes driving the affect heuristic operate at an associative level, these should be highly correlated with/predicted by other associative measures. On the basis of current conceptualisations of the affect heuristic, we hypothesised that implicit association tasks would predict more variance within TPAH performance than explicit attitude tasks (which are theorised to reflect deliberative processing).
(2) In order to determine whether it is the risk and benefit judgements within the TPAH themselves that are associative, we modified a GNAT designed to examine implicit risk and benefit associations with the risk issues used here (nuclear power and climate change). We focused on climate change and nuclear power as these are of particular global societal importance at the current time (Spence and Pidgeon 2009). Importantly, inclusion of this task

also provides us with a ‘speeded’ implicit version of the original TPAH task which makes it equivalent to the evaluative GNAT in terms of cognitive effort and response mode.

(3) In order to examine whether the TPAH task taps affective processes, we examined the relationship between responding on an affective attitude scale and performance on the TPAH task.

We also measured social desirability responding as this is deemed to be good practice when using self-report measures and socially desirable responding has been shown to influence judgements of controversial risk issues (Fleming et al. 2007).

Method

Pilot study to determine stimuli for GNAT tasks

The stimuli used in the implicit tasks were chosen from a pilot study of 56 undergraduates, who were asked to produce five words they most easily associated with risk and benefit, and climate change and nuclear power to find the words most commonly associated with these topics. We removed clearly valenced words so that stimuli were not distinct enough to prompt participants to re-evaluate the category (Govan and Williams 2004). So, for example, if participants produced strongly emotive words such as ‘bomb’ or ‘fall out’ in relation to nuclear power, this could encourage participants to focus on the particularly negative aspects of nuclear power which may have biased the results obtained. Research suggests that it is important that the exemplars adequately represent the category. This is because participants are found to make their responses to the category labels rather than to individual exemplars (De Houwer 2001). Therefore, results will represent associations with the categories (nuclear power and climate change) rather than an average of the actual exemplars used. Our pilot study demonstrated that these exemplars were indeed associated with the categories used.

Participants

From an undergraduate participant mailing list, 151 participants (97 female, 54 male) were recruited. Only fluent English speakers were included. Two participants did not complete all measures and were removed from further analysis leaving 149 participants. Participants received an inconvenience allowance of £8 for taking part.

Design and procedure

The study had a repeated measures design. Prior to completing five experimental tasks (three GNATs, a priming task and a TPAH task), participants completed some explicit attitude and social desirability measures online using Test Pilot software (Test Pilot 2002). The two testing sessions were separated by an average of five days in order to avoid priming/overshadowing effects between the explicit attitudes measure and the associative tasks. The questionnaire was delivered online in order to reduce demand characteristics and social desirability effects, and to enhance disclosure. Participants completed the experimental stage in a laboratory where all tasks were presented on a computer. Participants completed each task individually, with instructions presented on screen. Precise details about the performance of each of the tasks reported here can be found in the measures section below. The order of the five experimental tasks was counterbalanced for each participant. Participants also completed the explicit risk–benefit measures in the lab. Ethical approval was provided by the School of Psychology Ethics Committee, at the University of Nottingham.

Measures

We assessed the same constructs (nuclear power and climate change) in each of the tasks investigated here (semantic differential scales (designed to measure attitudes explicitly) (Crites, Fabrigar, and Petty 1994), the three GNATs, the TPAH and an affective priming task). The explicit measures were chosen as these have been used effectively in past research on controversial risk-related topics and the relationship between explicit and implicit attitude measures (e.g. Spence and Townsend 2007), and explicit gut risk measures have been shown to predict unique variance in explaining attitudes (Ranganath, Smith, and Nosek 2008). The GNAT was chosen for two reasons. Firstly, because it affords assessment of issues in a context-free manner (Spence and Townsend 2006) which means that judgements about a particular risk issue can be made independently of other issues. Secondly, the GNAT format is ideal for producing the amended risk–benefit implicit task (essentially a speeded-up version of the TPAH task where judgement of risk and benefit are made, but which is equivalent in terms of cognitive effort and response mode to the traditional evaluative GNAT which uses good-bad judgements). A priming task was selected as an additional associative task to compare to the GNAT, because such tasks have been used robustly in social psychology and studies suggest that the comparison of at least two types of associative task is desirable as they may measure slightly different processes (DeHouwer 2003; Spence 2005). The TPAH task used was the original format described by Finucane et al. (2000).

