Goal-directed emotions nudge R&D investment decisions

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Abstract: R&D investment is a risk-taking decision for innovations. However, a trade-off relationship exists between short-term profit and R&D expenditure (present vs. future), because of the uncertainty involved. Choosing to invest in R&D is thus seen as a risk-taking propensity of the decision-makers, and how to perceive the risk is susceptible of their cognitive system. This study included three empirical studies involving R&D investment situations. It looked at how goal-directed emotion worked for the decision-maker's risk-taking propensity, and how this motivated to construct her/his goal-directed efforts in R&D investment. Study 1 showed that the affect heuristic confirmed the decision-maker's risk-taking propensity, and the electrodermal activity (EDA) measure in Study 2 revealed that the affect heuristic contributed to the goal-directed emotion. The last experiment (Study 3) revealed how one's risk-taking propensity, motivated by the decision-maker's goal-directed emotion, modulated the goal-directed efforts. Finally, the implications and suggestions for the decision-makers with regard to the R&D investment were discussed.

Keywords: goal-directed emotion; affect heuristic; risk-taking; goal-directed effort; R&D investment.

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1 Introduction

R&D investment is considered a most challenging activity in corporate management (Schumpeter, 1942; Crépon et al., 1998; Hall, 2002). In particular, planning and allocating corporate monetary resources are the key decisions to be made. Many studies have proposed analytical techniques and methods to support such decision making [e.g., technology value assessment model (Luehrman, 1998)]. However, studies in behavioural economics have claimed that such rational decision making cannot be fully warranted (Simon, 1979). For instance, MacGregor et al. (2000) revealed that the decision-maker's imagination and emotional affect tended to be highly associated with allocation and planning, and Ganzach (2000) demonstrated that the investors overestimated their success when an option was perceived to be good and underestimated it when an option was perceived to be bad.

This to some extent irrational (or experientially triggered) decision might be associated with a different propensity for risk-taking toward investment options. Slovic et al. (2004) posited *affect heuristic* [i.e., *risk-as-feeling* (Finucane et al., 2000)] with regard to one's risk perception, and many studies have identified that this also influences the investments and financing of corporations (Baker et al., 2004; Van Kleef et al., 2009; Ezzi et al., 2016). In particular, Barker and Mueller (2002) claimed that a firm's R&D investment strategy tended to resemble the decision-maker's personal risk-taking attitudes (Malmendier et al., 2010) and volitions (Tang et al., 2012; Nambisan and Baron, 2013).

More specifically, Loewenstein and Lerner (2003) studied such experience-guarded risk perception in investing, and a series of similar research studies (Azouzi and Anis, 2012; Charles and Kasilingam, 2015; Lad and Tailor, 2016) confirmed that affect positively (or negatively) serves one's motivation to achieve long-term R&D goals. Bagozzi and Pieters (1998) supported this finding by revealing that *goal-directed emotion* affects how the decision-makers appeal or appease their myopic desires to the prospective outcomes. Higgins (1997) was also in line with this by explaining *promotional and preventive self-regulation*, which is a motivational way to approach (or avoid) a positively (or negatively) perceived future goal (i.e., *flight vs. fight*). However, due to the fact that it is not be tenable for being epistemically tested a direct financial investment, previous studies have been limited to collecting imaginative responses to several investment statements. Also, changing the initial investment plan is often occurred depending on the interim outcomes, but this adjustment process has not been fully addressed in previous studies. Turner et al. (1987) is also noted for this study, because there exists a collective interest in R&D investment (Van de Ven et al., 2007).

Still, R&D investment is mostly regarded to involve rational decision making on which emotional affect should not easily act, however, this study intends to reveal the role of affect with regard to the R&D investment (Abdel-Khalik, 2014; Billings et al., 2018). It looked at how goal-directed emotion worked for the decision-maker's risk-taking propensity, and how this emotional orientation motivated to construct her/his goal-directed efforts in R&D investment. The three empirical studies administered various investment information in different settings (prospective outcome, public investment and diet-workout), to determine if risk-taking propensity toward R&D investment could be differently formed depending on situations and contexts in which the reputable *affect heuristic* (Finucane et al., 2000; Slovic et al., 2004) would positively (or negatively) guard the effortful R&D investment decisions toward the long-term goals

[i.e., *affect as information* (Clore et al., 2001)]. This relationship would explain how a corporate decision on R&D could be endogenously construed by the exogenous factor, rational decision making would otherwise be purported. In Section 2, we review the literature on risk-taking attitude with regard to managerial decision making for R&D investment. Three empirical studies – two laboratory and one mock-field experiment – are described in Section 3, Section 4 and Section 5. The implications and suggestions for the decision-makers are discussed in Section 6 to secure a better R&D investment decision.

2 Background of the research design

Risk perception is the conceived probability distribution of possible outcomes for particular alternatives, and risk-taking attitude is determined by the evaluation of the perceived risk over the expected value of possible outcomes (Highhouse and Yüce, 1996). Indeed, risk-taking attitude is generally affected by an *in-situ* risk propensity of situation or context (Nicholson et al., 2005), and how much a person is willing to take risks depends on how she or he subjectively perceives the risk probabilities of each alternative.

R&D investment is also an act of risk-taking (Wiseman and Gomez-Mejia, 1998) because of its high degree of uncertainty (Dixit et al., 1994) on the long-term horizon (Bange and De Bondt, 1998). Numerous scholars (Drucker, 1986; Porter, 1992; Marginson and McAulay, 2008) have claimed that decision-makers such as a firm CEOs are often asked to take risks while they are under the conflict of interest by short-term profitability against long-term goals, by which they often tend to sacrifice R&D investment (i.e., future uncertain risk) to chase relatively short-term profitability. This risk-averse attitude was confirmed again in a survey reporting that about 80% of the financial executives among 401 companies had at one point considered decreasing their R&D expenditure to increase their target profit (Graham et al., 2005). Moreover, Osma and Young (2009) found that, when the stakeholders signalled high risk and high return, the CEOs tended to first reduce R&D expenditure. Indeed, the risk perception of R&D investment dictates decision making on short-term profit, so when the risk perception is nudged, the decision-maker's risk-taking propensity (and of course, the act that follows) can be controlled.

When people evaluate and perceive a risk, they are influenced by *affect heuristic* (Finucane et al., 2000; Slovic et al., 2004). To account for this, Slovic et al. (2004) proposed dual modes of thinking: *experiential system* and *analytical system*, as shown in Table 1. The analytical system refers to the normative rational mindset that is an effortful, formal logic, slow, and conscious thinking process, while the experiential system is the intuitive cognition system that is effortless, mostly automatic, fast, and involves unconscious awareness.

In the experiential system, individuals are likely to perceive risks as an image of affect [i.e., *risk as feeling* (Loewenstein et al., 2001; Slovic et al., 2004)], rather than deliberatively evaluating the risks and relying on the rules of logic and evidence. In effect, this dual processing theory (Kahneman and Frederick, 2002) shows selective application of cognition in decision making wherever and whenever uncertainty is involved.

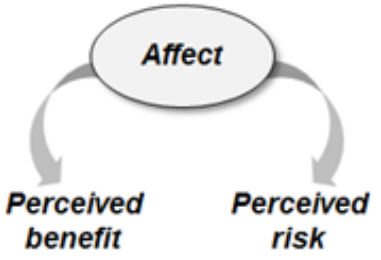
In particular, affect heuristic (Slovic et al., 2004) helps understand how a person perceives a risk in conjunction with the prospective benefits of the alternative (see Figure 1). Finucane et al. (2000) explained that emotional affect influences an individual's experiential thinking such as good/bad or nice/awful, and it then makes a difference in the evaluation of risk and benefit perception. Indeed, the stimulation that directs the affect serves as a cue (Clore et al., 2001) to activate one's memory on the risk perception process, and this could alter her or his risk-taking attitude when rating the probabilities of the alternatives.

