INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.
Functional components of social support and cellular immune response: Individuals high in appraisal support are characterized by enhanced immune function

Uchino, Bert N., Ph.D.

The Ohio State University, 1993
FUNCTIONAL COMPONENTS OF SOCIAL SUPPORT AND CELLULAR IMMUNE RESPONSE: INDIVIDUALS HIGH IN APPRAISAL SUPPORT ARE CHARACTERIZED BY ENHANCED IMMUNE FUNCTION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

By

Bert N. Uchino, B.A., M.A.

* * * * *

The Ohio State University
1993

Dissertation Committee: John T. Cacioppo
Janice K. Kiecolt-Glaser
Richard E. Petty
William von Hippel

Approved by

Advisor

Department of Psychology
ACKNOWLEDGEMENTS

This dissertation marks the attainment of a long-term personal goal. There are many people, however, who have been instrumental in the process. First, I would like to express my sincere appreciation to Dr. John T. Cacioppo for being my advisor, colleague, and friend. He has skillfully and patiently guided me in my academic pursuits and facilitated my personal growth. I owe much to his influence. I would also like to express my appreciation to Dr. Janice K. Kiecolt-Glaser for her expert insight on our collaborative projects. Much of our research could not have been done without her guidance. Gratitude is expressed to Drs. John T. Cacioppo, Janice K. Kiecolt-Glaser, Richard E. Petty, and William von Hippel for their willingness to be on my dissertation committee and for their helpful suggestion and comments.

The collaborative efforts of Drs. John T. Cacioppo, Ronald Glaser, Janice K. Kiecolt-Glaser, William Malarkey, Dennis Pearl, and Sandra Sgoutas-Emch on this program of research is gratefully acknowledged. Appreciation is also expressed to Dave Lozano, Kathlene Merendo, the nursing staff of the Clinical Research Center, Sue Mosely,
Julianne Dornes, Leigh Ann Kutz, Karen Brown, Hsiao-yin Mao, and Marco Vasquez for their assistance at various stages of this research project. I would also like to thank Steve Crites, Wendi Gardner, Jeff Feinstein, Dave Klein, Mary Snydersmith, and Karen Quigley for their constructive comments. Special thanks to the social psychophysiology lab members and the social psychology area for creating a challenging and supportive academic environment.

I also wish to express much love to my sister Debbie and her husband Morio, my brother Derek and his wife Yoko and his daughter Denise, my sister Dawn and her husband Jason, my friend Teri Horibe and her parents Arthur and Helen Horibe, and special friends Jeff Chung, Steve Crites, Irv Culpepper, Glenn Nochi, Sean Okumura, and Joe Priester. My growth is a reflection of their influence. I would especially like to acknowledge my parents Harold and Evelyn Uchino for their unconditional love and support. I now know more than ever that I would not have achieved my goals without their influence. Finally, thank you God for life and the pursuit of my dreams.
VITA

April 6, 1966 .................. Born - Honolulu, Hawaii

1989 ......................... B.A., University of Hawaii at Manoa, Honolulu, Hawaii

1991 ......................... M.A., The Ohio State University, Columbus, Ohio

1990-1992 .................... Graduate Research Associate, Caregiver Research Project, The Ohio State University, Columbus, Ohio

PUBLICATIONS


FIELDS OF STUDY

Major Field: Psychology
TABLE OF CONTENTS

ACKNOWLEDGEMENTS ........................................ ii
VITA .......................................................... iv
LIST OF TABLES ........................................ vii
LIST OF FIGURES ........................................ viii

CHAPTER

| I. SOCIAL SUPPORT AND CELLULAR IMMUNE RESPONSE | PAGE |
| IN MEN .................................................... | 1 |
| Introduction ........................................... | 1 |
| Method .................................................. | 14 |
| Results .................................................. | 20 |
| Discussion ............................................. | 32 |

| II. SOCIAL SUPPORT AND CELLULAR IMMUNE RESPONSE | PAGE |
| IN WOMEN: A REPLICATION AND EXTENSION ........... | 35 |
| Introduction ........................................... | 35 |
| Method .................................................. | 37 |
| Results .................................................. | 41 |
| General discussion .................................... | 57 |

NOTES ........................................................ 70

APPENDICES

A. Table 7: Social relationships and immune function ........................................ 72

B. Experimental questionnaires for studies 1 and 2 ......................................... 85

REFERENCES .................................................. 96
### LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. STUDY 1 MEAN IMMUNE BASELINE AND REACTIVITY MEASURES</td>
<td>21</td>
</tr>
<tr>
<td>2. STUDY 1 CORRELATIONS BETWEEN SOCIAL SUPPORT AND BASELINE IMMUNE MEASURES</td>
<td>24</td>
</tr>
<tr>
<td>3. STUDY 1 CORRELATIONS BETWEEN SOCIAL SUPPORT AND MEASURES OF IMMUNE REACTIVITY</td>
<td>25</td>
</tr>
<tr>
<td>4. STUDY 1 CORRELATIONS BETWEEN SOCIAL SUPPORT AND PERSONALITY VARIABLES</td>
<td>30</td>
</tr>
<tr>
<td>5. STUDY 2 CORRELATIONS BETWEEN SOCIAL SUPPORT AND BASELINE IMMUNE MEASURES</td>
<td>42</td>
</tr>
<tr>
<td>6. STUDY 2 CORRELATIONS BETWEEN SOCIAL SUPPORT AND PERSONALITY VARIABLES</td>
<td>45</td>
</tr>
<tr>
<td>7. SOCIAL RELATIONSHIPS AND IMMUNE FUNCTION</td>
<td>72</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PATH ANALYSIS EXAMINING THE POTENTIAL MEDIATIONAL INFLUENCE OF ALCOHOL CONSUMPTION ON THE RELATIONSHIP BETWEEN APPRAISAL SUPPORT AND CON A</td>
<td>27</td>
</tr>
<tr>
<td>2. HYPOTHETICAL PATH MODEL DEPICTING THE MEDIATIONAL INFLUENCE OF DEPRESSION ON THE ASSOCIATION BETWEEN SOCIAL SUPPORT AND IMMUNE FUNCTION</td>
<td>47</td>
</tr>
</tbody>
</table>
THE POTENTIAL MEDIATIONAL INFLUENCE OF DEPRESSION ON THE RELATIONSHIP BETWEEN APPRAISAL SUPPORT AND PERCENT CD8⁺.


These developments suggest that social relationships, or the relative lack thereof, constitute a major risk factor for health — rivaling the effects of well-established health risk factors such as cigarette smoking, blood pressure, blood lipids, obesity, and physical activity. Indeed, the theory and evidence on social relationships and health increasingly approximate that available at the time of the U.S. Surgeon General's 1964 report on smoking and health (10), with similar implications for future research and policy (House, Umberson, & Landis, 1988, p. 541).