Explicit measures

Explicit attitudes. Participants completed an online questionnaire assessing explicit attitudes toward both nuclear power and climate change. Explicit attitudes were measured using the seven-point semantic differential scales devised by Crites, Fabrigar, and Petty (1994) which divide attitude into affective, cognitive and evaluative components and have been used in much previous research (Giner-Sorolla 2004; Huskinson and Haddock 2004; Spence and Townsend 2006). There were eight items in the affective component (e.g. love–hateful), seven in the cognitive (e.g. useful–useless) and four in the evaluative (e.g. positive–negative). High scores reflect higher negative affective, cognitive and evaluative attitudes.

Explicit risk–benefit ratings. Participants completed an explicit risk–benefit measure for each issue (climate change and nuclear power) in order to provide an explicit/deliberative comparison to the spontaneous TPAH risk–benefit judgements. Participants rated the risk issue on a scale from 1 to 7, with '1' representing 'beneficial' and '7' representing 'risky'. They completed two measures for each topic; one which asked them to report their 'gut response' and the second to report their 'considered response'. Gut responses measured explicitly like this have been demonstrated to contribute unique variance in explaining attitudes that is distinct from indirect/automatic measures and direct/controlled measures (Ranganath, Smith, and Nosek 2008). An example of a gut risk item used here is, 'Please indicate what you think your "gut reaction" was to the topic of climate change, i.e. your immediate response, before you had time to reflect on it fully'. An example of a considered risk item is, 'Please now indicate what you think your actual feeling is toward climate change, once you have had time to give it consideration'.

Associative (implicit) measures

GNATs. In the GNAT task, participants must respond to certain categories (Go) and not to others (No-Go). We used an evaluative GNAT, with personalised attribute titles, 'I like' (for positive evaluations) and 'I dislike' (for negative evaluations), in order to reduce extra-personal associations (Olson and Fazio 2004). In 'Go' trials, participants 'Go' (respond by hitting the space bar on a computer keyboard) to exemplars from the target category (in this case, the risk issue – climate change or nuclear power) and exemplars reflecting the positive valence attribute (e.g. 'happy', 'excellent', etc). Participants also responded to exemplars from the target category and the negative valence attribute (e.g. 'horrible', 'nasty'). (The GNAT tasks used were all context-free in that they only evaluated one target attitude issue at a time, i.e. climate change or nuclear power.)

To explore whether it is primarily risk–benefit specific implicit associations that drive performance on the TPAH task, we modified an implicit task so that respondents made 'risky and beneficial' judgements as opposed to 'I like' and 'I dislike' judgements. Similar modifications have been made to implicit tasks previously in order to measure implicit associations with more specific attributes such as 'fear' (Teachman 2007), 'risky' and 'safe' (Siegrist, Keller, and Cousins 2006), and 'gain' and 'loss' (Ronay and Kim 2006).

Following previous research, the GNATs consisted of 20 practice trials and 80 critical trials (Spence and Townsend 2007). Performance was analysed comparing reaction times in each condition, and, therefore, a response window of 800 ms was used for target words and 400 ms for distracter items. If participants did not respond after this time, the trial was recorded as 'no response' and the task proceeded. Reaction times from each condition were analysed as the use of response latency rather than error rates results in greater internal reliability (Nosek and Banaji 2001). Reaction times on the GNAT tasks less than 300 ms were recoded as 300 ms as was recommended by the researchers who devised these tasks (Greenwald, McGhee, and Schwartz 1998). For the evaluative GNAT, the mean difference between the 'I like' and 'I dislike' conditions was taken to provide a single composite score for each participant. Thus, higher scores on the evaluative GNAT would mean a more negative attitude ('I dislike' responses were faster than 'I like' responses). For the risk GNAT, the mean difference between the 'risky' and 'beneficial' conditions was taken to provide a single composite score for each participant. Here, higher scores on the risk GNAT would mean a greater level of perceived benefits compared to risks.