Table 1 Dual modes of thinking

Experiential system	*Analytical system*
• Holistic	• Analytic
• Affective: pleasure-pain oriented	• Logical: reason oriented
• Associationistic connections	• Logical connections
• Behaviour mediated by 'vibes' from past experiences	• Behaviour mediated by conscious appraisal of events
• Encodes reality in concrete images, metaphors and narratives	• Encodes reality in abstract symbols, words and numbers
• More rapid processing: oriented toward immediate action	• Slower processing: oriented toward delayed action
• Self-evidently valid: 'experiencing is believing'	• Requires justification via logic and evidence

Source: Adopted from Slovic et al. (2004)

Figure 1 Model of affect heuristic



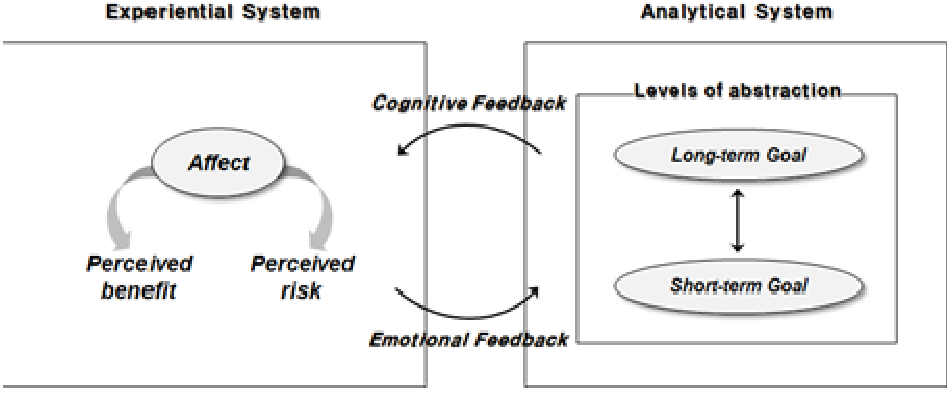
Source: Revised from Finucane et al. (2000)

By the same token, as an investment problem is given, decision-makers would face both perceived benefits and risks in conjunction with emotional affect. Slovic et al. (2004) explained that affect heuristic tended to intervene in such risk evaluation processes considering future financial outcomes (perceived benefit, e.g., revenues) against possibly failed resource allocation (perceived risk, e.g., sunk cost). Numerous studies (Grable and Roszkowski, 2008; Azouzi and Anis, 2012; Ezzi et al., 2016), for instance, confirmed that this emotional affect tends to influence the corporation's financial decision such as stock investment, realty purchase, or stock-option distribution.

Indeed, corporate financing activities in previous studies were confirmed to be highly associated with short-term decisions. Though R&D investment is an essential corporate financing activity, the long-term goals that it can achieve might perturbate one's

emotional affect, by which the *long-term* perceived risk or benefit can also be changed. In particular, decision-maker's volition would be involved here (Tang et al., 2012; Nambisan and Baron, 2013). In this regard, Carver and Scheier (2000) revealed that goal-directed behaviours can be manipulated by the affect that serves as another type of information in the feedback loop [i.e., *affect as information* (Clore et al., 2001), see Figure 2].

Figure 2 Feedback loop in association with the levels of goal and affect



In conjunction with Slovic's dual modes of thinking, the feedback loop explains that emotional affect could relay the perceived benefit and risk with the levels of a goal. This means that affect itself can work as the input and output in our cognitive system, and how to allow this propagation is associated with one's goal-directed efforts.

Bagozzi and Pieters (1998) had a similar stance by claiming *goal-directed emotion*, which means that one's anticipatory emotion elicited by the prospective benefit and risk motivates one's subjective goal-directed behaviours (Bagozzi et al., 2003; Schlösser et al., 2013). According to this claim, positive anticipatory emotion directs an individual to expand the current states to see the future benefit. Such goal-directed emotion then forgoes one's volitional process [i.e., motivation (Tang et al., 2012; Nambisan and Baron, 2013)] to manage the subjective risk-perception process. Finally, the positive or negative affect repeatedly works as feedback in the subsequent decisions. Indeed, such emotional affect (either positive or negative) seems to have the role of both *feedback* and *feedforward* (Thayer and Lane, 2000, see Figure 2) in one's risk-taking propensity to manipulate goal-directed behaviours (Carver and Scheier, 2000).

Higgins (1997, *regulatory focus theory*) otherwise saw goal-directed behaviours as a cognitive maintenance process. The study claimed that promotional and preventive feedback works positively and negatively in one's rational regulation process (i.e., self-regulation) to evaluate prospective benefits and risks. This deliberative risk-perception then manipulates the subjective thoughts, motivation, and behaviours towards a goal. Strathman et al. (1994) claimed that that this cognitive motivation, which controls myopic desires, would be strengthened when one's consideration is consulted to focus more on future consequences.

In effect, both the cognitive and emotional feedback loops seem to be critical in R&D investment, and central to this study is how affect can manage or be managed by the

feedback loops. A note in forming the goal-directed emotion is further needed here. Recently, unlike most business entrepreneurs, social entrepreneurs (Weerawardena and Mort, 2006) have started focusing on future issues (e.g., sustainable energy, food shortages and inequality), but founding and operating successful social businesses is difficult, as investors are much less willing to support risky ventures (Miller et al., 2012). Hsee and Weber (1997) posited that one's risk preference can be altered by the discrepancies of self and others' interests, which is in line with Turner et al.'s (1987) theory (*self-categorisation theory*) that distinguishes the self (e.g., 'I' and 'me') and collective interest (e.g., 'we' and 'us'). Also, Mandel (2003) claimed that risk-taking for others (i.e., collective interest) tends to be more regressive (i.e., risk-aversive) than that of self-interest. Loewenstein et al. (2001) observed that one's affect aroused from the prospective outcomes for other people was delayed rather than instantly provoked. Thus, collective risk-perception tends to be more conservative, while self-interest is more risk-seeking.

Considering this, corporate R&D investment seems to be made not only for individual purposes, but also for a collective purpose (Van de Ven et al., 2007). For instance, Faro and Rottenstreich (2006) demonstrated that the decision makers with more self-interest (e.g., firm founders) tend to choose more risky alternatives than those with more collective interest. Particularly, in a firm's R&D investment, Chrisman and Patel (2012) presented that a family business tends to show more risk-seeking than the agencies [e.g., employed CEO (Wiseman and Gomez-Mejia, 1998)] with a stronger volition formed by positive affect (Tang et al., 2012; Nambisan and Baron, 2013). Indeed, such discrepancy seems to be a prerequisite for analysing how the emotional affect (providing either cognitive or emotional feedback) in one's risk-taking propensity affects progress toward the long-term goal.

This study thus intends to empirically demonstrate how risk-taking propensity in terms of R&D investment can be modulated by affect in conjunction with one's volition toward long-term goals. There are two research questions:

1 how the psychological feedback loop, as shown in Figure 2, changes risk-taking attitude

2 how the levels of goals, as shown in Figure 2, change goal-directed emotions.

To address these questions, three empirical studies were examined. The first experiment intended to determine if positive (or negative) information manipulates one's emotional affect to make different R&D investments, and the second experiment aimed to demonstrate different goal-directed emotions. Based on these two experiments, the last experiment, a 'work-out and diet program' carried out in a private gym, mimicked decision making in R&D investment to show how one's risk-taking propensity motivated by his/her goal-directed efforts could be modulated by different goal-directed emotions.

3 Experiment 1: willingness-to-pay for R&D investment of cancer medicines

This experiment was designed to mimic a fictitious R&D investment situation to see if and how affect changes one's propensity to engage in a particular R&D investment. Our study design considered that affect would be modulated by the prospective outcome of

the investment, and this was given in either a positive or negative way. Further, to cross-examine the effect of investment information, positive and negative information was quasi-experimentally alternated in this experiment. Hence, the primary purpose of the experiment was to see if positive (or negative) investment information (prospective outcome) would change one's propensity for risk-taking.

