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Stress in nurses: stress related affect and its determinants examined over the nursing day.

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Abstract

Background. Nurses are a stressed group and this may affect their health and work performance. The determinants of occupational stress in nurses and other occupational groups have almost invariably been examined in between subject studies.

Purpose. To determine if the main determinants of occupation stress i.e., demand, control, effort and reward, operate within nurses.

Methods. A real time study using personal digital assistant based ecological momentary assessment to measure affect and its hypothesized determinants every 90 minutes in 254 nurses over 3 nursing shifts. The measures were negative affect, positive affect, demand/effort, control, and reward.

Results. While the effects varied in magnitude between people, in general increased negative affect was predicted by high demand/effort, low control and low reward. Control and reward moderated the effects of demand/effort. High positive affect was predicted by high demand/effort, control and reward.

Conclusions. The same factors are associated with variations in stress related affect within nurses as between.

Keywords. Occupational stress, nursing, demand, control, reward, ecological momentary assessment

Introduction

Nursing is often stressful [1] and associated with burnout, [2] intention to leave the profession [3] and errors and safety violations [4, 5] which may be distress related [6]. It is therefore important to study stress in nurses both to increase our understanding of the processes that determine stress and because of the potential impact stressed nurses may have on the delivery and outcome of health care.

Two models of the causes of work-related stress dominate the literature on the environmental effects of stress: Karasek's [7] demand control model and Siegrist's [8] effort reward imbalance model. Karasek hypothesizes that high demand is associated with stress but this is moderated by control so that the combination of high demand and low control is particularly stressful, while Siegrist proposes that high extrinsic effort (a very similar concept to demand) causes stress but this is moderated by reward so that high effort and low reward (the effort reward imbalance) leads to most stress. These models both in their original form and with additions and modifications [9] have received extensive study. There is considerable support for the central importance of demand or effort, control and reward as determinants of stress and some, less consistent, support for the role of control and reward as moderators of the effects of demand and effort [10, 11, 12]. Studies of nurses have shown that high demand and low control relates to poor physical and mental functioning [13], increased sickness absence [14] and burnout [15]. Similarly effort reward imbalance has been shown to relate to poor general health and psychological wellbeing [16], the intention to quit nursing [17] and burnout [18, 19].

Virtually all studies of occupational stress have examined the differences in stress and its determinants <u>between</u> people and attempted to determine, for example, whether people in high strain occupations or who perceived their work to have many demands or low control or reward report more stress and experience more ill health [e.g., 20, 21]. Very few studies have examined if the processes that determine the differences between people are also associated with variations in stress within people. It has been very forcibly argued that at a fundamental level psychological theories should apply to and be tested within people and that processes and theories that are important in differentiating between people do not necessarily apply within an individual [22]. This can have important implications for interventions to reduce stress and its consequences. First, many interventions are directed at changing what are thought to be critical processes within the individual. If these processes are not in fact critical for most individuals then such interventions are unlikely to be helpful and could even be harmful for some. Second, the alternative approach is to change aspects of the environment, especially the work environment, and the effects can only be assessed by observing changes within individuals experiencing different environmental conditions.

Stone and Shiffman [23] and others [24] have described ecological momentary assessment (EMA) in which data of interest are recorded frequently, in real time, and in the critical environment. Johnston et al. [25] used EMA methods to study the success of the demand control and effort reward imbalance models in explaining variations in self rated stress in a pilot study of nurses. They developed a personal digital assistant (PDA) based method which assessed affect and the main constructs from the demand control and effort reward imbalance models and tested it on a small sample of nurses measured frequently over three nursing shifts. They obtained preliminary information which suggested that such measurement was acceptable and that variations in a one item rating of self-reported stress did relate as predicted to the occurrence of high demand and low control and high effort and low reward. We build on Johnston et al. [25] by examining a larger group of nurse participants, assessed frequently over three work shifts using more comprehensive measurement of stress related affect. It is clear from many reviews [11, 12] that the processes identified by the demand control and effort reward imbalance models are associated with negative emotional outcomes and so related transitory states are likely to be associated with negative affect. It is less clear (and seldom examined) if these processes predict positive affect.