A large body of literature currently exists suggesting that poor social relationships are related to increased morbidity and mortality (see reviews by Broadhead, Kaplan, James, Wagner, Schoenbach, Grimson, Heyden, Tibblin, & Gehlbach, 1983; House, Landis, & Umberson, 1988). For example, Blazer (1982) obtained measures of social support in a stratified random sample of older adults. A 30 month follow-up assessment revealed that perceptions of social support were strong predictors
of mortality rates, even after controlling for standard risk factors (e.g., age, health status etc.). That is, individuals with relatively high perceptions of support had lower mortality rates compared to individuals relatively low in perceived support. House et al. (1988) also reviewed evidence from six large prospective studies indicating higher mortality rates for individuals who were more socially isolated (e.g., Kaplan, Salonen, Cohen, Brand, Syme, & Puska, 1988; Orth-Gomer & Johnson, 1987).

An important and relatively unexplored issue concerns the physiological mechanisms that are responsible for such long-term health consequences (Kiecolt-Glaser & Glaser, 1989; Uchino, Kiecolt-Glaser, & Cacioppo, 1992). A recent meta-analysis conducted by Herbert and Cohen (in press) suggest that interpersonal stressors (e.g., bereavement) appear to be associated with the most negative immune changes. In the present research, we use cellular immune function as a window through which to investigate the potential long-term health consequences of social relations.

The Immune System as a Potential Physiological Mechanism Linking Social Support and Health

The immune system is generally responsible for the body's defense against infectious and malignant disease (see Kiecolt-Glaser & Glaser, 1988a; Calabrese, Kling, &
Gold, 1987; Borysenko, 1987 for basic introductions to the immune system). Most cells of the immune system are located in the thymus, bone marrow, lymph nodes, spleen, tonsils, appendix, and Peyers' patches. Due to the diverse location of immune cells, circulating blood plays an important role in transporting immune cells between organs and to sites of antigens.

A distinction has classically been made between two major responses of the immune system: the humoral immune response and cellular immune response. The humoral immune response refers to the function of B-lymphocytes that proliferate and produce antibodies and immunoglobins to combat bacteria and viruses in body fluids. The cellular immune response consists of helper T-cells and suppressor T-cells that are critical in defending against intracellular viruses, transplanted tissue, cancer cells, fungi, and protozoans. When confronted with an antigen, helper T-cells proliferate and induce B-lymphocytes to produce antibodies. When sufficient antibodies are produced, suppressor T-cells act as regulators to turn off the activity of helper T-cells. Helper T-cells also aid in the proliferation of cytotoxic T-cells that destroy invading cells by migrating to the invasion site and producing cytotoxic factors when attached to the invading cell. Natural killer cells are another important
component of the cellular immune response and serve to defend against cancerous and virus-infected cells.

Although there is no single generally accepted measure of immunocompetence, researchers in the field of psychoneuroimmunology (PNI) have utilized various measures to index immune function. A distinction has typically been made between quantitative and functional measures of the immune system (Kiecolt-Glaser & Glaser, 1989). Quantitative measures include absolute counts or percents of important immune cells such as helper T-cells, suppressor T-cells, and natural killer cells. Although the relationship of such quantitative measures to health outcomes are not clear, these measures are typically examined because both the number and relative balance of immune cells (e.g., ratio of helper T-cells to suppressor T-cells) are important in mounting an effective immune response (Herbert & Cohen, in press). Functional measures examine the performance of immune cells under challenge. One common measure is the blastogenic response of lymphocytes to the plant mitogens concanavalin A (Con A) and phytohemmaglutinin (PHA). Blastogenesis provides an in vitro model of lymphocyte proliferation in response to antigens. Con A appears to stimulate both helper and suppressor T-cells, whereas PHA appears to primarily stimulate helper T-cells (Reinherz & Schlossman, 1980).
In general, greater proliferation is interpreted as a better immune response. In addition, measures of natural killer cells activity (NKCA) are taken by incubating NK cells with tumor cells and examining the ability of NK cells to lysis (i.e., destroy) tumor cells. Greater NK cell activity is also thought to reflect a better immune response.

It is important to note that social relationship have been associated with alterations in the immune system (see Table 7 in Appendix A for an overview). The loss of important social relations appear reliably linked to negative changes in immune function (e.g., Bartrop, Luckhurst, Lazarus, Kiloh, & Penny, 1977; Schleifer, Keller, Camerino, Thornton, & Stein, 1983; Kiecolt-Glaser, Fisher, Ogrocki, Stout, Speicher, & Glaser, 1987a; but see Spratt & Denney, 1991). Bereaved individuals, for instance, evidence suppressed lymphocyte proliferation to the mitogens Con A and PHA compared to pre-bereavement baselines (Schleifer, Keller, Camerino, Thornton, & Stein, 1983), and lonely individuals have been characterized by higher antibody levels of the Epstein-Barr virus (EBV), presumably reflecting poorer cellular immune regulation (Glaser, Kiecolt-Glaser, Speicher, & Holliday, 1985), lower NKCA (Kiecolt-Glaser, Garner, Speicher, Penn, Holliday, & Glaser, 1984a; Kiecolt-Glaser, Ricker, George,
Messick, Speicher, Garner, & Glaser, 1984b), and decreased blastogenic response to PHA (Kiecolt-Glaser et al., 1984b).

Marital disruptions also appear to be associated with changes in immune function. Kiecolt-Glaser et al. (1987a) examined the influence of marital quality and marital disruption (e.g., divorce) on subsequent immune function. Women in relatively poor marriage evidenced lower blastogenic response to both PHA and Con A than women in relatively good marriages. In addition, women in recently disrupted marriages (i.e., separation for 1 year or less) were characterized by lower blastogenic responses to PHA and Con A, increased antibody levels of the EBV, and lower percent NK cells and helper T-cells compared to married women (also see Kiecolt-Glaser, Kennedy, Malkoff, Fisher, Speicher, & Glaser, 1988).

In an attempt to examine the potential interpersonal mechanisms by which marriages may have an influence on immune function, Kiecolt-Glaser, Malarkey, Chee, Newton, Cacioppo, Mao, & Glaser (in press) examined 90 newlywed couples engaged in a marital conflict discussion task. Importantly, negative, but not positive behaviors during the conflict task, were consistently related to immune function. Negative behaviors during the conflict task were associated with decreased blastogenic response to
PHA, Con A, and T3; decreased NKCA and percent macrophages; increased total T-lymphocytes, helper T-cells, and helper to suppressor ratio 24 hours later compared to a baseline assessment. Kiecolt-Glaser et al. (in press) suggest that these immune differences may represent the ability of low negative affect couples to buffer the stressfulness of their shared experiences during the course of the study.