3.1 Experimental design

A total of 41 subjects (female = 22, mean age = 27.8) was recruited for this study (see Table 2). They voluntarily participated and were given $20 at most, depending on investment performance. All the participants were students from the Graduate School of Management at a university (*double blinded for review*).

Table 2 Subject information (Study 1)

	Condition I	*Condition II*	*Total*
Number	20	21	41
Mean age (s.d.)	27.9 (5.64)	27.8 (3.33)	27.8 (4.60)
Sex Male	10	9	19

The participants were asked to 'act' as the CEO of a fictitious pharmaceutical company that develops a cancer medicine for its R&D investment portfolio. During the ten decision making trials (see Figure 3), their R&D reservoir starts at 100 points (which was assumed to equal one million USD) at each trial, and they decide how many points (with a maximum of 100 points) they wanted to invest from the available fund at each trial. If an investment succeeded, they were paid back twice as much as they had invested; otherwise, they lost all the points invested. The failure or success outcomes of the investment decision were generated by a random function that reflected 50/50 risk perception. Note that, to avoid the *sunk cost fallacy* (Lichtenberg, 1992), at every trial, the available fund was reset to 100 points. The total experimental rewards were then the sum of all points obtained from the ten trials. The maximum of $20 meant that the participant achieved all successes (100 point investment, two times return on investment, ten trials = 20,000 points). This experimental setting was deliberate to minimise the effect of the sunk cost fallacy, and at the same time, maximise the effects of the affect.

Each participant was randomly assigned to one of the two experimental conditions (Condition I and Condition II). Condition I presented the positive investment outcomes [see Table 3(a)]. That is, they were given the positive (or promising) impressions of their prospective investment decision, and then decided how much they wanted to invest (i.e., willingness-to-pay – WTP) in each of the first five trials. The next five trials conversely provided the negative images [see Table 3(b)] to see if their previous investment decisions would be adjusted accordingly. Condition II was the other way around, i.e., negative and then positive. The philosophy behind this A/B experimental design was grounded on Zillmann et al.'s (1999) study that one-sided photographs would bias one's risk perception. The order of the positive images presented in a half of the ten trials was randomised (the same for the negative images in the next five trials) in both Conditions I and II.

Figure 3 Experimental protocol (Study 1) (see online version for colours)

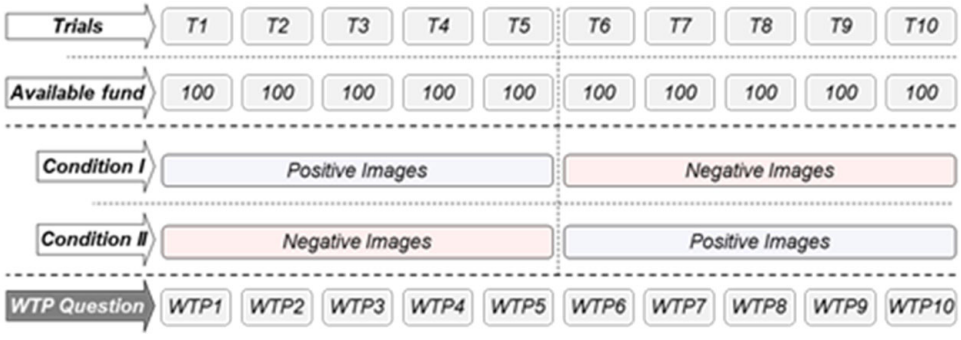
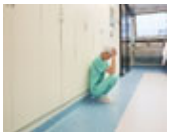
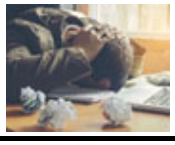


Table 3(a) Images for positive stimulation (see online version for colours)

1st trial	*2nd trial*	*3rd trial*	*4th trial*	*5th trial*
				
				

Table 3(b) Images for negative stimulation (see online version for colours)

1st trial	*2nd trial*	*3rd trial*	*4th trial*	*5th trial*
				
				

The images used in this study were selected by two independent researchers who were not involved in this study. A total 40 images were searched with the keywords (‘cancer patient’, ‘cancer cure’, ‘investment success’, ‘investment failure’), and the images were reviewed by other ten people with the seven-points Likert scale [extremely negative (1) to extremely positive (7)]. It showed that the mean between positive and negative images were statistically distinguishable (independent t-test, negative = 2.43, positive = 5.48, $t = 24.19$, $p < 0.01$), and the highly scored five from the positive and negative images were finally chosen for the experimental stimuli (negative = 1.73, positive = 5.90, $t = 25.90$, $p < 0.01$).

The mean of WTP was statistically compared among the conditions to identify the effects of positive or negative information in risk-taking decisions using independent *t*-test.

3.2 Results

Table 4 shows the mean WTPs in all ten trials. The overall mean WTPs (mean = 49.29) simply indicate that our participants had *extreme aversion* (Simonson and Tversky, 1992). However, they tended to invest more when faced with positive (or negative) outcomes (positive = 54.78, negative = 43.80, $t = 4.16$, $p < 0.01$).

Table 4 Mean of WTPs by information type (independent *t*-test)

Information type	*Mean (s.d.)*	*t-value*	*Sig.*
Positive information	54.78 (27.20)	4.16	<.01
Negative information	43.80 (26.20)		
Total	49.29 (27.23)	-	-

Note that at the sixth trial, the prospective outcome (i.e., the independent variable) was changed from positive to negative (and *vice versa*). Figure 4 shows how the propensity of the investment decision was changed. If there was no effect of the prospective outcome change at the 6th trial and afterward, the mean WTP of the 6th–10th trial should have been no different than those of the 1st–5th trials. Table 5 shows that Condition I had no significant difference between the positive and negative images (p = n.s.). However, in Condition II, the positive outcomes of the 6th trial and afterward evoked positive affect that might change the risk-taking attitude formed by the first five trials. An independent *t*-test confirmed this ($t = 6.75$, $p < 0.01$).