This report is concerned with the associations, within nurses, between their perception of their work situation and stress related affect. We examine: 1) whether periods of high demand and effort are associated with higher negative affect (NA), 2) if periods of high control and reward are associated with lower NA and 3) if control and reward moderate the effects of demand/effort on NA such that the greatest NA is experienced when demand or effort is high and control or reward low. The relationship between the same predictors and positive affect (PA) are examined to establish if the determinants of NA also relate to PA.

Methods

Design and Procedure

This study employed a within and between subject design incorporating both cross-sectional and longitudinal elements. Levels of negative and positive affect at work, and the putative determinants of stress that influence affect were assessed in nurses in 4 large English hospitals. Nurses, selected at random from lists provided by the Human Resources Department, were contacted by letter and returned consent forms to locally agreed collection points. Packs of questionnaires were then sent to consenting nurses and dates agreed for the completion of the PDA diaries. PDAs were delivered by research assistant to the participant's ward and demonstrated prior to the first shift on which diaries were to be completed. The PDAs were programmed to run for the next three shifts and were returned to the research assistant upon completion. The study was approved by the North West Manchester Research Ethics Committee (06/MRE08/35), and by the appropriate NHS R&D authorities for each of the four participating NHS Trusts.

Participants

We tested 254 nurses from medical and surgical wards in each of the 4 hospitals. Two of the hospitals provided 75 nurses, one 69 and one 35. All qualified nurses working at least 22 hours per week on medical and surgical wards were eligible. All shift patterns were accepted. Approximately 16% of the nurses approached volunteered. EMA diaries were obtained from 254 nurses and 233 of these completed baseline questionnaires and provided basic demographic details. To check that the sample was representative we compared it with the total work force in 3 of the 4 hospitals we studied (the figures were not available for the fourth) on nursing grade, gender and type of ward. The distribution of nursing grades and the split between medical and surgical wards were very similar but men were slightly over represented in the sample tested at 14.6 % compared to 9.4% in the population that we sampled from.

Materials

Nurses completed baseline questionnaire measures including the Positive and Negative Affect Scale (PANAS) [26] followed by PDA measures obtained frequently over 3 nursing shifts.

The format for the diary questions was very similar to that used by Johnston et al. [25]. It was operationalised using specially written software on Dell Axim 50 PDAs. In addition to EMA, nurses used the PDA to record critical incidents and end of shift ratings [27]. Data entry on the PDA was prompted by an auditory alarm that occurred throughout the shift at approximately ninety-minute intervals (with a window of +/- 15 minutes determined randomly by the program). There were therefore usually between six and nine diary entries per shift, depending on shift length. All ratings were done on analogue scales and the participants indicated their state by tapping with a stylus at the appropriate point on the scale. Participants rated their mood at that moment on 9 scales measuring how alert, tired, happy, stressed, angry, energetic, sad, frustrated and nervous they were (see the Electronic Supplementary Material (ESM), Appendix 1, for examples of the PDA displays). The mood adjectives were taken from Kamarck et al. [28] and have been used extensively in real time studies [29]. Following factor analysis (see data analysis section) NA was assessed by averaging stressed, angry, sad, frustrated and nervous and PA by averaging alert, happy and energetic. Further questions were mapped on the constructs central to the demand control and effort reward imbalance models i.e. demand/effort, control, and reward. Demand/effort was assessed by asking how hard and how fast participants had worked over the previous 10 minutes. The two scales, which correlated 0.77, were averaged. There is considerable overlap between the concepts of 'demand' and 'effort' in how they are usually measured. They were therefore treated as a single construct in the diary, in order to reduce measurement burden and confusion among the participants. Single scales were used to measure control ("control over work") and reward which was as operationalised as "work has been appreciated".