To our knowledge, only a limited number of studies have directly examined the association between social support and immune function (Thomas, Goodwin, & Goodwin, 1985; Baron, Cutrona, Hicklin, Russell, & Labaroff, 1988; Jemmott & Magloire, 1988; Theorell, Orth-Gomer, & Eneroth, 1990; Kiecolt-Glaser et al., 1991; Glaser, Kiecolt-Glaser, Bonneau, Malarkey, Kennedy, & Hughes, 1992; Levy, Herberman, Whiteside, Sanzo, Lee, & Kirkwood, 1990; McNaughton, Smith, Patterson, & Grant, 1990; Schlesinger & Yodfat, 1991). These studies are conceptually consistent with prior research on social relationships and immune function by indicating that higher levels of social support are associated with greater immunocompetence. For example, Baron et al. examined the association between social support and immune function in 23 spouses of cancer patients. High levels of social support were associated with increased blastogenic response to PHA and increased
NKCA, whereas no differences as a function of social support were found for Con A, percent of T-lymphocytes, and total lymphocytes.

**Social Support as a Multi-dimensional Construct**

Much of the early research has implicitly conceptualized social support as a unidimensional construct. For example, studies on social support and mortality have relied primarily on general measures of social integration or perceptions of overall support. It has become increasingly evident, however, that social support may best be conceptualized as a multi-dimensional construct (e.g., Cohen & McKay, 1984; Cutrona & Russell, 1989). The importance of a multi-dimensional social support construct arises from the view that under certain conditions, some forms of support may be relatively more effective than others (Cutrona & Russell, 1989). For example, Cutrona & Russell (1989) argue that uncontrollable life events are more likely to elicit emotion-focused coping. Therefore, emotional support may be a more effective support resource for uncontrollable events.

Cohen, Mermelstein, Kamarck, & Hoberman (1985) list four functional components of perceived social support that are important when faced with stressors: (1) appraisal, the availability of someone to talk to about
problems, (2) tangible, the availability of material aid, (3) belonging, the availability of people to do things with, and (4) self-esteem, the availability of a positive comparison when comparing the self with others. There are several complexities when examining specific social support components that should be noted. First, many life events may require more than one form of support. Thus, the separation of support components in the real world may be difficult. In addition, there are some forms of support that may be important for most life events. For example, Cohen & Wills (1985) argue that appraisal and self-esteem support may be universally beneficial because people can always benefit from useful information or reassurances of their worth. Results are generally consistent with this notion, particularly in the case of appraisal support (Cohen et al., 1985).

It is important to note that only one study examined multiple functional components of social support and its relationship to immune function (Baron et al., 1988). Baron et al. (1988) found that the relationships between social support and immune function were consistent across different support types. However, the authors note that caring for a spouse with cancer may have acted to mobilize others in their support networks such that a high level of support was being received on all components.
Personality and Perceptions of Social Support

An important theoretical question is the extent to which perceptions of social support are confounded with personality measures (Lakey & Cassady, 1990; Connell & D’Augelli, 1990; Bolger & Eckenrode, 1991; Kessler, Kendler, Heath, Neale, & Eaves, 1992). For example, Bolger and Eckenrode (1991) suggest that neuroticism may lead to lower perceptions of social support via mood induced biases (e.g. negativity bias). Consistent with their mood bias explanation, Bolger and Eckenrode (1991) reported that the beneficial effects of perceived social support on examination anxiety were nonsignificant when statistically controlling for personality variables such as neuroticism. Therefore, investigations of the effects of social support on immune function may need to consider the potential role of personality variables.

Overview

As part of a larger program project on individual differences in physiological reactivity, Study 1 assessed immune function in 22 undergraduate males both during rest, and in response to 12 minutes of acute psychological stress (i.e., mental arithmetic). Physiological reactivity to acute psychological stressors provides information on an individual’s reactivity to daily hassles and stressors (Turner, 1989). All participants also
completed the interpersonal support evaluation list (ISEL) and personality measures of neuroticism and extraversion.

Study 1 attempted to address several limitations of the past literature on social support and immune function. First, to the best of our knowledge, only nine studies have examined the relationship between social support and cellular immune function (Thomas et al., 1985; Baron et al., 1988; Jemmott & Magloire, 1988; Theorell et al., 1990; Kiecolt-Glaser et al., 1991; Glaser et al., 1992; Levy et al., 1990; McNaughton et al., 1990; Schlesinger & Yodfat, 1991), and only Kiecolt-Glaser et al. (1991) have employed detailed measures of both quantitative and functional immune response. Therefore, one aim of Study 1 was to examine the association between social support and immune function using comprehensive measures of both quantitative and functional immune response. We expected that functional measures of the immune system at rest (e.g., blastogenic response to Con A) would evidence greater immunocompetence in individuals high in social support (Baron et al., 1988; Kiecolt-Glaser et al., 1991).

To our knowledge, only Baron et al. (1988) has examined the association between multiple functional components of social support and cellular immune response. In the current study, we utilized the interpersonal support evaluation list (ISEL) that contains information
on four functional components of social support. Therefore, a second aim of Study 1 was to examine the relationship between multiple components of social support and immune function. Due to the general importance of appraisal support (Cohen et al., 1985), we hypothesized that the appraisal component would predict basal immunocompetence. In addition, based on social support models that emphasize the importance of matching the stressor with support types (e.g., Cutrona & Russell, 1989), we expected that self-esteem support might be associated with lowered immune reactivity to the acute psychological stressor. In particular, the mental arithmetic stressor used in this study is likely to elicit feelings of failure or inadequacy, a situation in which self-esteem support is predicted to be especially beneficial (Cohen & McKay, 1984).

Finally, an important theoretical question is the extent to which perceptions of social support are confounded with personality measures (Lakey & Cassady, 1990; Connell & D’Augelli, 1990; Bolger & Eckenrode, 1991; Kessler, Kendler, Heath, Neale, & Eaves, 1992). For example, Bolger and Eckenrode (1991) suggest that neuroticism may lead to lower perceptions of social support via mood induced biases (e.g., negativity bias). None of the prior studies on social support and cellular
immune function has investigated the potential confounding influence of personality per se. Thus, we also examined the potential confounding influence of personality factors on perceptions of support and immune function. Based on past research on social relationships and physiological function that has taken into account potential negativity biases (Kiecolt-Glaser et al., 1991; Uchino et al., 1992; Uchino, Kiecolt-Glaser, & Cacioppo, in press), we hypothesized that personality per se will be unable to account for associations between social support and immune function.
Method

Subjects

Twenty-four undergraduate men were selected from an initial sample of forty-four because they were relatively low or high in heart rate reactivity to a speech stressor. Subjects received $25.00 for approximately 2.5 hours of participation in the study that was conducted at the Clinical Research Center (CRC) of the Ohio State University Hospital. The inclusion criteria for participation were that subjects: (a) were in good health, (b) were within 20% of their ideal body weight, (c) had no past history of psychological disorder, (d) had no past history of chronic illness and were not on any chronic medication, (e) did not use tobacco products, (f) consumed less than 10 alcoholic beverages a week, (g) had not experienced any recent negative life event (e.g., death in the family), and (h) were not math, speech, or needle phobic. Subjects were asked to refrain from ingesting anti-inflammatory agents, antihistamines, or alcohol up to 24 hours before their test day. Two subjects failed to participate in the CRC study, resulting in a sample of twenty-two individuals.