The exemplar stimuli used in the tasks are shown in Table 1. The positive and negative attribute stimuli were taken from previous work on implicit attitudes towards risk issues (Spence and Townsend 2007). As noted earlier, the stimuli for the climate change/nuclear power and risk/benefit categories were devised from a pilot study with undergraduate students to find the words most commonly associated with these topics.

Table 1. Implicit task stimuli (GNATs and priming task).

Category label	Exemplars
I like	Excellent, good, happy, pleasant, wonderful
I dislike	Bad, horrible, nasty, unpleasant, terrible
Nuclear power	Uranium, fission, plutonium, atom, energy
Climate change	Global warming, ozone, greenhouse, environment, ice caps
Risky	Danger, uncertain, chance, loss, gamble
Beneficial	Money, reward, gain, help, advantage

Participants were only asked to complete one traditional evaluative GNAT – on nuclear power (rather than for both nuclear power and climate change) – as a comparative baseline to the new, modified risk GNATs in order to minimise the length of the experimental testing session.

For the modified risk GNATs, all elements of the tasks remained the same except that the stimuli were changed to reflect risk and benefit instead of positive and negative. Attribute category labels were changed to 'risk' and 'benefit' and exemplars related to these labels were used.

For all GNAT tasks, the category exemplars were explicitly presented at the start of the experiment so that participants were in no doubt as to which stimuli were grouped together. Note that here the word 'ozone' was used as an exemplar for the category climate change (albeit a separate environmental issue). This was retained given the strong associations it had with the category of climate change reflecting the common misconception that the two are related (as has been found in mental models work in this field (Bostrom et al. 1994)). The stimuli are presented in Table 1.

Priming task. To maintain consistency with the GNATs, the nuclear power and climate change exemplars were presented as the target stimuli here, and the primes used were the risk–benefit words described above. The underlying logic of the priming task is similar to the GNAT, as congruent pairings of stimuli or responses are assumed to facilitate processing (De Houwer 2003). Faster response times to risk-primed target stimuli compared to benefit-primed targets indicates closer association of the target with risk than benefit (the pairing being congruent and therefore processed more quickly).

Each target was presented 10 times, preceded by one of 10 primes each time (four risk-primed responses (danger, uncertain, change and loss), four benefit primed responses (money, reward, gain and help) and two neutral primes (chair and desk). The neutral primes were considered filler items and were not included in analyses (Spruyt et al. 2007)). There were five exemplars for each risk issue (e.g. 'fission' and 'uranium' for nuclear power and 'ozone' and 'environment' for climate change). (See Table 1 for all exemplars.) A single composite score for each participant was calculated (the difference between the mean reaction time to risk-primed targets and benefit-primed targets). Order of presentation was randomised. Each target stimulus was preceded by a fixation cross, the prime and a mask. Participants responded by clicking the right mouse button for 'risky' and left mouse button for 'beneficial' in response to target stimuli. Responses shorter than 300 ms or greater than 1500 ms were recoded to 300 or 1500, respectively, to reduce outliers (Ulrich and Miller 1994). The data on the priming task for one participant were removed as responses were greater than 1500 ms across all categories. On this task, faster responses to a risk issue when primed with a positive word would reflect a positive implicit attitude, whereas faster responses when primed with a negative word would indicate a negative implicit attitude.

TPAH task

We used the TPAH task specified by Finucane and colleagues (2000). Participants make judgements about the risk or benefit of various issues (including a practice task with 'football' and 'surfing' to familiarise them with the task). During the task, a seven point scale ranging from 1 – 'not at all risky (beneficial)' to 7 'very risky (beneficial)' was shown with endpoints labelled. Responses were made using corresponding (1–7) keys on the keyboard. The name of the risk issue was shown at the top of the screen and a ticking clock sound was played for 5.2 s. After this, a red sign flashed up saying 'Respond Now!' and a beeping sound was played until a rating was given. Participants were presented with 11 risk topics during the task, including nuclear power and climate change, each presented twice – once with the question 'How risky do you think X is?' and once with the question 'How beneficial do you think X is?' The presentation of items was randomised.