Data analysis

The 9 mood scales were factor analyzed to improve the reliability of the mood measures and reduce the risk of chance findings achieving significance if all 9 scales were analyzed separately. A principal components analysis followed by varimax rotation of the average scores for each participant on the 9 affect scales showed there to be two clear factors with Eigen values of 4.3 and 1.6. The first factor represented negative affect (NA), and consisted of the following adjectives (factor loadings in brackets); stressed (0.78), angry (0.86), sad (0.80), frustrated (0.83) and nervous (0.76) and factor two captured positive affect (PA) and consisted of alert (0.78), happy (0.77) and energetic (0.90). The scale "tired" loaded moderately on both factors (0.39, -0.48) and was not included in the factors. Stone et al. [30] also classified similar mood scales used in a form of real time measurement into NA, PA and a single item measure of tiredness.

To confirm the applicability of the factor analysis at the level of an individual entry, the data were analyzed for separate occasions of measurement. There was sufficient data for analysis from the first 6 measurements on each of the three shifts. The same factor structure was seen across the 18 factor analyses with factor 1 representing NA and factor 2 PA. On the individual measurement occasions, Cronbach alphas for NA ranged between .74 and .87 with a median of .81. For PA alpha varied between .61 and .76 with a median value of .70. The validity of such EMA measurement does not depend on it relating closely to questionnaire equivalents but some degree of positive relationship might be expected. The PANAS [26] questionnaire measures of NA and PA were related to their EMA equivalent using multilevel modeling in models with 3 levels, participant, shift and time within shift (see below). The intercept was random at all levels. The scores were standardized to indicate the size of the relationships more clearly. NA assessed by questionnaire related positively to the EMA measure ($\beta = .313$, SE = .046 $p<.001$) as did PA ($\beta = .288$, SE= .044, $p<.001$).

The main analyses were conducted using MLwiN V 2.18 and V 2.22. Statistical testing was based on multilevel linear modeling [31]. We tested 3-level models in which the EMA measures at each observation (Level 1) were nested within shifts (Level 2) which were nested within participants (Level 3). The Level 1 variables were diary captured demand/effort, reward, control, NA, PA, shift and the time into the shift when the measure was taken, with the start of the shift taken as zero time. The PDA software converted the analogue values to scores between 0 and 100 and following Johnston et al. [25] the diary scores for demand/effort, control and reward were rescaled into 1-5 when used as predictor variables. This led to more interpretable regression models.

The demand control and effort reward imbalance models were examined in an analysis with two main effects (demand/effort and either control or reward) and interaction terms representing demand/effort by control and demand/effort by reward. The main dependent variables were NA and PA; in addition the models were tested on the 5 individual items making up the NA scale, see ESM Appendix 2. The intercept was always treated as a random effect at all levels. The regression slopes of the relationship between main predictor variables and the outcome (NA or PA) were allowed to vary randomly between participants, i.e. the degree and direction of relationship between predictor and outcome was not required to be the same in all participants. To illustrate this, plots were obtained of the individual regression lines for each participant predicting the outcome from selected predictors. This standard procedure is described by Hox [30], page 28-30 and is available in MLwiN, [32], page 57-67. The control variables of shift and time into shift were treated as fixed. The predictor variables were centered within participants since we were primarily interested in the relationships within an individual over the period of real time measurement. Most of the repeatedly measured data was moderately autocorrelated. A multilevel model including autocorrelation between occasion level residuals was used, as described by Rasbash et al. [33]. The alpha level was set at $p<.01$ with Bonferroni correction.

Results

Demographic details of participants are shown in Table 1. Their average age was 39.1 (range 21-62 years). Over the three shifts 5522 diary entries were requested and 4475 completed (a missing entry rate of 18.9%). Removal of obvious errors, such as when all ratings for an entry were set to 0 or end of shift entries completed at the start of the next shift, reduced this to 4259 regular diary entries. The correction for time series effects requires complete data at each time point and this reduced the final number of observations to 4237 from 254 participants across the 3 shifts, an average of 16.8 entries per participant (range 1 to

29). Missing data were not imputed. Thirty two participants provide data for only 2 shifts and 10 for only one; all were included in the analyses. The average values for the sample including overall and within subject standard deviations, bivariate correlations and intraclass correlations are shown in Table 2.