Figure 4 Result of the investment value

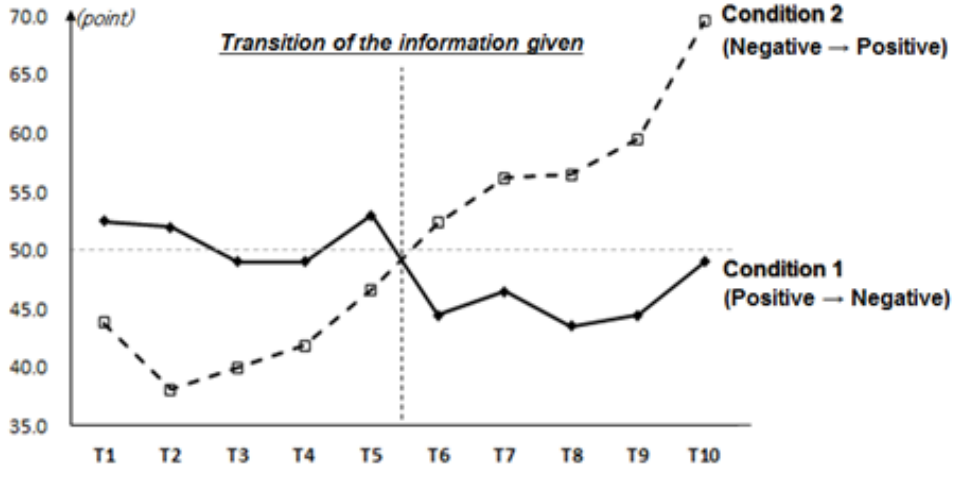


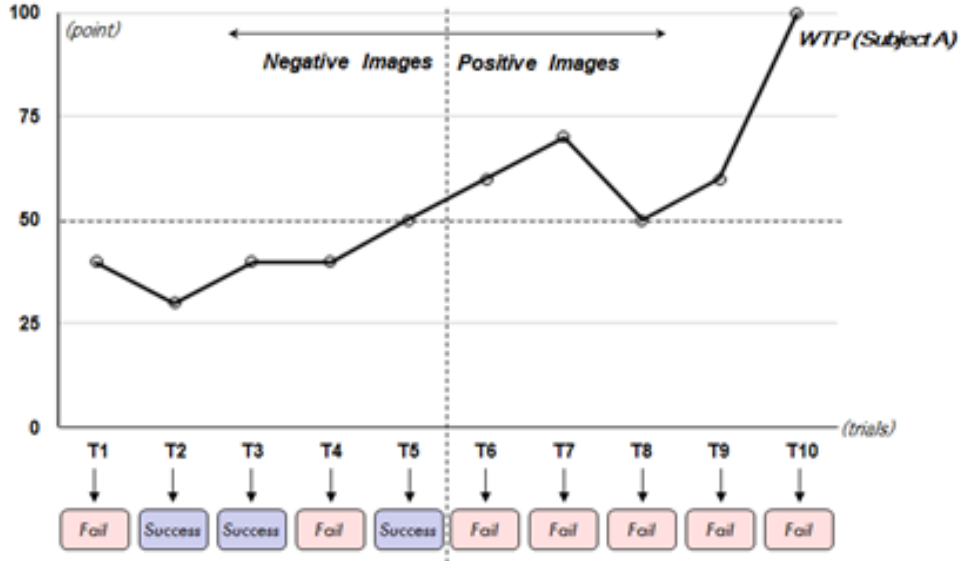
Table 5 WTP results (independent *t*-test)

Classification			*Mean (s.d.)*	*t-value*	*Sig.*
Condition	*Stimulation*				
I	Positive	(1st–5th trials)	51.10 (27.34)	1.35	n.s.
	Negative	(6th–10th trials)	45.60 (30.03)		
II	Negative	(1st–5th trials)	42.70 (20.14)	6.75	< 0.01
	Positive	(6th–10th trials)	58.81 (25.45)		

3.3 Conclusions and discussion

This study simply repeated the effect of affect heuristic triggered by the prospective outcomes. Hence, the mean WTPs throughout the experiment were around half of the available investment funds (i.e., *extreme aversion*); however, but when positive information overtook negative information (i.e., 42.70 → 58.81 in Condition II), participant propensity for risk-taking might have been influenced. For example, Figure 5 is the WTP of a subject in Condition II. When the negative information was given in the first five trials (1st–5th), her WTP did not exceed 50 points even though she won three among five trials. However, when a positive stimulus was provided in the sixth trial, her WTP was equal to or greater than half of the available funds even though she lost five times in a row. However, this trend was not repeated in Condition I (positive → negative), where participant' investment was consistent at around half of the available fund. Loewenstein (2000) explained that this *hot-cold empathy gap* does not fully grasp how subject behaviours and preferences are being driven by their current state, so they think the current state will persist for a long period of time.

Figure 5 WTP result for one subject (Condition II: negative-positive) (see online version for colours)



Although this experiment partially demonstrated the WTP gap due to the positive affect (Fredrickson, 2001) formed by the prospective outcomes, several limitations should be avoided in the following experiment. First, the visual stimuli [i.e., positive (or negative) images for the prospective outcomes] might not be highly conducive to the WTP decisions, by which the experimental apparatus would have forced the participants to focus on the investment performance due to the reward money. To avoid this, the next experiment was not subject to participant investment outcomes. Second, in accordance with the first limitation, the positive (or negative) emotional state of our participants was assumed to be evoked by positive (or negative) pictures or their perceptual imagery (Thomas, 2006). The following experiment considered more realistic information to evoke solid emotional responses (e.g., virtual reality – VR). Also, instead of WTP, we employed a physiological measure of emotional affect in the next experiment. Finally, decision making in R&D investment can have a dual meaning, which have been claimed that entrepreneurs and agencies (e.g., employed CEO) seemed to treat R&D investment decision making differently (Wiseman and Gomez-Mejia, 1998; Van de Ven et al., 2007). This issue should be also addressed in the following experiment.

4 Experiment 2: WTP in private/public investment

The previous study presented empirical evidence that positive (or negative) emotional information could facilitate (or demotivate) one's monetary resource allocating decision when the affect heuristic works in one's risk-taking propensity. However, different intentions [i.e., self and collective interest (Turner et al., 1987)] are engaged when evaluating the risks with regard to positive or negative future outcomes. In examining this, the different goal-directed emotions are essential, as briefly discussed in Section 2. Hsee and Weber (1997), in this regard, claimed that one's risk perception would be affected by possible gains and losses differently provoked by the individual or collective stances. A note of Loewenstein et al. (2001) is needed here. They claimed that risk perception from someone else's perspective is more analytical rather than emotional. An important point to examine in this experiment is thus that such an effect might also occur in R&D investment.

In addition, to facilitate more *in-situ* decision making, we employed the VR technology to evoke greater affect (Bateman et al., 2009; Innocenti, 2017), and the house-fund investment situation was considered in this experiment. Here, goal-directed emotion was associated with goal level – personal vs. public. The former was used for individual interest, and the latter for collective interest. Our primary concern was to determine if goal-directed emotion would differently influence one's decision making based on goal level.

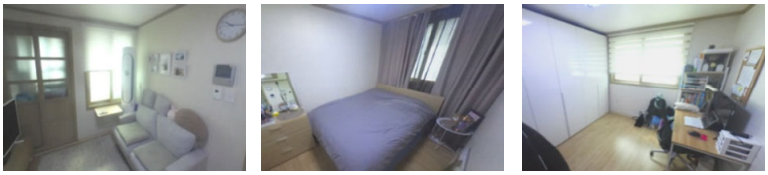
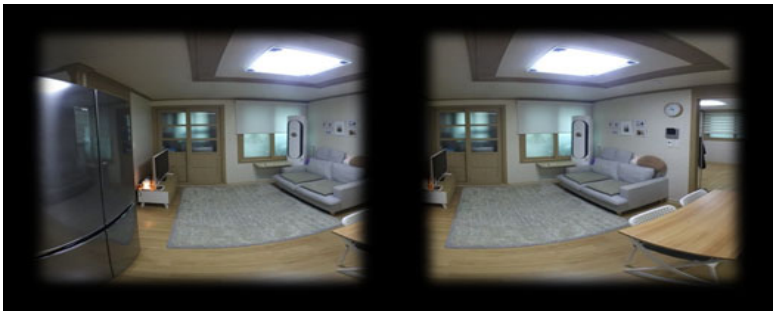
4.1 Experimental design

A total 62 subjects (female = 33, mean age = 28.52) was recruited for the experiment (see Table 6). Subjects, who were students at the Graduate School of Management at a university (*double blinded for review*), voluntarily participated and were given $10 as a reward. The subjects were randomly allocated into the following two conditions, then.

Table 6 Subject information (Study 2)

		Group 1 (private investment)	*Group 2 (public investment)*	*Total*
N		31	31	62
Age (s.d.)		28.55 (4.45)	28.48 (7.09)	28.52 (5.87)
Sex	Male	17	12	29
	Female	14	19	33

Table 7 Information types (see online version for colours)

	Provided materials
Text only	• Sales option: purchase • Direction: south-east • Size: 62.81 m^2 • Rooms: living room + 2 bedrooms • Floor: 3rd • Station area: 7 minutes from a subway station
Text + image	Text only + the following images 
Text + VR	Text only + the following VR 

Note: VR content was established using the CupixTM platform (http://www.cupix.com) and projected by Oculus-Rift.

The experiment was designed to a 2 (investment types, private vs. public, between-variable) × 3 (information types, text-only vs. text with image vs. text with VR, within-variable) format. The investment types figuratively resembled the self and collective interests, by which the principal goal of the collective-interest is more associated with connectedness and interdependence with others than former (Turner et al., 1987; Loewenstein et al., 2001; Mandel, 2003). Thus, the investment options were given as the *MyHome Fund* [which is *a monthly investment for five years to purchase a house where I will live* (Group1)] and the *Public-House Fund* [which is *a monthly*

investment for five years to use in construction of a public-house where the others will live in social purposes (Group2)].