For each risk issue (nuclear power and climate change), we created a single composite TPAH task score (to encompass both riskiness and benefit responding) in order to examine the relationship between this measure and the other tasks in the most parsimonious manner. Prior research investigating affect heuristic responding has used single scales (Poortinga and Pidgeon 2005). (We also felt it would be difficult to interpret the meaning of a result whereby implicit tasks correlated with the risk-TPAH but not the benefit-TPAH judgements).[1] To create TPAH scores, we subtracted benefit scores from risk scores for each of the risk issues (climate change and nuclear power separately). This yielded a scale from −6 to +6 which was bipolar in nature (i.e. both +6 and −6 indicated strong affect heuristic responding). In order to create a unipolar scale, whereby a low score meant low/no reliance on affect heuristic processing and a high score meant high reliance on affect heuristic processing, we reversed the negative scores (such that −7 became +7, −6 became +6 and so on). The new composite scale ranged from 0 (no affect heuristic processing) to 6 (high use of affect heuristic processing).

Social desirability

This was measured with the short 10 item (2(10) version) of the Marlowe-Crowne Social Desirability scale which has been found to have similar internal consistency to the original measure (Strahan and Gerbasi 1972). Examples of items include 'I never hesitate to go out of my way to help someone in trouble' and 'I have never intensely disliked anyone' which are rated as 'true' or 'false'.

Results

Preliminary data analysis

As many of the variables in the data-set demonstrated significant skew, Spearman's RHO (one-tailed) correlations are reported throughout. Initial zero-order correlations revealed that the affective, evaluative and cognitive components of the explicit attitude measures were very highly correlated (r_s max = 0.90). As we were particularly concerned with whether the TPAH reflected affective processing, we used only this component as our explicit measure. The higher the score on this scale, the more negative the affective response toward the risk-issue in question.

The measures were designed to provide an explicit analogue of the TPAH tasks ('gut risk' ratings and 'considered-risk' ratings were significantly positively correlated for climate change ($r_s = 0.58$, $p < 0.007$) and for nuclear power ($r_s = 0.63$, $p < 0.006$)). However, the correlations were not large enough to suggest that these scales should be collapsed into one explicit risk–benefit rating scale.

Before creating the composite TPAH scores, we checked for evidence of the affect heuristic in terms of the inverse correlation generally found between risk and benefit scores. We found significant negative correlations for risk and benefit on the TPAH tasks for both climate change ($r_s = -0.47$, $p < 0.007$) and nuclear power ($r_s = -0.44$, $p < 0.006$).

In line with much of literature on implicit tasks (Bosson, Swann, and Pennebaker 2000), the reliability (Cronbach's alpha) of the implicit measures used here was low (max $\alpha = 0.3$).

Statistical analyses

There was no correlation between TPAH performance and performance on any of the implicit measures (evaluative-GNAT, risk-GNATs or priming task). The evaluative GNAT did not correlate with the risk–benefit GNAT (speeded affect heuristic task). However, the explicit attitude measure and the explicit risk measures (gut and considered) were significantly correlated with the TPAH measures for both climate change and nuclear power (see Tables 2 and 3).

In order to account for potential effects of social desirability, performance on all measures was correlated with scores on the short version of the Marlowe-Crowne social desirability scale (see Tables 2 and 3). No significant associations were revealed.

Forced entry regression analyses were performed to examine which of the significant correlates with TPAH performance predicted unique variance in TPAH

Table 2. Correlations between explicit and implicit measures and TPAH performance for climate change ($n = 149$).

	TPAH	GNAT-risk	Priming	Affective attitude	Explicit gut risk	Explicit risk-considered	Social desirability
TPAH		0.12	−0.01	0.44*	0.44*	0.59*	−0.09
GNAT-risk			−0.10	0.12	0.11	0.19	0.01
Priming				−0.10	−0.15	−0.04	0.08
Affective attitude					0.48*	0.50*	−0.08
Explicit gut risk						0.58*	−0.11
Explicit risk-considered							−0.12
Social desirability							

*Significant at the (Bonferroni corrected) 0.007 level (two-tailed).