The demand control model was examined in a model that included shift, time into shift and demand/effort, control and the demand/effort by control interaction, see Table 3. The fixed effects show that NA increased as demand/effort increased, diminished as control increased and the demand/effort by control interaction was significant. A simple slopes plot is shown in Figure 1(a). As predicted, control moderated the effect of demand/effort. The consistency of all the effects in this model was very high with the estimates suggesting that the model applies to over 90% of nurses. The variance estimates show that the slopes for demand/effort and control varied reliably between participants. This is illustrated in Figure 2(a) in which the individual regression slopes of NA on demand/effort are shown; for clarity the intercept was fixed for this plot. It can be seen that demand/effort was associated with much greater increases in NA in some participants than others but in virtually all participants the slope was positive. Demand/effort was associated with an increase in PA, as was control. Control did not moderate the effects of demand/effort on PA.

The results of modeling the effort reward imbalance model are shown in Table 4. Reward was related to decreased NA and moderated the effect of demand/effort on NA as predicted (see Figure 1(b) for simple effects plot), although the effect was not very consistent as it was estimated that over 30% of nurses do not show it. The individual regression slopes of this interaction are shown in Figure 2(b). This interaction has a negative slope (see the fixed effects details in Table 4) but some participants showed markedly different relationships to the sample as a whole. While most individual slopes are negative, the positive slopes suggest that in a few individuals high reward in combination with high demand/effort produced the greatest NA. Reward was associated with increased PA and did not moderate the effect of demand/effort on PA

Discussion

In a sample of nurses measured frequently over 3 work shifts, PDA based EMA methods were able to assess work related affect and its putative determinants. In within participant analysis a summary measure of NA related positively to demand/effort, negatively to control and control moderated the effects of demand/effort. PA related positively to demand/effort and control. Periods of increased perceived reward were associated with less NA and greater PA and reward moderated the effects of demand/effort on NA.

The primary aim of this report was to determine if the processes known to predict the differences between people in work related stress also operate within people, nurses in this case. It appears that they do. Models of occupation stress are primarily concerned with the negative effects of the work situation and make the clearest predictions for negative emotions. Within the nurses in this study NA was related as predicted to factors identified by leading theorists as critical. NA was highest at periods of high demand/effort, low control and low reward. As well as specifying the factors thought to determine stress both Karasek and Siegrist [7, 8] specify the relationship between these factors with control moderating the effect of demand (Karasek) and reward moderating the effect of effort (Siegrist). Both effects were seen in relation to NA which was at its highest when demand/effort was high and control or reward low. This is a very powerful demonstration that the models of occupational stress that have been applied between people also apply within individuals over the working day. This finding also confirms the results of an earlier much smaller and more limited study [25]. Neither control nor reward moderated the effects of demand/effort on PA.
Interestingly, and unexpectedly, demand/effort was associated positively with PA. This

indicates that demand/effort has both good and bad aspects since it is associated with high negative and positive affect in the majority of nurses.

The demonstration that the same relationships hold within individuals as between them is of importance. The results of the fixed effects aspects analysis suggest that the relationships obtained are not trivial. Of equal importance to the size of these effects is the consistency of these relationships. Both theoretically and practically it is important to know if these relationships are found in most nurses. The estimates of the percentage of the sample showing the predicted relationships suggest that most of the effects occur in at least 80% of nurses. The consistency of the expected relationships was particularly strong for the factors examined in the tests of the demand control model with NA. When the moderating effects of control are allowed for the positive effect of demand/effort, the negative effect of control and its moderating effect were all seen in over 90% of nurses. This is a very powerful demonstration of the applicability of the demand control model within individuals. The effort reward imbalance model did not fit the data so consistently, with the expected moderating effect of reward being seen in less than 70 percent. However we caution against a premature decision that the effort reward imbalance model is less applicable within nurses. We asked participants to rate how "appreciated" they felt and while this captures aspects of reward it is unlikely to encompass the complete concept, many aspects of which do not vary over short time periods. Moreover reward was a strong, consistent predictor of PA and so is clearly not a trivial variable. We think it best to interpret these findings as showing that perceptions of reward are important correlates of affect within people and that reward is worthy of further study.