Based on Bateman et al. (2009), three information types were employed in this study – *text only*, *text plus images*, and *text plus VR* (see Table 7). The Latin square design (LSD) (Dénes and Keedwell, 1991) was administered to eliminate order effects.

All participants were guided to spend up to 1,000 USD/month for investment; while doing this, we also collected electrodermal activity (EDA) to see how a particular piece of information made one's different arousal toward positive (or negative) affect. The recorded WTP and EDA were analysed by an independent *t*-test and split-plot ANOVA (SPANOVA).

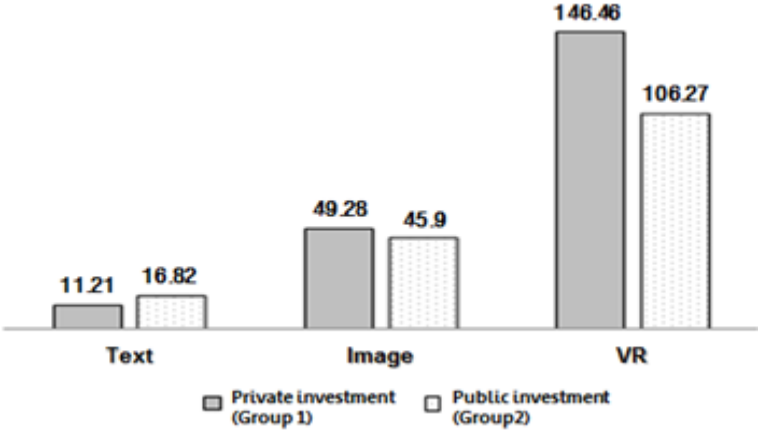
4.2 Results

Table 8 shows the mean WTP by group. The mean WTP in private investment (mean = 50.29) was significantly higher than that in the other investment plan (mean = 31.99, $t = 5.38$, $p < 0.01$). As for information type, VR resulted in higher investments (i.e., higher WTP) in both private and public, which was confirmed through SPANOVA analysis [$F(1.95, 117.24) = 44.59$, $p < 0.01$] and did not reveal any interaction effects. It seems that VR stimulation increased subjective risk-taking propensity to produce greater WTP in both groups.

Table 8 WTP results (independent *t*-test)

Stimulation	*Mean (s.d.)*		*t-value*	*Sig.*
	Group 1	*Group 2*		
Text only	430.65 (262.26)	228.06 (164.37)	3.64	< 0.01
Text + image	464.52 (234.95)	292.90 (183.38)	3.21	< 0.01
Text + VR	613.55 (245.20)	438.71 (204.07)	3.05	< 0.01
Total	502.09 (257.71)	319.89 (202.97)	5.38	< 0.01

Figure 6 EDA result (unit: kOhms)



Note: *The EDA was calculated by comparing the participant's stimulated value with the stable states.

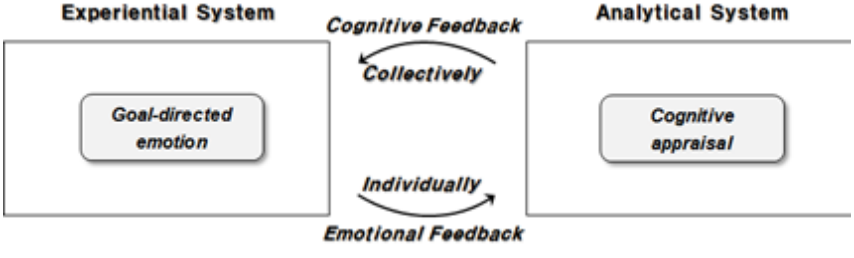
Figure 6 shows the EDA result by the types of information presented. The SPANOVA results, in general, showed that our participants were more aroused as more visualised formats of stimuli were given [$F(1.71, 192.43) = 1{,}230.25$, $p < 0.01$]. In particular, in the VR format (i.e., when they showed highest affect), the private investment group scored a higher EDA than the others (independent *t*-test, private investment = 146.46, public investment = 106.27, $t = 9.01$, $p < 0.01$). This implies that goal-directed emotions seem interact with one's risk-taking decisions (Slovic et al., 2004), by which such affect would be less influenced when more public interest was engaged. That said, goal-directed emotions would manipulate one's decisions to differently perceive the risks (i.e., WTP decisions) in association with the different intentions [i.e., self and collective interest (Turner et al., 1987)].

4.3 Conclusions and discussion

This study provided evidence of risk-taking propensity aligned with self and collective interest. The self-interest group (Group 1) invested more than the other group (Group 2); however, the latter was less influenced by the instant emotional affect, which implies that they tended to employ a more analytic system to evaluate the risk of investment.

As shown in Figure 7, this can be seen as the emotional affect in one's cognitive appraisal process (Scherer et al., 2001) to the prospective investment outcomes. Our results are to some extent at odds with Loewenstein et al. (2001), which revealed that individuals perceived risks by integrating affective and cognitive appraisals, although the former would have a stronger influence over the latter. Also, our results are not consistent with Slovic et al. (2004), who claimed that individuals were likely to perceive risks based on the instant affect, even when factual information was simultaneously provided. Indeed, goal-directed emotion formed by emotional feedback seemed to serve subjective risk perception, encouraging subjects to take more risks in individual decision making, while the collective risk-taking propensity might be less affected by the intervention of cognitive appraisal.

Figure 7 Feedback loop in association with goal-directed emotion



This study provides evidence for affective risk-taking propensity based on goal-directed emotion; however, some limitations should be taken into consideration. First, the experimental apparatus could not clearly dictate the differences between private and public investment situation. Though the two experimental situations were not able to clear-cut the two investment options, it was regarded that the options considered in the study would make a different propensity to one's risk-taking behaviour. Second, one of the key characteristics in R&D investment should be consideration in the long-term time

horizon (Bange and De Bondt, 1998), hence, Experiments 1 and 2 in this study would not be appropriate to determine how R&D investment decisions would be affected by the information (or prospective outcomes) provided. Third, the unrealistic risk probability for possible outcomes (50/50 success rate in Experiment 1 and absence of probability in Experiment 2) could not sufficiently reflect the realistic uncertainty of R&D investment (Dixit et al., 1994). Further, decision making in the previous experiments was more imaginary than putting actual efforts to reach to prospective outcomes. In the next field experiment, we considered a 'workout and diet program' carried out to mimic realistic decision making in R&D investment. This would be able to answer how one's risk-taking propensity motivated by his/her goal-directed efforts could modulate the different goal-directed emotions.

5 Experiment 3: willingness-to-exert-effort in a diet and workout program[1]

The previous experiments revealed that the emotional affect associated with prospective end-outcomes could alter one's decision making propensity; however, the experimental setting and task were too limited to compare them with general R&D investment situations. According to a process model of emotion regulation (Gross, 2002), emotion may be regulated by the emotion generative process:

a selection of the situation

b modification of the situation

c deployment of attention

d change of cognitions

e modulation of responses, which the previous studies only addressed the last three processes.

This experiment thus comprised a longitudinal decision making situation to see how one's risk-taking propensity would be mitigated by the positive (or negative) emotion arising from selection and modification of the situation by prospective positive (or negative) end-outcomes, which lead to different goal-directed emotions. The longitudinal perspective in this experiment is also interesting because emotion often acts on a shorter-term basis (Slovic et al., 2004), while R&D investment decision should be touted as more analytical over a longer-term. That is, even though one's emotion is highly associated with risk propensity, however, in the long-run, it might be less influential (Lerner et al., 2015), in which this study attempts to identify how these two operate in tandem in a more realistic context. Further, this field experiment is also considered the subjective efforts to obtain prospective outcomes (Bagozzi et al., 2003), so this would support perseverant decision making for realistically mimicking R&D investment.