Table 3. Correlations between explicit and implicit attitude measures and TPAH judgements for nuclear power ($n = 149$).

	TPAH	GNAT-evaluative	GNAT-risk	Priming	Affective attitude	Explicit gut risk	Explicit risk-considered	Social desirability
TPAH		−0.12	0.00	0.02	0.35*	0.32*	0.33*	−0.16
GNAT-evaluative			−0.10	−0.01	−0.02	−0.03	−0.05	0.12
GNAT-risk				0.10	0.01	−0.10	0.01	0.08
Priming					0.12	0.08	0.02	0.18
Affective attitude						0.56*	0.66*	−0.06
Explicit gut risk							0.63*	−0.05
Explicit risk-considered								−0.11
Social desirability								

*Significant at the 0.006 level (two-tailed).

Table 4. Prediction of TPAH task performance for climate change: multiple regression results.

	B	SE *B*	*β*	*p*	95% CI for *B*	
					Lower	Upper
Constant	−3.38	0.91				
Gut risk-benefit	0.17	0.15	0.10	0.26	−0.13	0.48
Considered risk-benefit	0.50	0.14	0.32	<0.001	0.23	0.77
Affective explicit attitude	0.08	0.02	0.26	0.001	0.03	0.12

Note: $R^2 = 0.31$ ($^*p < 0.001$).

Table 5. Prediction of TPAH task performance for nuclear power: multiple regression results.

	B	SE *B*	*β*	*p*	95% CI for *B*	
					Lower	Upper
Constant	−0.44	0.34				
Gut risk-benefit	0.17	0.19	0.09	0.38	−0.21	0.54
Considered risk-benefit	0.18	0.17	0.12	0.31	−0.17	0.53
Affective explicit attitude	0.39	0.27	0.18	0.15	−0.14	0.92

Note: $R^2 = 0.11$ ($^*p = 0.004$).

responding. (Only variables that were significantly correlated with TPAH performance were entered into the models.) The analyses meet the recommended ratio of 10:1 (subjects-to-variables) required for multivariate analyses (Tabachnick and Fidell 2001).

For climate change, three predictors were entered into the model to predict TPAH performance: the explicit attitude measure and the explicit risk ratings (‘gut risk’ and ‘considered risk’). Here, only considered risk ratings and the affective attitude scale significantly predicted TPAH responding (see Table 4).

For nuclear power, three predictors were entered into the model to predict TPAH judgements: the explicit attitude measure and the explicit risk ratings (‘gut risk’ and ‘considered risk’). As the TPAH scale for nuclear power was significantly skewed, log-transformed data (for all variables included in the analysis) was used to perform this regression analysis. None of the variables included in the analysis predicted TPAH performance (see Table 5).

Discussion

In the present study, we wanted to determine whether the affect heuristic operates at an associative level of processing. Previous studies have shown the importance of associative measures in assessing perceived risk and risk communication (Siegrist, Keller, and Cousins 2006; Spence and Townsend 2006, 2007; Visschers et al. 2007, 2012). Here, we designed a study specifically to assess whether the affect heuristic is driven by associative processing. We found that TPAH task performance was not associated with performance on any of the three implicit measures used here. Instead, performance on the TPAH was significantly associated with the explicit (deliberative) attitude and risk-specific measures for climate change. This is an extremely important finding because it suggests that the affect heuristic may be driven much more by deliberative processes than previously suggested in the literature (Slovic et al. 2004, 2007; Hine et al. 2007). It must be noted, however, that the original work on the affect heuristic did evidence a relationship between the affect heuristic and deliberative processing (information on risk or benefit influenced subsequent judgements of risk and benefit (Finucane et al. 2000)). Theoretically, the two systems of processes (associative processes and deliberative processes) are thought to interact (Zajonc 1980; Finucane et al. 2000; Gawronski and Bodenhausen 2006), with deliberative processes building on associative processes where there are cognitive resources and capacity for this. If the TPAH does indeed incorporate some level of deliberative processing, then this leads to the question of what kinds of information are incorporated. In other words, what kinds of information may moderate the relationship between implicit and explicit measures? Previous research has highlighted a variety of moderator variables of the implicit–explicit relationship including social sensitivity of the topic and attitude strength (Nosek 2005). Future research should consider what other kinds of deliberative information people may use when making time-pressured risk and benefit judgements as required within the affect heuristic task, and explore these aspects as moderators between implicit and explicit measures of attitude and risk/benefit.