Procedure

The day before participation in the study, subjects were reminded to refrain from exercise and consuming
alcohol or non-prescription medication, and from eating or drinking anything except water after midnight. The study was run in the mornings and consisted of three components: (1) informed consent, explanation of the task, and insertion of an 18 gauge indwelling catheter into the antecubical vein of the subject’s arm; (2) 30 minute supine rest period followed by a baseline blood draw; (3) 12 minutes of mental arithmetic with random 100 dB noise blasts followed by a post-task blood draw.

The mental arithmetic task consisted of 12 minutes of serial subtractions which subjects performed without stopping. Subjects were told that any errors would be corrected by the experimenter and to continue on from the corrected number. In addition, subjects were prompted to speed up their responses at the start of minutes 2, 4, and 6. The serial subtraction problems were as follows:

- minutes 1 and 2: 2907 by 3s,
- minutes 3 and 4: 6828 by 7s,
- minutes 5 and 6: 9561 by 13s,
- minutes 7 and 8: 5113 by 8s,
- minutes 9 and 10: 8318 by 14s,
- and minutes 11 and 12: 9994 by 17s.

During minutes 7 through 12, subjects were also presented with a random 100 dB noise blast administered via a headphone set. The experimenter explained to the subject that the noise blasts were intended to make the task more challenging.
The blood draws prior to and following the experimental stressor provided the materials for the immune assays. Complete blood counts (CBC and differentials) were performed by the Clinical Immunology Laboratory at the OSU hospital. Peripheral blood leukocytes were isolated by density gradient centrifugation on Ficoll-Metrazoate gradients from 40 cc of heparinized venous blood, washed with complete RPMI 1640 medium, counted, and then prepared for the following assays:

**NK cell activity (lysis).** The procedures used for NK cell activity in this study have been described in detail elsewhere (Glaser, Rice, Speicher, Stout, & Kiecolt-Glaser, 1986). In sum, cells were prepared at 100:1, 50:1, 12.5:1, 6.25:1, and 3.12:1 effector to target cell ratios and were seeded in triplicates, in 96-well microtiter plates (Costar Corp.). Additional wells containing only target cells (K562) in medium containing 1% sodium dodecyl sulfate were used to determine spontaneous and maximum release of radioactivity, respectively. NK lysis values were standardized at the 25:1 effector/target ratio using a logistic regression (Kazimer, Whisler, Stephens, Pearl, and Yates, 1989).

**Lymphocyte cell counts.** The percentage of NK, CD4⁺, and CD8⁺ were determined by flow cytometry using the
monoclonal antibodies, T4, T8, and NKH-1 (Coulter), respectively and using procedures from our laboratory (Kiecolt-Glaser et al., 1991). Cell culture supernants were assayed for lymphokines using commercially available kits from Genzyme, Inc. (Cambridge, MA). Absolute numbers were calculated by using the percentage of these cells and absolute number of lymphocytes taken from the complete blood counts.

Blastogenic response to Con A and PHA. The procedures used in this study are described in Kiecolt-Glaser et al. (1991). Cells were prepared (5 x 10^6) in complete RPMI 1640 medium, treated with concanavalin A (Con A) and phytohemmaglutinin (PHA) and incubated for 48 hours. The concentrations for Con A and PHA were 2.5, 5.0, 10.0, and 20.0 ug. All samples were run in triplicate and counts per minute were determined by averaging the triplicate samples and reported as the log 10 transformed values of the counts per minute. Due to technical problems, the blastogenic responses to PHA at the 5.0 ug concentration were not assayed.

It is also important to monitor the nutritional status of the subject to rule out changes in the immune response that are related to malnutrition. Therefore, we measured serum albumin at baseline, as described in Kiecolt-Glaser et al. (1991). Immunologic data are
excluded if serum albumin is out of the normal range. All subject's data, however, fell into the normal range.

Post-Experimental Questionnaires

Interpersonal Support Evaluations List (ISEL). The ISEL contains 40 questions (Cohen et al., 1985) and responses range on a 6 point scale (1 = I agree very much, 6 = I disagree very much). The ISEL measures the perceived availability of the following support resources: (1) appraisal, the availability of someone to talk to about problems, (2) tangible, the availability of material aid, (3) belonging, the availability of people to do things with, and (4) self-esteem, the availability of a positive comparison when comparing the self with others. Cohen et al. (1985) report that the internal consistency for the scales range from .60 to .92 with a four week test-retest reliability of .87 for the total scale, .87 for appraisal, .82 for belonging, .71 for self-esteem, and .80 for tangible. The reliability of the ISEL has also been established over a 6 month period.

As evidence for the beneficial effects of support, the ISEL has been shown to predict depression after controlling for social anxiety. Therefore, it does not appear that the ISEL is serving as a proxy for a related personality factor. In addition, a prospective study revealed that the ISEL was negatively related to
depression and psychiatric symptomology at time two, after partialling for time one criteria (Cohen et al., 1985). Cohen et al (1985) also note that there is a trend for appraisal support to have beneficial effects across studies.

Eysenck personality questionnaire (EPQ). The EPQ contains 90 T/F statements and measures the personality dimensions of extraversion, neuroticism, psychoticism, and lie (Eysenck & Eysenck, 1975). Only data for the extraversion and neuroticism subscales were collected in this study. Eysenck & Eysenck (1975) found that the one month test-retest correlations were typically in the .80 to .90 range, whereas the alpha coefficients were typically above .80. Moreover, correlations among the scales were low, ranging from -.23 to .07, suggesting that the EPQ is measuring different constructs (Eysenck & Eysenck, 1975).
Results

Preliminary Analyses

Participants in the current study were selected because they were relatively low or high in heart rate reactivity to a speech stressor. To examine any potential confoundings with our measure of social support, correlations were computed between the ISEL and heart rate reactivity to the speech stressor. Results revealed that heart rate reactivity was nonsignificantly related to components of the ISEL (r's -.13 to .10). Thus, it appears that the ISEL is not confounded with the selection factor used in the study.