In this experiment, we saw similar and comparable features between the diet-workout situation and R&D investment (see Table 9). To lead to both successful weight loss and investment outcomes, the positive features should appeal to the decision-maker, appeasing the negative features. Hence, prominent is that the long-term goal (i.e., successful weight loss or successful investment outcomes) be well aligned to suppress

short-term temptation, so the decision-maker can take risks for prospective long-term outcomes.

Table 9 Common characteristics between R&D investment and a diet-exercise situation

	R&D investment	*Diet-exercise*
Positive features to trigger investment	• High sustainability	• Healthy life span
	• Long-term revenue	• High quality of life (e.g., physical strength, good body shape)
	• Improved business model	• Improved daily activity
	• Reputation	• Self-image as an active person
	• Unexpected new opportunities	• Positive side effect (i.e., mental health)
	• Sense of achievement	• Sense of accomplishment
Negative features to hinder the investment	• Uncertain of investment outcomes	• Uncertain of diet success
	• Heavy commitment for new business	• Physical efforts for exercise
	• Counter by short-term profitability	• Temptation to food (short-term benefit)
	• Time-consuming	• Delayed achievement of final goal
	• Consistent effort to success	• Will-power weans over time
	• Initial financial investment is huge	• Initial resolution is hard

Previous studies on decision making have seen the same line of thought. Strathman et al. (1994), for instance, revealed that promotional motivation to attain prospective outcomes (e.g., the image of a healthy life span) could improve one's intention to be healthy by provoking a more positive affect. This approach was confirmed in a fictitious investment situation (Howlett et al., 2008). Similarly, Sengupta and Zhou (2007) demonstrated that diet choice is comparable to investment choice, where both temptation to either eat unhealthy food or focus on return of investment (ROI) can promote one's affect to take more risks. In particular, Segar et al. (2011) noted that one's willingness-to-exert-effort (WTE) toward a long-term goal was higher when an emotion-laden motivation (e.g., imagine your good body shape) was given than with neutral ones (e.g., workout 5 days/week), which was similarly confirmed in the financial investment domain (Zhou and Pham, 2004). Indeed, given a situation, a motivation to change the situation by focusing on how to achieve the prospective outcomes seems to determine one's risk-taking propensity, and the emotion associated with the efforts needed has been studied less in this regard.

Our diet-workout experiment was thus designed to project how goal-directed emotions would influence decision making in a weight loss program, underlying cognition regarding interpretation of the situation to modulate the following response (Gross, 2002). In this regard, the physical effort to alter the current situation in the diet-exercise experiment is tenable to examine the mental effort of an investment decision (Hossain and Yang, 2019). The primary aim of this experiment is to demonstrate how one's risk-taking propensity would be differently grounded by the affect associated with one's goal-directed efforts.

Table 10 Subject information (Study 3)

		Group 1 (neutral-positive)	*Group 2 (emotional-positive)*	*Group 3 (neutral-negative)*	*Group 4 (emotional-negative)*	*Total*
N		13	11	15	17	56
Age (s.d.)		28.62 (7.05)	27.91 (4.09)	28.50 (4.11)	27.76 (4.79)	28.18 (4.60)
Sex	Male	5	5	6	10	26
	Female	8	6	9	7	30
Attrition		2	1	5	6	14

5.1 Experimental design

A total of 56 subjects (female = 30, mean age = 28.18) voluntarily participated after responding to an advertisement in a fitness centre[2] (see Table 10). The participants voluntarily joined a three-week workout program proposed by the study and performed the program at their convenience. Thirteen subjects did not complete the weight loss program, however. In the recruitment process, the participants were told that the experiment aim was to study the effectiveness of food consumption and the workout program, so they had to report the food consumed and body weight every day for three weeks. When they completed the experiment, they were given a $50 voucher and randomly allocated to one of the four groups.

The experiment was designed with 2 (emotional vs. neutral) × 2 (positive vs. negative) conditions, and the text messages used in the study are shown in Table 11. In line with Segar et al. (2011), the text messages were either neutral (e.g., *You lost 1.5 kg from your last report*) or emotionally-laden information (e.g., *Imagine your slim and healthy body in front of others when you complete the program*). Also, positive texts (e.g., *You achieved 60% of your target weight, and you have only seven days left to achieve success in your diet*) and negative information (e.g., *You will fail if you do not work as hard as you did in the last seven days*) were presented, similar Zhou and Pham (2004) and Sengupta and Zhou (2007). All this information was given by health trainers *via* e-mail and mobile SMS.

Table 11 Examples of the feedback texts for each group

Group identification		*Text-messages proved to subjects*
Group 1	Neutral-positive	• Your goal is set to reach 60 kg by Sep. 5th. • You achieved 60% of your target weight, and you have only 7 days left to achieve success in your diet.
Group 2	Emotional-positive	• Imagine the slim and healthy body shape you will have at the end of the workout program. • Others will think you are completely changed; to reach that goal, you need to better control your diet.
Group 3	Neutral-negative	• Your goal sets to reach 60 kg until Sep. 5th. • Now you did not make it, and you have to endure 7 days more to avoid failure.
Group 4	Emotional-negative	• Imagine your big body shape and that nobody loves you. • You will fail if you do not work hard.

The experiment was carried out for three weeks (Strychar, 2006), and all the subjects were asked to visit and work out at the fitness centre seven times (two times per week and once to finalise the experiment). Daily food consumption was reported directly to the health trainers and was converted to kilocalorie units using the Korea Ministry of Food and Drug Safety (MFDS) caloric database. We also asked participants to report body weight during the seven visits. Basal metabolic rate (BMR) was measured by InBody™, and the recommended food consumption was set based on individual BMR. This was deliberate to mimic an investment situation – the initial goal to set based on future efforts.

The attrition rate, food consumption based on BMR, and weight loss were analysed using different methods. The first was to see if the information presented had an effect on

attrition rate, which was validated by chi-square test. The second was designed to identify one's risk-taking propensity (i.e., diet control based on BMR), where an individual's food consumption records compared to his or her BMR was analysed by ANOVA and post-hoc analysis. Weight loss was measured at seven points during the three-week program. The workout program remained constant, but the participants had to self-manage food consumption based on the given information via either email or SMS. This was analysed by repeated measures ANOVA (RMANOVA) to determine the longitudinal effect of the given information.

5.2 Results

Table 12 shows that 25% of the participants did not successfully complete the experiment. In particular, negative information (Groups 3 and 4) tended to decrease motivation toward the workout program (11 out of 32). However, few participants presented positive information quit before completion (3 out of 24, Groups 1 and 2). This difference was statistically analysed by chi-square test [$\chi^2(1, N = 56) = 3.50, p < 0.1$]. The findings from the previous experiment were in line with this result.

Table 12 Attrition rate of the experiment

	Neutral	*Emotional*	*Total*
Positive	*Group 1* (2/13)	*Group 2* (1/11)	(3/24)
Negative	*Group 3* (5/15)	*Group 4* (6/17)	(11/32)
Total	(7/28)	(7/28)	(14/56)

These results could be interpreted to indicate that positive feedback presented our participants with two motivational triggers: *control food consumption* and *continue a workout program*. The former seems to be linked to the long-term goal for a firm to restrain *near-term earnings*, which means focusing more on short-term gains (Marginson and McAulay, 2008), and the latter is related to goal-directed efforts to take further risks for achieving the long-term goal, which mimics the *long-term ROI* (Billings et al., 2018). This will be further discussed later.

Table 13 shows the food consumption (converted to kilo-calories) of those who completed the three-week workout program. Similar to the previous results, Group 4 seemed to overeat (mean 144.73 kcal over target BMR). Interestingly, Group 2 had highly controlled their food consumption compared to the other groups (mean overeat kcal = 5.27, 124.86 for Group 1, 92.53 for Group 3 and 144.73 for Group 4). Analysis of variance [$F(3, 878) = 3.10, p < 0.05$] and post-hoc Turkey HSD analyses confirmed that Group 2 (emotional and positive information) best managed food consumption ($M = 5.27$, $SD = 281.19$), while Group 4 (emotional and negative) showed the worst self-management ($M = 144.73$, $SD = 688.74$). This can be seen that when both *emotional and positive information* was given, participants were more able to resist the short-term temptation (in our case, food consumption). However, this was not the case in Group 4 (mean = 144.73).