While the model fit was good within most individuals, the degree of relationships varied between people and a minority of participants did not show the expected effects. This is important both theoretically and practically. Theoretically one needs to know why some individuals show counter theoretical relationships. Why, for example, do some people in conditions of high demand/effort report more NA when they perceive that they are being rewarded more? This could relate to aspects of their personality (are they cynical individuals for example) or it could relate to the particular circumstances that led to the reward, perhaps an obviously distressed nurse elicits appreciative (rewarded) behavior from a patient or colleague. These are questions for future research on the personal and situational factors that moderate the relationships shown in this study. The practical implication is that while it may be of benefit to many if nursing could be made less demanding or the nurse provided with more reward, a significant few might not benefit and may even be disadvantaged.

We consider that the diaries were practical. EMA measurement is a compromise between coverage of the areas of interest, psychometric soundness and practicality. The average time for EMA diary entries was under 50 seconds so little time was spent on this aspect of the diaries. Systematic data was obtained that interrelated as predicted. Data completion rates were high with over 80% of entries completed. This is impressive if one recalls that the participants were nurses working on busy medical and surgical wards. Rutledge et al. [29] report a similar figure in an EMA study of a mixed group of physicians and nurses. There was substantial variation between hospitals in completion rates with the highest being over 90% while the lowest was just over 70%. It is not possible to determine the cause of this variation since the staff running the study varied between hospitals and the hospitals differed in their characteristics. It is our impression that completion rates are higher when, unremarkably, the researcher administering the PDA emphasizes the importance of attempting to complete all entries but differences in organization climate between hospitals are also likely to be important. We consider that this study has many positive features including the substantial sample of nurses of all grades assessed over many measurement occasions in the work environment and the high completion rate. The obvious limitation is that predictor and outcome were measured at the same time using one instrument. Clearly one cannot draw causal conclusions from this study. However the detailed pattern of the results, the support for the theoretical predictions, particularly the support for the moderating effects of control and reward, and the different results with different outcome measures strongly suggest that the findings are not primarily due to common method variance. In addition we have shown in this sample that serious incidents (identified by the participant at the end of the shift) were associated with a subsequent increase in NA [27]. Future work should attempt to obtain separate, ideally objective, measures of the work situation and the participants' stress related responses. The low rate of volunteering for the study, 16%, is also a concern. The nature of the sample can powerfully affect how well mean values generalize to the true population but has a smaller effect on the interrelationship between measures which is, of course, the focus of this study. Nevertheless in future studies it would be very helpful if EMA measurement could be made attractive to more nurses.

Conflict of interests statement The authors have no conflicts of interests to disclose.

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Table 1
Demographic details of sample

	N	%
Gender		
Female	200	87.3
Male	29	12.7
Marital Status		
Single	67	29.5
Married	124	54.6
Divorced/Separated	18	7.9
Other	18	7.9
Nursing Grade		
5	168	74.0
6	32	14.1
7	27	11.9
Ward		
Medical	179	70.2
Surgical	32	29.8
Shift Pattern		
Fixed days	20	8.7
Fixed nights	7	3.1
Rotating shifts (no nights)	36	15.7
Rotating shift (including nights)	166	72.5

Notes
Demographic details may not sum to N=233 due to missing data.
In UK grade 5 nurses are junior staff nurses, grade 6 senior staff nurses, grade 7 are charge nurses.

Table 2. Means, between and within participant standard deviations, intraclass correlations and bivariate correlations for the ecological momentary assessment measures.