We next examined the effectiveness of the acute psychological stressor on both quantitative and functional immune measures (see Table 1; Sgoutas-Emch, Cacioppo, Uchino, Malarkey, Pearl, Kiecolt-Glaser, & Glaser, in press). One-way (Period: Baseline vs. Stressor) within-subjects ANOVAs were conducted. Results revealed that the acute psychological stressor increased the number of circulating suppressor/cytotoxic T-cells (CD8\(^+\)), \(F(1,19) = 5.10, p < .04\), decreased both the ratio of CD4\(^+\) to CD8\(^+\), \(F(1,19) = 18.93, p < .001\) and the number of circulating NK cells, \(F(1,19) = 17.57, p < .001\), and increased NKCA, \(F(1,18) = 24.00, p < .001\). There was no significant
Table 1. Mean Immune Baseline and Reactivity Measures.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Baseline</th>
<th></th>
<th></th>
<th>Reactivity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>SEM</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>CD4⁺</td>
<td>20</td>
<td>663.79</td>
<td>57.20</td>
<td>20</td>
<td>-67.17</td>
</tr>
<tr>
<td>CD8⁺</td>
<td>20</td>
<td>306.80</td>
<td>35.59</td>
<td>20</td>
<td>61.41</td>
</tr>
<tr>
<td>CD4⁺/CD8⁺</td>
<td>20</td>
<td>2.77</td>
<td>0.45</td>
<td>20</td>
<td>-0.64</td>
</tr>
<tr>
<td>NK Cells</td>
<td>20</td>
<td>140.40</td>
<td>21.76</td>
<td>20</td>
<td>66.83</td>
</tr>
<tr>
<td>Con A 2.5 ug</td>
<td>22</td>
<td>4.60</td>
<td>0.02</td>
<td>22</td>
<td>-0.04</td>
</tr>
<tr>
<td>Con A 5.0 ug</td>
<td>22</td>
<td>4.68</td>
<td>0.03</td>
<td>22</td>
<td>-0.02</td>
</tr>
<tr>
<td>Con A 10.0 ug</td>
<td>22</td>
<td>4.16</td>
<td>0.05</td>
<td>22</td>
<td>-0.07</td>
</tr>
<tr>
<td>Con A 20.0 ug</td>
<td>21</td>
<td>3.11</td>
<td>0.07</td>
<td>21</td>
<td>-0.10</td>
</tr>
<tr>
<td>PHA 2.5 ug</td>
<td>22</td>
<td>4.82</td>
<td>0.04</td>
<td>22</td>
<td>-0.03</td>
</tr>
<tr>
<td>PHA 10.0 ug</td>
<td>22</td>
<td>4.76</td>
<td>0.03</td>
<td>22</td>
<td>-0.01</td>
</tr>
<tr>
<td>PHA 20.0 ug</td>
<td>22</td>
<td>4.60</td>
<td>0.04</td>
<td>22</td>
<td>-0.02</td>
</tr>
<tr>
<td>NKCA</td>
<td>21</td>
<td>51.60</td>
<td>4.89</td>
<td>19</td>
<td>20.16</td>
</tr>
</tbody>
</table>
effect of the stressor on circulating helper T-cells (CD4+).

A 2 (Period: Baseline vs. Stressor) X 4
(Concentration: 2.5 vs. 5.0 vs. 10.0 vs. 20.0) within-subjects ANOVA on Con A revealed a main effect for Period, $F(1,20) = 6.72, p < .02$, and Concentration, $F(3,60) = 573.24, p < .001$. As expected, the stressor led to decreased blastogenic response to Con A. The Concentration main effect reflected the increase in blastogenesis at the first two concentrations then a subsequent decrease for the last two. The Period X Concentration interaction was not significant. Similar analyses of PHA revealed only a significant Concentration main effect, $F(2,42) = 31.18, p < .001$, reflecting a gradual reduction in blastogenic response to PHA at higher concentrations.

Social Support and Immune Function

We performed two sets of analyses to examine the association between social support and immune function. First, correlations were computed between social support and baseline measures of immune function. To examine the association between social support and reactivity to an acute psychological stressor, we computed residualized change scores by regressing task values on baseline values; thereby eliminating baseline dependencies.
Table 2 reveals the correlations between social support and baseline measures of immune function. Results revealed that only support appraisals were consistently related to cellular immune function. Individuals high in appraisal support showed greater blastogenic response to both Con A and PHA. In addition, higher appraisal support was associated with lower numbers of circulating CD8+ and NK cells. Similar effects were found for the total ISEL score but these effects appear to be primarily due to support appraisals. Table 3 summarizes the associations between social support and immune reactivity using residualized change scores. None of the correlations was significant.1

An intake questionnaire provided information on the following potential health-related variables: average hours of exercise per week, average alcoholic beverages per week, height, weight, hours of sleep and number of caffeinated beverages prior to the CRC study, and hours of vigorous activity during the past week. To examine any possible confoundings between appraisal support and these potential health-relevant variables (Kiecolt-Glaser & Glaser, 1988b), correlations were computed.

Results of the analyses revealed that individuals higher in appraisal support exercised more hours per week \(r = .52, p < .05\), and drank on the average more
Table 2. Correlations Between Social Support and Baseline Immune Measures.

<table>
<thead>
<tr>
<th>Baseline Measure</th>
<th>Appraisal</th>
<th>Belonging</th>
<th>Tangible</th>
<th>Self-Esteem</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD4⁺</td>
<td>-.26</td>
<td>-.19</td>
<td>.02</td>
<td>-.15</td>
<td></td>
</tr>
<tr>
<td>CD8⁺</td>
<td>-.61*</td>
<td>-.51*</td>
<td>-.30</td>
<td>-.54*</td>
<td></td>
</tr>
<tr>
<td>CD4⁺/CD8⁺</td>
<td>.47*</td>
<td>.33</td>
<td>.24</td>
<td>.40</td>
<td></td>
</tr>
<tr>
<td>NK Cells</td>
<td>-.60*</td>
<td>-.14</td>
<td>-.19</td>
<td>-.33</td>
<td></td>
</tr>
<tr>
<td>Con A 2.5 ug</td>
<td>.31</td>
<td>.23</td>
<td>.45</td>
<td>.37</td>
<td>.37</td>
</tr>
<tr>
<td>Con A 5.0 ug</td>
<td>.48*</td>
<td>-.10</td>
<td>.37</td>
<td>.39</td>
<td></td>
</tr>
<tr>
<td>Con A 10.0 ug</td>
<td>.50*</td>
<td>.37</td>
<td>.29</td>
<td>.44*</td>
<td></td>
</tr>
<tr>
<td>Con A 20.0 ug</td>
<td>.46*</td>
<td>.29</td>
<td>.50*</td>
<td>.48*</td>
<td></td>
</tr>
<tr>
<td>PHA 2.5 ug</td>
<td>.13</td>
<td>-.07</td>
<td>.22</td>
<td>.12</td>
<td></td>
</tr>
<tr>
<td>PHA 10.0 ug</td>
<td>.50*</td>
<td>.05</td>
<td>.30</td>
<td>.34</td>
<td></td>
</tr>
<tr>
<td>PHA 20.0 ug</td>
<td>.53*</td>
<td>.14</td>
<td>.29</td>
<td>.37</td>
<td></td>
</tr>
<tr>
<td>NKCA</td>
<td>-.01</td>
<td>.03</td>
<td>.15</td>
<td>.08</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p < .05
Table 3. Correlations Between Social Support and Measures of Immune Reactivity.