We did, however, observe the inverse correlation between perceived risks and benefits for both nuclear power and climate change that we would expect from previous studies on the affect heuristic. This suggests that the affect heuristic was indeed operating when participants made risk–benefit judgements here. Clearly, the affect heuristic is a powerful and valuable idea within risk research and the results of the present study do not detract from this. An obvious extension of this work would be to explore the possibility of increasing the ‘implicitness’ of the TPAH. A key difference between the TPAH and implicit measures of attitude is that the TPAH asks for judgements of risk and benefit directly, whereas implicit measures of attitude infer this indirectly. Future research could also consider the possibility of inferring risk and benefit judgements indirectly, and what this would mean for the concept of the affect heuristic.

Interestingly, the affect heuristic effect size we reported for nuclear power (-0.44) was slightly larger than that found in an earlier study (-0.30) which reported a wide range of effect sizes depending on the risk issue being judged (Finucane et al. 2000). Hence, in future research it would also be interesting to compare performance on our tasks using a risk issue with a large effect size (e.g. alcoholic beverages) with one with a smaller effect size (e.g. air travel). In future research, it may also be interesting to compare risk–benefit correlations, affective measures and implicit attitudes between hazards.

Moreover, the regression analysis for nuclear power TPAH revealed no significant independent predictors. Our results suggest that this may be because in the main, participants did not use affect heuristic processing to make judgements about nuclear power (there was no or a small difference in their judgements of risk and benefit). However, the inverse correlation reported above suggests that affect heuristic is to some extent operating for judgements of risk and benefit about nuclear power. It is clear that an individual differences approach to examining affect heuristic responding (such as the one used here in creating a composite affect heuristic score for each participant) may yield different results from studies that examine aggregated risk and benefit scores (using the correlation between these scores to measure the presence of affect heuristic responding). Indeed, post hoc examination of our data for gender differences revealed that females' ratings were significantly higher than males' for nuclear power on the considered and gut risk measures and the affective explicit measure. (No other tasks or ratings showed gender effects.)

An alternative plausible explanation for the lack of association between the TPAH and implicit tasks could reflect the complexity of implicit associations and the tasks that have been designed to measure them. In all the tasks presented here, we measured responses to the target issues climate change and nuclear power. However, it could be that our modified risk-specific GNATs may tap slightly different associative processes than the evaluative GNAT, and the priming task may measure different processes again. Indeed, De Houwer (2003) provides an in-depth structural analysis of implicit measures of associations and highlights the different operational processes underlying the IAT/GNATs and affective priming. Whilst performance on GNATs relies on compatibilities between stimuli presented and responses required, performance on affective priming tasks relies on compatibilities between pairings of stimuli presented. In addition, affective priming tasks primarily examine implicit associations to stimuli at the level of the exemplar, whereas GNATs examine associations at both the level of the exemplar and the category level, though the category level is found to dominate (De Houwer 2003). The lack of convergence between the GNATs and the priming task used here may, therefore, reflect the differential strengths of compatibility responses examined by the tasks (indeed, this is one of the reasons that both of these tasks were utilised here). Indeed, it is interesting to note that most investigations of the correlation between the IAT and priming tasks have found no relationship (Marsh, Johnson, and Scott-Sheldon 2001; Fazio and Olson 2003).

It is also important to note that in our priming task, the participants clicked the left mouse button for 'risky' and the right mouse button for 'beneficial' in response to target stimuli. The response mode (risky or beneficial) was not randomised to the left/right mouse button. Ideally, the allocation of risky or beneficial should have been randomly allocated to mouse button to account for finger predominance (participants may have responded faster with their index finger generally as compared to their middle finger).