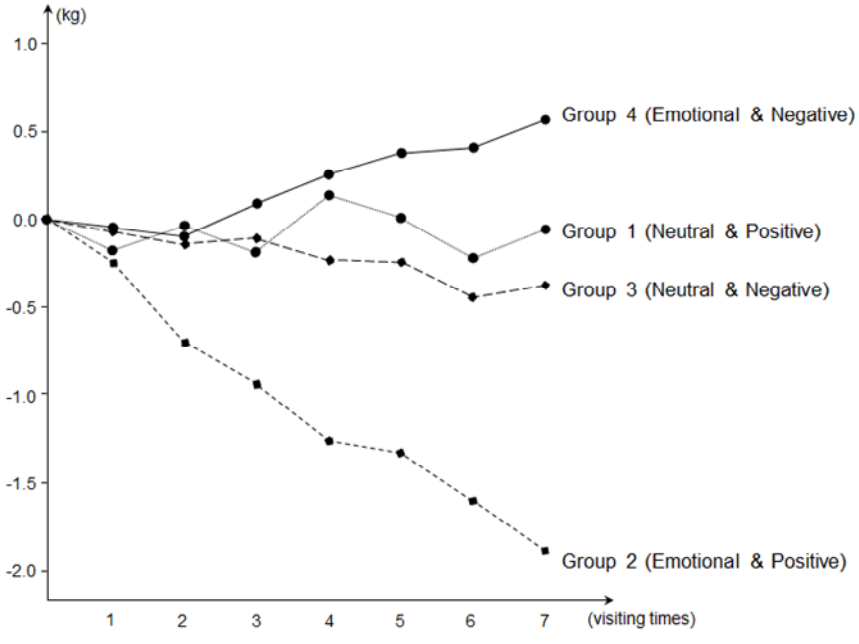
Figure 8 depicts the weight changes over the three-week workout program. Note that the participants had to report their weight after each of seven workout sessions over the three weeks. Group 2 outperformed the other groups during the workout program, which again confirmed the results of the previous analysis. An RMANOVA confirmed that

Group 2 lost significant weight compared to the other groups at all seven points [Greenhouse-Geisser (Epsilon < 0.75), $F(4.01, 152.46) = 2.23$, $p < 0.01$]. This finding is not new, Custers and Aarts (2005) revealed the effects of positive information, and Zeelenberg et al. (2008) discovered a similar effect of emotional information. The positive and emotional information used in our experimental context was novel.

Table 13 Results of food consumption against BMR (one-way ANOVA)

(Unit: kcal)	*Group 1 (neutral-positive)*	*Group 2 (emotional-positive)*	*Group 3 (neutral-negative)*
Mean (s.d.)	124.86 (464.53)	5.27 (281.19)	92.53 (459.03)
(Unit: kcal)	*Group 4 (emotional-negative)*	*F-value*	*Sig.*
Mean (s.d.)	144.73 (688.74)	3.10	< 0.05

Figure 8 Results of weight-change



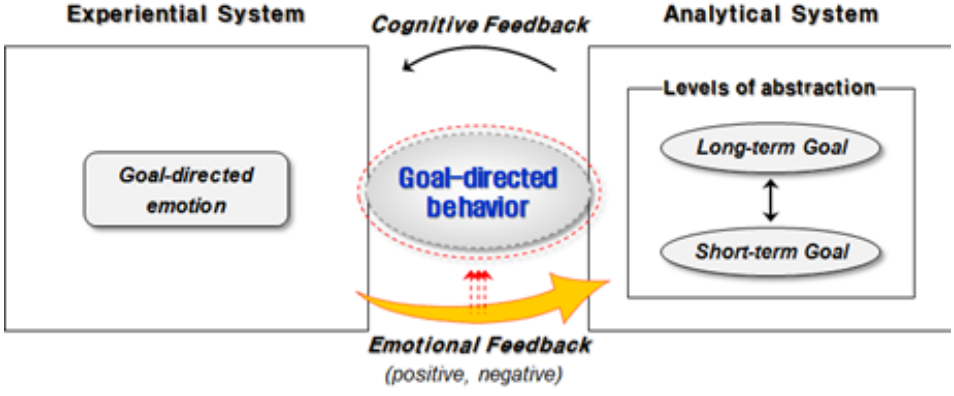
5.3 Conclusions and discussion

This study provides evidence of the involvement of positive and emotional stimulation in one's WTEs to attain prospective outcomes. The experimental results supported this claim, Group 2 (emotional-positive information) showed an extraordinary risk-taking propensity (i.e., control of food consumption), and weight loss performance, accordingly.

These results can be seen as the effects of positive affect, supporting numerous studies (Fredrickson, 2001; Fredrickson and Branigan, 2005; Ferguson and Bargh, 2004; Stanton et al., 2014) revealing that positive emotion acts to increase one's risk-seeking propensity. By the account of Bagozzi et al. (2003), this can also be seen that both

emotional and positive information prevented our participants from succumbing to a short-term benefit (i.e., controlling food consumption) and helped to maintain their efforts (i.e., following the workout program) to maximise (or minimise) positively (or negatively) anticipated emotions. That is, our participants might anticipate future outcomes from positive-emotional information (e.g., *Imagine the slim and healthy body shape you will have at the end of the workout program*), and such self-fulfilling imagines (Merton, 2016) would cause their goal-directed behaviour to align with the future outcome. Indeed, the prime cognitive mode formed by this positive emotional state (Gross, 2002) makes people less reluctant to take risks (i.e., limiting preference for short-term gains), increasing effortful behaviours. Conversely, negative emotion seemed to make people short-sighted (Lerner et al., 2015), affected more by the cognitively perceived negative states (Loewenstein and Lerner, 2003), and motivation might have been readily intimidated by its effect. This is depicted in Figure 9.

Figure 9 Feedback loop in association with goal-directed emotion and effort (see online version for colours)



Arguably, the findings above can hint at managerial trade-offs in R&D investment between short-term profitability and long-term returns (Drucker, 1986; Porter, 1992; Marginson and McAulay, 2008), where decision makers such as CEOs seems more favourable near profits than a long-term R&D investment (Graham et al., 2005; Osma and Young, 2009). In this regard, Johnsen and Sørensen (2017) argued that highly motivated entrepreneurs would be more susceptive to this fantasy formed by positive and emotional outcomes, and Foo et al. (2009) showed that the decision maker's WTE for future outcomes could be significantly increased if positive goal-directed emotion was engaged. Vereshchagina and Hopenhayn (2009) also claimed that positively perceived future opportunities (i.e., promotive motivation) could increase the risk level of firm investment, where positive goal-directed imagination can lead to underestimation of future risks.

6 General discussion

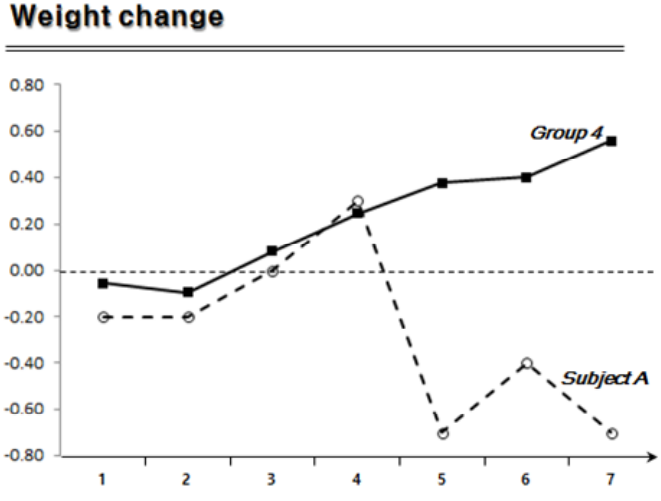
This study portrayed that affect has a critical role in risk-taking propensity by mimicking R&D investment, which is the most challengeable decision for firm future (Schumpeter,

1942; Crépon et al., 1998; Hall, 2002). Still, R&D investment is mostly regarded to involve rational decision making on which emotional affect should not easily act, however, this study shed light on the role of affect in conjunction with the decision maker's risk-taking propensity (Abdel-Khalik, 2014; Billings et al., 2018).