<table>
<thead>
<tr>
<th>Baseline Measure</th>
<th>Appraisal</th>
<th>Belonging</th>
<th>Tangible</th>
<th>Self-Esteem</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD4⁺</td>
<td>.19</td>
<td>-.11</td>
<td>.26</td>
<td>.23</td>
<td>.30</td>
</tr>
<tr>
<td>CD8⁺</td>
<td>-.16</td>
<td>-.16</td>
<td>-.13</td>
<td>-.14</td>
<td>-.13</td>
</tr>
<tr>
<td>CD4⁺/CD8⁺</td>
<td>-.25</td>
<td>.01</td>
<td>.18</td>
<td>.03</td>
<td>-.01</td>
</tr>
<tr>
<td>NK Cells</td>
<td>.06</td>
<td>.09</td>
<td>.12</td>
<td>-.13</td>
<td>.13</td>
</tr>
<tr>
<td>Con A 2.5 ug</td>
<td>-.04</td>
<td>-.15</td>
<td>.01</td>
<td>-.10</td>
<td>.13</td>
</tr>
<tr>
<td>Con A 5.0 ug</td>
<td>.09</td>
<td>-.28</td>
<td>.19</td>
<td>.20</td>
<td>.28</td>
</tr>
<tr>
<td>Con A 10.0 ug</td>
<td>.08</td>
<td>-.21</td>
<td>.11</td>
<td>.12</td>
<td>.31</td>
</tr>
<tr>
<td>Con A 20.0 ug</td>
<td>-.30</td>
<td>-.36</td>
<td>-.28</td>
<td>-.24</td>
<td>-.15</td>
</tr>
<tr>
<td>PHA 2.5 ug</td>
<td>-.06</td>
<td>-.12</td>
<td>-.03</td>
<td>-.12</td>
<td>.07</td>
</tr>
<tr>
<td>PHA 10.0 ug</td>
<td>.12</td>
<td>-.07</td>
<td>.11</td>
<td>.15</td>
<td>.27</td>
</tr>
<tr>
<td>PHA 20.0 ug</td>
<td>.19</td>
<td>.11</td>
<td>.19</td>
<td>.12</td>
<td>.25</td>
</tr>
<tr>
<td>NKCA</td>
<td>-.19</td>
<td>-.33</td>
<td>-.08</td>
<td>-.11</td>
<td>-.08</td>
</tr>
</tbody>
</table>

Note: * p < .05
alcoholic beverages per week ($r = .42, p < .05$). No other correlation approached significance. Subsequent analyses aimed at examining the implications of these associations revealed that the average hours of exercise and the number of alcoholic beverages per week were not significantly associated with the blastogenic response to PHA, number of CD8$^+$, ratio of CD4$^+$ to CD8$^+$, and the number of NK cells. The number of alcoholic beverages, however, was significantly associated with the blastogenic response to Con A ($r = .59, p < .01$).

Result of our analyses suggest that alcohol may be mediating the association between appraisal support and blastogenic response to the mitogen Con A. To examine such a possibility, a path analysis was conducted using RAMONA PC (Browne & Mels, 1990). In the analyses, maximum likelihood estimates were used to derive the parameters estimates for each path in the model. Figure 1 depicts the results of the path analysis. Results revealed that the path between appraisal support and Con A was only marginally significant when considering the mediating influence of alcohol consumption. Thus, it appears that average alcoholic consumption may be partially mediating the association between appraisal support and Con A (see Baron & Kenny, 1986 for a discussion of mediational criteria). Importantly, it does not appear that any
Figure 1. Path analysis examining the potential mediational influence of alcohol consumption on the relationship between appraisal support and Con A (* p < .05).
FIGURE 1.
potential health-related variable measured in this study was mediating the association between appraisal support and (1) PHA, (2) number of CD8\(^+\), (3) ratio of CD4\(^+\) to CD8\(^+\), and (4) number of NK cells.\(^3\)

**Is Personality Contributing to the Relationship Between Social Support and Immune Function?**

To examine the potential confounding influence of personality per se, we calculated correlations between social support and the personality measures of neuroticism and extraversion (see Table 4). The total ISEL score and many of the subscales were highly correlated with the personality factors. Importantly, support appraisals were not significantly correlated with either neuroticism or extraversion. Nevertheless, we examined the significant correlations between support appraisals and baseline immune function while controlling for both neuroticism and extraversion. The only correlation that decreased moderately was the association between support appraisals and the blastogenic response to Con A at 20.0 ug (i.e., .46 to .35). Although the association between appraisal support and the ratio of CD4\(^+\) to CD8\(^+\) only decreased from .47 to .44, the inclusion of the statistical controls were enough to decrease the significance of the correlation to \(p < .07\). All other correlations were of similar magnitude and statistical significance. Therefore, results of our
Table 4. Correlations Between Social Support and Personality.

<table>
<thead>
<tr>
<th>Personality</th>
<th>Appraisal</th>
<th>Belonging</th>
<th>Tangible</th>
<th>Self-Esteem</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuroticism</td>
<td>-.22</td>
<td>-.48*</td>
<td>-.41</td>
<td>-.58*</td>
<td>-.48*</td>
</tr>
<tr>
<td>Extraversion</td>
<td>.22</td>
<td>.71*</td>
<td>.42</td>
<td>.77*</td>
<td>.61*</td>
</tr>
</tbody>
</table>

Note: * p < .05
analyses suggest that support appraisals were not confounded with personality factors, and personality per se cannot explain the significant associations between appraisal support and baseline immune function.
Discussion

The results of Study 1 are consistent with past research suggesting that higher levels of social support are associated with increased immunocompetence. Our results further suggest that a particular functional component of social support is associated with enhanced immune function. It is important to note that these effects were limited to resting measures of immune function. If under resting conditions the immune system can be conceptualized as a surveillance system, the relatively lower number of circulating suppressor/cytotoxic cell and NK cells may reflect the healthier status of individuals high on appraisal support. This interpretation is consistent with the finding that individuals higher in appraisal support also evidenced greater blastogenic response to PHA and Con A, and a greater ratio of helper T-cells to suppressor/cytotoxic T-cells.

We found no significant association between social support and immune reactivity to the acute psychological stressor despite evidence that the stressor altered immune function (see Sgoutas-Emch et al., in press). According to social support models that emphasize the importance of matching the stressor with specific support types (e.g., Cutrona & Russell, 1989), we expected that self-esteem
support might buffer the immune effects of the acute psychological stressor.

There are at least two explanations for the nonsignificant associations between social support and immune reactivity. First, we examined the influence of prior perceived support on immune reactivity. It is conceivable that mobilizing current social support processes may have been more effective. For example, an individual high in self-esteem support may indeed show lowered immune reactivity to the stressor had a friend been present who gave them encouragement. Future research is needed to examine the potential stress buffering effects of social support processes in an interpersonal context. Second, it is also important to note that the current sample size only allowed us to detect large effect sizes (Cohen, 1992). Thus, it is possible that an association exists between perceptions of social support and immune reactivity, but that we did not have the statistical power to detect such relatively smaller effects.