	Mean	SD (between)	SD (within)	ICC	Correlations*				
Measure					NA	PA	D/E	C	R
Negative Affect (NA, 0-100)	15.61	17.21	6.24	0.43	1.00				
Positive Affect (PA, 0-100)	60.92	23.38	6.77	0.44	-0.18	1.00			
Demand/Effort (D/E, 1-5)	3.62	1.43	1.03	0.17	0.27	0.11	1.00		
Control (C, 1-5)	3.93	1.38	0.85	0.28	-0.21	0.24	0.16	1.00	
Reward (R, 1-5)	3.23	1.51	0.83	0.40	-0.14	0.24	0.23	0.42	1.00

*All correlations significant p<.001

Table 3. Fixed and random effects of demand/effort, control and interaction of demand/effort by control on negative affect and positive affect.

Predictor	Estimate Beta Weight	SE	Standardized Estimate β	Percentage showing effect#
		Fixed Effects		
		Negative Affect		
Intercept (I)	15.91	0.89	-	-
Shift	-0.53	0.35	-0.03	-
Time into shift	0.18	0.06	0.04	-
Demand/effort (D)	2.26**	0.18	0.19	90.8
Control (C)	-2.72**	0.22	-0.22	91.8
DxC	-0.90**	0.11	-0.10	93.3
		Positive Affect		
Intercept	67.86	1.18	-	-
Shift	-0.58	0.44	-0.02	-
Time into shift	-1.51	0.08	-0.23	-
Demand/effort (D)	1.80**	0.30	0.11	70.8
Control (C)	2.80**	0.25	0.17	91.8
DxC	-0.40	0.17	-0.03	-

Random Effect Variances

		Estimate Variance	SE
	Negative Affect		
Level 3: Person	Var (I)	136.8	14.03
	Var (D)**	2.89	0.65
	Var (C)**	3.80	0.89
	Var (DxC)	0.36	0.22
Level 2: Shift	Var (I)	11.82	4.04
Level 1: Time into Shift	Var (I)	118.7	3.97
	Alpha^	39.06	3.68
	Positive Affect		
Level 3: Person	Var (I)	254.5	25.59
	Var (D)**	10.8	1.80
	Var (C)**	4.04	1.24
	Var (DxC)**	1.81	0.52
Level 2: Shift	Var (I)	3.39	6.64
Level 1: Time into Shift	Var (I)	218.3	7.38
	Alpha^	82.25	6.73

** $p<.003$; nominal alpha $p<.01$ Bonferroni corrected for 3 simultaneous tests.
# Estimated from the random effects variance if fixed effect significant and appropriate random effect included in the model. ^Alpha is a time series parameter and the covariance between two observations t time units apart is alpha*1/t.

Table 4. Effects of demand/effort, reward and demand/effort by reward interaction on negative affect and positive affect.

Predictor	Estimate Beta Weight	SE	Standardized Estimate β	Percentage showing effect#
		Fixed Effects		
		Negative Affect		
Intercept (I)	16.03	0.89	-	-
Shift	-0.80	0.35	-0.04	-
Time into shift	0.19	0.06	0.04	-
Demand/effort (D)	2.31**	0.19	0.19	91.4
Reward (R)	-2.17**	0.24	-0.19	80.9
DxR	-0.59**	0.15	-0.08	67.5
		Positive Affect		
Intercept	67.87	1.18	-	-
Shift	-0.51	0.42	-0.02	-
Time into shift	-1.52	0.08	-0.23	-
Demand/effort (D)	1.61**	0.29	0.10	69.5
Reward (R)	3.08**	0.29	0.20	87.0
DxR	-0.21	0.22	-0.02	-