Our main finding shows how goal-directed emotion impacts the decision maker's risk-taking propensity, by which the affect acts as a signal [i.e., *affect as information* (Clore et al., 2001)] to nudge one's cognition to holistically evaluate the possible outcomes [i.e., *risk-as-feeling* (Loewenstein et al., 2001)]. Then, this process foregoes the analytical risk-evaluation process to appeal or appease the perceived benefits and risks. This affect further tends to lead one's goal-directed efforts to approach or avoid the positively (or negatively) anticipated emotion (Bagozzi et al., 2003; Schlösser et al., 2013). In effect, the individual decision-maker might control her/his goal-directed efforts (i.e., overcoming myopic decisions) by reflecting her or his risk-taking propensity based on one's (imagery) affect toward the future outcomes.

Note that our study does not that affect completely dictates the decision making behaviour in the R&D decision. For example, Figure 10 shows a subject case from Study 3 who did not follow the general pattern of Group 4 (given emotional-negative information). Although most of the participants in that group quit the weight loss challenge, this was not true for the subject case (Subject A in Figure 10). This participant said in the post-interview that she had a specific goal or strong *intention* for weight loss and so worked hard. This supports the cognitive process impacts her risk-taking propensity and her goal-directed effort [i.e., *rational regulation process* (Higgins, 1997; Carver and Scheier, 2000)]. This cognitive maintenance process seemed to divert her from emotional feedback to focus more on her goal.

Figure 10 Example of a subject from Experiment 3 (diet-exercise), Group 4 (emotional-negative)

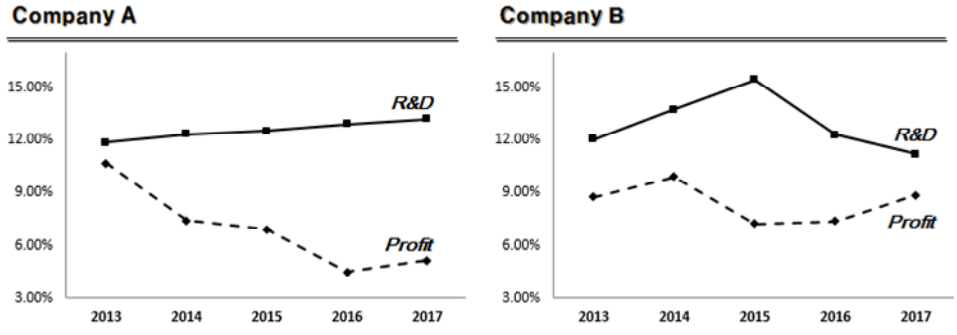


To conclude, cognition is also associated with risk-taking propensity (Higgins, 1997; Strathman et al., 1994); however, at the same time, individuals are likely to perceive the risks and benefits of goal-directed emotion (Loewenstein et al., 2001; Slovic et al., 2004).

This tandem process might be related to how a person makes the risk-taking decisions associated with R&D investment (Hastie and Dawes, 2010; Murphy, 2018).

In this sense, one voice speaking louder than the other is the nature of decision making. Figure 11, for example, shows two Korean companies that compete in the same business type and sales size. Company A increased R&D investment, sacrificing short-term profitability, while Company B reduced R&D expenditure to maintain its average short-term profit. The different patterns between the two companies might have arisen from different goal-directed emotion (Bagozzi and Pieters, 1998). Company A had been run by the family business, and the newly appointed CEO was highly motivated to impact prospective futures (i.e., risk-taking). In Company B, however, the agency was more risk-neutral (Chrisman and Patel, 2012; https://goo.gl/bxrcsf). Kato and Wiklund (2001) claimed that an entrepreneur's hedonic affect would serve as a strong instinctive motivator to undermine the risks despite lower returns when he or she would like to develop new products or technologies. Indeed, this might be the reason why many innovative corporations run by the founders would move forward, as they are not focused on short-term profitability [e.g., Tesla, Google, Facebook, Samsung, Hyundai (Romer, 1994)]. Our study supports the idea that goal-directed emotion helps to increase the volition for future long-term returns.

Figure 11 Profit rate and R&D intensity of Companies A and B (2013–2017, %)



Note: Profit rate = profit per sales and R&D intensity = R&D investment per sales.

The implications of this study can be seen in two-fold: firstly, companies might be able to exploit the goal-directed emotion *tactically* when they need to increase some R&D projects ignoring the levels of short-term profitability, by which a strategical R&D investment planning can be further set. For instance, the technologies that a prospective outcome is highly expected (e.g., COVID-19 vaccines) would not be much affected by the current profits.

Second, the goal-directed emotion can attribute one's imagery to the final outcome rather than the process to the decision making. The *sunk-cost fallacy* (Lichtenberg, 1992), *escalation of commitment* (McCarthy et al., 1993; Moon, 2001), *concorde effect* (Arkes and Ayton, 1999) are all touted as this misattribution. That being said, Ohlert and Weißenberger (2020) demonstrated that as a decision-maker is aware of she/he had fall into the cognitive bias, it would help them to step-back and escape from the biases. For this, we note that the 'personas' technique in design decision making (Friess, 2012) seems to highly incubate the awareness of goal-directed emotion, with which one's emotional empathy to the situation would re-direct her/his decision making process

[i.e., *feedback* and *feedforward* (Thayer and Lane, 2000)]. Indeed, such techniques might be helpful for the field decision-makers to manipulate their risk-taking propensity in conjunction with the goal-directed behaviours (Carver and Scheier, 2000).

7 Limitation and future research

Risk-taking plays a key role in R&D investment decisions, and this study provided evidence of decision-maker goal-directed emotion (Bagozzi and Pieters, 1998), which led to goal-directed efforts (Carver and Scheier, 2000). However, there are some limitations to generalising this conclusion.

The primary limitation of this study is the laboratory setting of the R&D investment situation. For instance, the experimental circumstances – the investment game (Study 1), the public-private investment (Study 2), and the diet-exercise program (Study 3) – could not fully represent an actual R&D investment situation (e.g., the history of decisions, sensitivity to gain/loss). Other studies have also employed this experimental research method (Benz and Meier, 2008; Bardsley et al., 2010), but there remains need for a method to match this empirical approach in a realistic R&D investment setting. We are planning to carry out a field study and personal communications (Abdel-Khalik, 2014; Billings et al., 2018) to confirm our findings.

For the research framework, we assumed that cognitive and emotional feedback would interact, but these interactions are not so clear that what triggers the other and how one achieves the other. Without a full understanding of the causality between goal-directed emotion and goal-directed effort, it seems difficult to modulate one's risk-taking propensity to lead one's behaviour (i.e., decision making). In this regard, some studies have emphasised one's personality traits to perceive risk (Nicholson et al., 2005; Lauriola et al., 2014), which is being planned for our next study. This need to consider furthers such as the emotional dimensions [i.e., *arousal and valence* (Lerner and Keltner, 2000; Lerner et al., 2015), *emotional intensity* (Gohm, 2003)] and the intensity of affect in one's memory [i.e., *availability heuristic* (Dube-Rioux and Russo, 1988)]. Also, the gender difference would be the one of the considerable perspectives to deal with the one's propensity to perceive risk (Charness and Gneezy, 2012; Bannier and Neubert, 2016). Finally, like the anecdotal evidence (shown in Figure 11), an interesting research topic would be how social innovation companies see R&D investment (Weerawardena and Mort, 2006) in terms of its social or business impact.

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Notes

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