An important aspect of the Study 1 is that the associations between appraisal support and resting immune function were generally unaffected by controls for personality variables. These results are consistent with research indicating that links between social support and
objective indices of health, such as physiological functioning or mortality, are relatively unaffected by controls for personality variable or their proposed confounding mechanism (e.g., House et al., 1988; Kiecolt-Glaser et al., 1991; Uchino et al., 1992; Uchino et al., in press). It is interesting to note that controls for personality variables appear to have a larger effect on more subjective measures of health such as self-reported symptomology (Watson & Pennebaker, 1989). Such a pattern of results is predictable if one assumes that such self-report measures also share a common "world view" component. Future research is needed to examine specific mechanisms that are responsible for such divergent results.
CHAPTER II
INTRODUCTION

To the best of our knowledge, Study 1 was the first to examine multiple functional components of social support and demonstrate that a particular functional component was associated with increased immunocompetence. We should note, however, that evidence for the beneficial effects of social support on health are generally weaker, albeit statistically significant for females (House et al., 1988; Shumaker & Hill, 1991). Thus, one aim of Study 2 was to attempt a replication of Study 1 with a female sample.

Study 1 demonstrated that personality factors were not contributing to the relationship between social support and immune function. There is strong evidence, however, that life stressors have a negative influence on immune function (O'Leary, 1990; Herbert & Cohen, in press). For example, Kiecolt-Glaser, Glaser, Shuttleworth, Dyer, Ogrocki, and Speicher (1987b) found that the chronic stress of caregiving for a family member with Alzheimer's Disease was associated with increased antibody levels of EBV, lower percent of helper T-cells,
and a lower ratio of helper T-cells to suppressor/cytotoxic T-cells compared to carefully matched control subjects. Therefore, individuals higher on social support may evidence greater immunocompetence due to lower levels of stress. In Study 2, we assessed levels of perceived stress and tested path models that hypothesized perceived stress was mediating the association between social support and immune function.

Depression is also known to reliably influence cellular immune response (Weisse, 1992; Herbert & Cohen, 1993). For example, Irwin, Daniels, Smith, Bloom, and Weiner (1987) found that the severity of changes in depressive symptoms from anticipatory bereavement to bereavement was strongly associated with changes in NKCA during the same period ($r = -.87$). Individuals higher on social support may have better immune function due to their lower levels of depression. An additional aim of Study 2 was to examine the influence of depression on the association between social support and immune function. We tested a mediational hypothesis in Study 2 that depression was mediating the association between social support and cellular immune function.
Method

Subjects

Forty-five undergraduate women were selected for participation in the study because they were relatively high in heart rate reactivity to a speech stressor. Subjects received $30.00 for approximately 2.5 hours of participation in the study that was conducted at the Clinical Research Center (CRC) of the Ohio State University Hospital. The inclusion criteria for participation were that subjects: (a) were in good health, (b) were within 20% of their ideal body weight, (c) had no past history of psychological disorder, (d) had no past history of chronic illness and were not on any chronic medication, (e) did not use tobacco products, (f) consumed less than 10 alcoholic beverages a week, (g) had not experienced any recent negative life event (e.g., death in the family), and (h) were not math, speech, or needle phobic. Subjects were asked to refrain from ingesting anti-inflammatory agents, antihistamines, or alcohol up to 24 hours before their test day.

Procedure

The day before participation in the study, subjects were reminded to refrain from exercise and consuming alcohol or non-prescription medication, and from eating or drinking anything except water after midnight. The study
was run in the mornings and consisted of two components: (1) informed consent and insertion of an 18 gauge indwelling catheter into the antecubical vein of the subject's arm; and (2) 30 minute supine rest period followed by a baseline blood draw.

The blood draws prior to and following the experimental stressor provided the materials for the immune assays. Complete blood counts (CBC and differentials) were performed by the Clinical Immunology Laboratory at the OSU hospital. Peripheral blood leukocytes were isolated by density gradient centrifugation on Ficoll-Metrazoate gradients from 40 cc of heparinized venous blood, washed with complete RPMI 1640 medium, counted, and then prepared for the following assays:

NK cell activity (lysis). The procedures used for NK cell activity in this study have been described in detail elsewhere (Glaser et al., 1986). In sum, cells were prepared at 100:1, 50:1, 25:1, 12.5:1, 6.25:1, and 3.12:1 effector to target cell ratios and were seeded in triplicates, in 96-well microtiter plates (Costar Corp.). Additional wells containing only target cells (K562) in medium containing 1% sodium deoxycholate were used to determine spontaneous and maximum release of radioactivity, respectively. NK lysis values were
standardized at the 25:1 effector/target ratio using a logistic regression (Kazimer et al., 1989).

**Lymphocyte cell counts.** The percentage of NK, CD4\(^+\), and CD8\(^+\) were determined by flow cytometry using the monoclonal antibodies, T4, T8, and NKH-1 (Coulter), respectively and using procedures from our laboratory (Kiecolt-Glaser et al., 1991). Cell culture supernants were assayed for lymphokines using commercially available kits from Genzyme, Inc. (Cambridge, MA). Absolute numbers were calculated by using the percentage of these cells and absolute number of lymphocytes taken from the complete blood counts.

**Blastogenic response to Con A and PHA.** The procedures used in this study are described in Kiecolt-Glaser et al. (1991). Cells were prepared (5 x 10\(^6\)) in complete RPMI 1640 medium, treated with concanavalin A (Con A) and phytohemagglutinin (PHA) and incubated for 48 hours. The concentrations for Con A and PHA were 2.5, 5.0, 10.0, and 20.0 ug. All samples were run in triplicate and counts per minute were determined by averaging the triplicate samples and reported as the log 10 transformed values of the counts per minute.

It is also important to monitor the nutritional status of the subject to rule out changes in the immune response that are related to malnutrition. Therefore, we
measured serum albumin at baseline, as described in Kiecolt-Glaser et al. (1991). Immunologic data are excluded if serum albumin is out of the normal range. All subject's data, however, fell into the normal range.

**Post-Experimental Questionnaires**

In Study 2, subjects completed the ISEL and the EPQ (see Study 1 for description). In addition, subjects completed the perceived stress scale (PSS) and the Beck depression inventory (BDI).

**Perceived Stress Scale (PSS).** We used the 14 item PSS to assess perceptions of stress. The Chronbach's alpha for the PSS has been reported at .75 (Cohen & Williamson, 1987). Cohen & Williamson (1987) found that individuals relatively high on perceived stress evidence poorer reported physical health and higher scores on health service utilization. The PSS was also correlated with increased alcohol and drug use (i.e., prescription and over the counter).