Moreover, we found that the implicit tasks used here (GNATs) generally had low reliability scores, which is very much in line with the literature (Bosson, Swann, and Pennebaker 2000). In future research, it may be useful to use different implicit measures such as the Single-Category Implicit Association Test (SC-IAT) (Karpinksi and Steinman 2006). Recall that we wanted to use an associative task where judgements of a target issue could be made independently and not in the context of another issue. At the time of data collection in the present study, the SC-IAT was a new and a relatively untested associative task, so we chose the GNAT as it had been used with reliable results in research on risk perception (Spence and Townsend 2006, 2007). However, the SC-IAT has since been successfully in relation to a number of topics including the stigma associated with mental illness (Wang et al. 2012), substance use in children (O'Connor et al. 2012) and eating behaviour in relation to snack foods (Lebens et al. 2011). Moreover, the SC-IAT has been used to examine the relationship between affect and implicit associations related to judgements about mobile phones and mobile phone base stations (Dohle, Keller, and Siegrist 2010). Indeed, Dohle, Keller, and Siegrist (2010) chose the

SC-IAT specifically because it has 'satisfactory psychometric properties' (1118). Using this task, may, therefore, yield estimates of associative processing which are more reliable than the GNAT. However, one recent study suggests that the SC-IAT can be more readily 'faked' (as compared to the IAT) when participants are given specific instructions to slow their reaction times (Stieger et al. 2011).

As noted previously, it is possible that the formulation of the current measure of the TPAH does not solely reflect associative processing. Two procedural points should be made in relation to this. First, one of the reasons we included the risk–benefit GNAT was to elicit speeded risk–benefit judgements for direct comparison to the evaluative GNAT. In essence, the risk–benefit GNAT was a speeded version of the TPAH task, equivalent in cognitive and response mode demanded in the evaluative GNAT. Second, there is a general problem with very low correlations between implicit measures observed in the literature (Fazio and Olson 2003). Thus, in common with most studies that employ implicit attitude tasks to measure associative processing, the results of our study must be interpreted with these issues borne in mind.

However, it is important to note that the regression analysis for climate change indicated that 31% of the variance in TPAH responses is explained by the explicit attitude and risk measures used here. Hence, in future research it will be important to explore the different proposed elements of associative processes in more detail in relation to the affect heuristic (e.g. examine whether processes are automatic vs. non-conscious vs. affective).

An interesting result to emerge from the research presented here is the significant relationship between TPAH performance and responses to the affective items on the explicit attitude scale, as research suggests that affective (good–bad) evaluation is the major predictor of the affective heuristic responding (Alkahami and Slovic 1994). We suggest, therefore, that in future work, a focus on affective processing is a priority as this has been linked to both the affect heuristic (Alkahami and Slovic 1994) and implicit attitudes (Dohle, Keller, and Siegrist 2010) with respect to judgements about to risk issues.

Another direction to explore in future research would be to consider the affect-inducing potential of the GNAT and other tasks completed here. It is possible that completing the tasks could induce a particular affective state (Visschers et al. 2012). However, it was not our intention to induce affect and we did not take measures of affect before and after task performance which would tell us whether the emotion induction was successful. Future studies could consider measuring emotional states before and after completing study tasks.

The present study represents an important first step towards greater understanding of the nature of the psychological processes that underpin the affect heuristic. This is crucial given that the affect heuristic has been highlighted as a vitally important construct in research examining judgements and heuristics (Kahenman 2002). Indeed, as noted in the introduction, the influence of affect on risk judgements has become a central focus of work in the fields of risk analysis and social cognition. In particular, the affect heuristic has been very useful with respect to the role that affect may have in explaining perceived risk (Finucane et al. 2000; Slovic et al. 2004, 2007; Peters, Burraston, and Mertz 2004; Hine et al. 2007). The results of the present study, however, suggest that the affect heuristic may not act at a purely associative level – its operation appears to be more deliberative in nature than was previously assumed. Future studies should use a range of associative and deliberative tasks using differing temporal dimensions to further explore the precise operation of the affect heuristic.

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