Random Effect Variances

		Estimate Variance	SE
		Negative Affect	
Level 3: Person	Var (I)	135.4	13.99
	Var (D)**	2.87	0.68
	Var (R)**	6.15	1.20
	Var (DxR)**	1.70	0.41
Level 2: Shift	Var (I)	12.19	4.17
Level 1: Time into Shift	Var (I)	120.1	4.06
	Alpha ^	40.43	3.77
		Positive Affect	
Level 3: Person	Var (I)	255.0	25.51
	Var (D)**	9.9	1.75
	Var (R)**	7.46	1.72
	Var (DxR)**	4.17	0.90
Level 2: Shift	Var (I)	1.13	6.38
Level 1: Time into Shift	Var (I)	212.0	7.25
	Alpha^	78.17	6.66

** $p<.003$; nominal alpha $p<.01$ Bonferroni corrected for 3 simultaneous tests.
# Estimated from the random effects variance if fixed effect significant and appropriate random effect included in the model. ^Alpha is a time series parameter and the covariance between two observations t time units apart is alpha*1/t.

Figure 1(a)

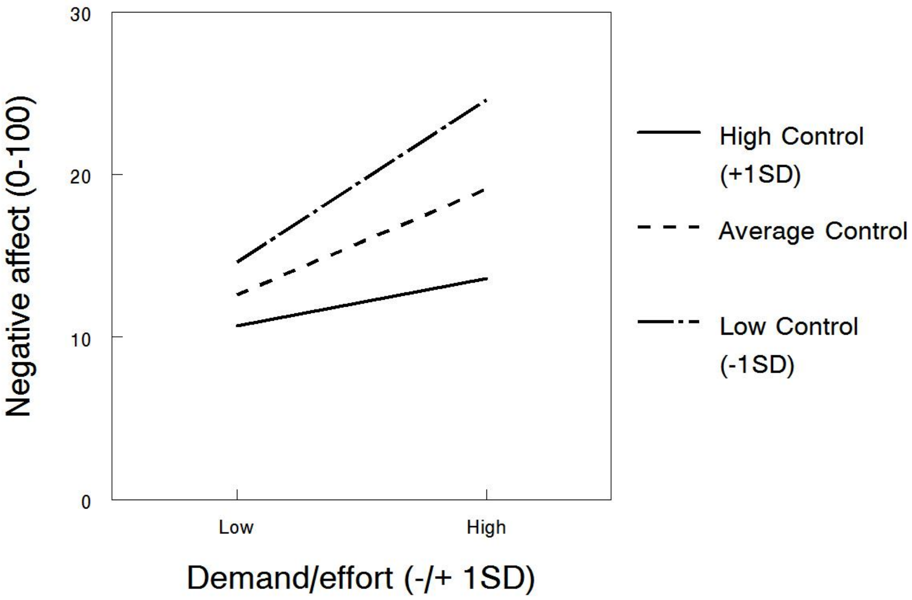


Figure 1(b)

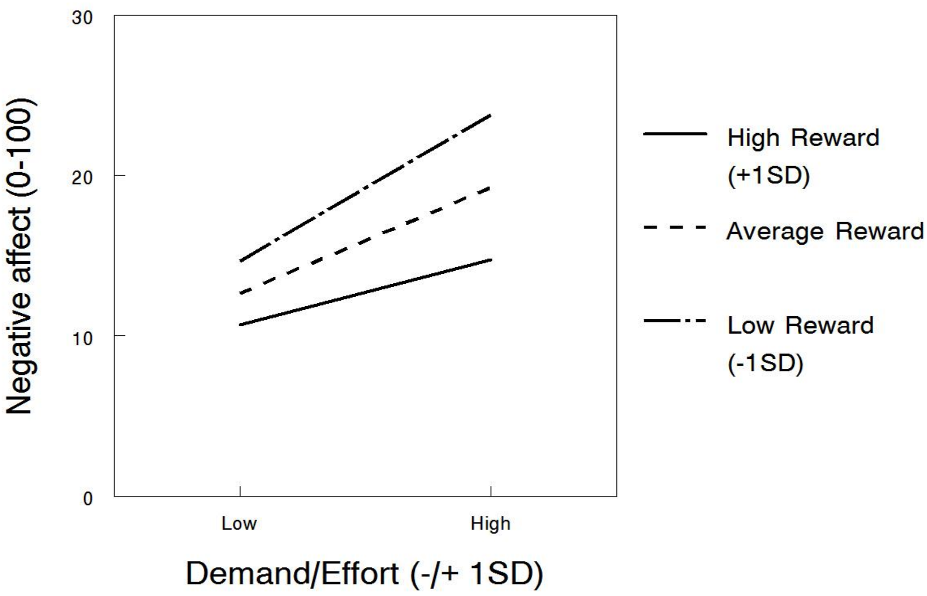


Figure 2(a)

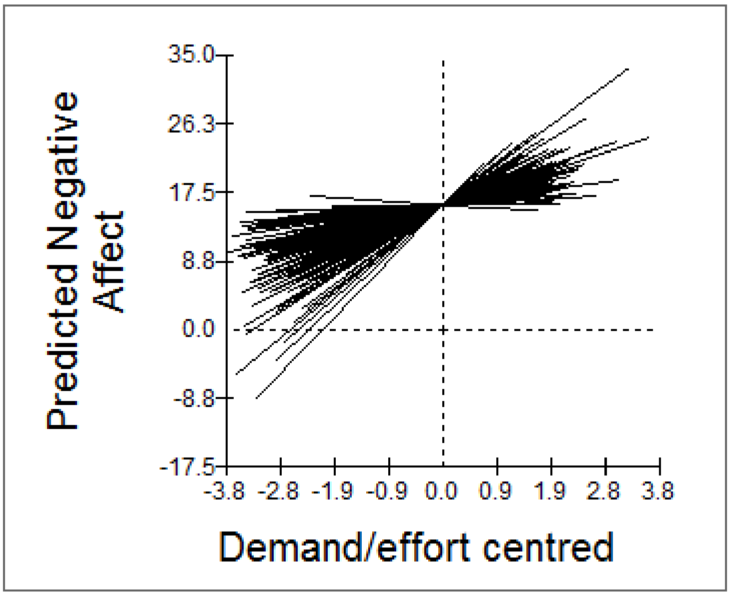
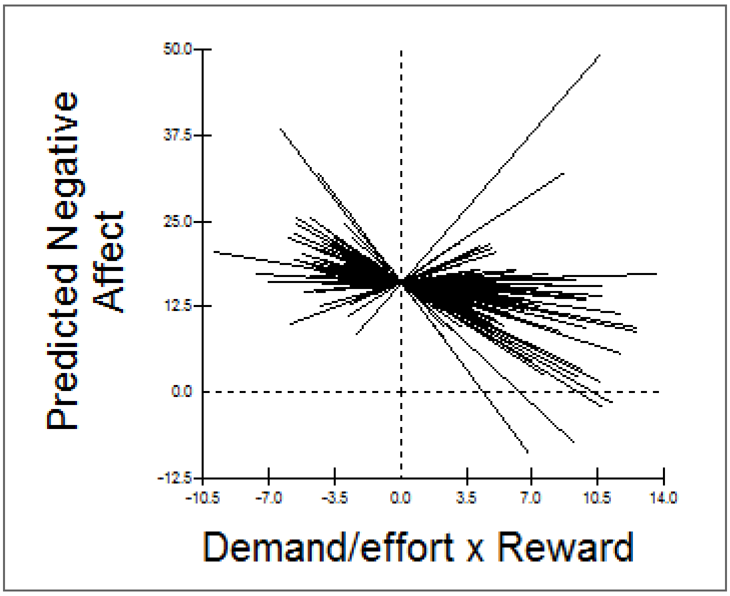


Figure 2(b)



Captions for Figures

Figure 1 (a, b). Plots of the interactions between the predictors on negative affect. (a) demand/effort by control, (b) demand/effort by reward.

Figure 2 (a b). Plots of individual regression slopes of negative affect on predictor variables. (a) Negative affect on demand/effort. (b) Negative affect on interaction of demand/effort and reward.