**Beck Depression Inventory (BDI).** The BDI contains 21 clinically derived items and appears to be a reliable and valid measure of depression (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). Beck et al. (1961) report a split-half correlation of .86 for the BDI. In addition, the BDI is strongly related to clinical ratings of depth of depression.
Results

Preliminary Analyses

Participant in Study 2 were selected because they were relatively high in heart rate reactivity to a speech stressor. To examine any potential confoundings with our measures of social support, correlations were computed between the ISEL and heart rate reactivity to the speech stressor. Results revealed that heart rate reactivity was nonsignificantly related to components of the ISEL ($r$'s = .11 to .28). Thus, the ISEL does not appear to be confounded with the selection factor used for Study 2.

In order to control for the potential influence of hormonal variations introduced by the menstrual cycle on immune function, studies typically schedule women during the same phase of the menstrual cycle (e.g., Kiecolt-Glaser et al., in press). We could not do this in the current study so we instead assessed levels of estrogen and progesterone. Correlational analyses revealed that no component of social support was significantly related to levels of estrogen or progesterone ($r$'s = -.23 to .23).

Social Support and Immune Function

Table 5 contains the correlations between social support and resting immune function. Replicating the results of Study 1, appraisal support was consistently related to cellular immune response. Individuals higher
Table 5. Correlations Between Social Support and Baseline Immune Measures.

<table>
<thead>
<tr>
<th>Baseline Measure</th>
<th>Appraisal</th>
<th>Belonging</th>
<th>Tangible</th>
<th>Self-Esteem</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD4⁺</td>
<td>-.34*</td>
<td>-.14</td>
<td>-.05</td>
<td>-.23</td>
<td>-.22</td>
</tr>
<tr>
<td>CD8⁺</td>
<td>-.32*</td>
<td>-.18</td>
<td>-.01</td>
<td>-.17</td>
<td>-.20</td>
</tr>
<tr>
<td>CD4⁺/CD8⁺</td>
<td>.05</td>
<td>.09</td>
<td>-.21</td>
<td>.03</td>
<td>-.01</td>
</tr>
<tr>
<td>NK Cells</td>
<td>-.34*</td>
<td>-.34*</td>
<td>-.19</td>
<td>-.21</td>
<td>-.33*</td>
</tr>
<tr>
<td>Con A 2.5 ug</td>
<td>-.19</td>
<td>-.07</td>
<td>.04</td>
<td>.21</td>
<td>.00</td>
</tr>
<tr>
<td>Con A 5.0 ug</td>
<td>.02</td>
<td>.04</td>
<td>.06</td>
<td>.23</td>
<td>.11</td>
</tr>
<tr>
<td>Con A 10.0 ug</td>
<td>.38*</td>
<td>.31*</td>
<td>.20</td>
<td>.07</td>
<td>.29</td>
</tr>
<tr>
<td>Con A 20.0 ug</td>
<td>.41*</td>
<td>.21</td>
<td>.14</td>
<td>-.06</td>
<td>.21</td>
</tr>
<tr>
<td>PHA 2.5 ug</td>
<td>-.04</td>
<td>-.06</td>
<td>.01</td>
<td>.32*</td>
<td>.07</td>
</tr>
<tr>
<td>PHA 5.0 ug</td>
<td>-.04</td>
<td>.03</td>
<td>.03</td>
<td>.34*</td>
<td>.10</td>
</tr>
<tr>
<td>PHA 10.0 ug</td>
<td>-.05</td>
<td>-.02</td>
<td>-.17</td>
<td>.22</td>
<td>-.01</td>
</tr>
<tr>
<td>PHA 20.0 ug</td>
<td>-.17</td>
<td>-.05</td>
<td>-.01</td>
<td>.13</td>
<td>-.03</td>
</tr>
<tr>
<td>NKCA</td>
<td>.11</td>
<td>.20</td>
<td>.15</td>
<td>.11</td>
<td>.17</td>
</tr>
</tbody>
</table>

Note: * p < .05
in appraisal support had greater blastogenic response to Con A, lower percent of CD4\(^+\), lower percent of CD8\(^+\), and lower percent of NK cells.\(^4\) In addition, belonging and self-esteem support were also associated with immune function. Individuals higher in belonging support evidence greater blastogenic response to Con A (10 ug) and lower percent of NK cells, whereas individuals higher on self-esteem support evidenced greater blastogenic response to PHA (2.5 and 5.0 ug).\(^5\)

As in Study 1, an intake questionnaire provided information on potential health-related variables (e.g., average hours of exercise per week, average alcoholic beverages per week, hours of vigorous activity during the past week). To examine the influence of these potential health-related variables on our results, correlational analyses were conducted. The only significant association was between appraisal support and hours of vigorous activity in the past week ($r = -.32$, $p < .05$). Results of additional analyses controlling for hours of vigorous activity revealed that the magnitude of the correlations between appraisal support and the percent of CD4\(^+\), CD8\(^+\), and NK cells decreased marginally (i.e., largest change in $r = .04$). However, the combination of (a) the statistical control and (b) the loss of 3 subjects in the analyses due to missing data on the health questionnaire contributed to
lowering the significance of the correlations between appraisal support and (1) the percent CD4⁺ (p < .07), (2) the percent CD8⁺ (p < .06), and (3) the percent NK cells (p = .07). Importantly, the association between appraisal support and the blastogenic response to Con A was unaffected when controlling for hours of vigorous activity.

Is Personality Contributing to the Relationship Between Social Support and Immune Function?

Table 6 contains the correlations between social support components and the personality measures of neuroticism and extraversion. The total ISEL score and many of the subscales were highly correlated with the personality factors. As in Study 1, however, support appraisals were not significantly correlated with either neuroticism or extraversion. Nevertheless, we examined the significant correlations between social support (i.e., appraisal, belonging, and self-esteem) and baseline immune function while controlling for both neuroticism and extraversion. The only associations that became nonsignificant were the correlations between self-esteem support and the blastogenic responses to PHA. Such a finding may be attributable to the role of social feedback on personality traits. All other correlations were unaffected by controls for personality variables.
Table 6. Correlations Between Social Support and Personality.

<table>
<thead>
<tr>
<th>Personality</th>
<th>Appraisal</th>
<th>Belonging</th>
<th>Tangible</th>
<th>Self-Esteem</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuroticism</td>
<td>-.17</td>
<td>-.37*</td>
<td>-.28</td>
<td>-.53*</td>
<td>-.41*</td>
</tr>
<tr>
<td>Extraversion</td>
<td>.14</td>
<td>.49*</td>
<td>.32*</td>
<td>.34*</td>
<td>.39*</td>
</tr>
</tbody>
</table>

Note: * p < .05
Therefore, results of our analyses replicated that of Study 1, and suggest that personality factors per se cannot explain the associations between appraisal and belonging support and immune function.

Is Perceived Stress or Depression Mediating the Association between Social Support and Immune Function?

Results of Study 2 demonstrated that appraisal support, and to a lesser extent, belonging support was associated with increased immunocompetence, independent of personality factors. We next conducted path analyses using RAMONA PC (Browne & Mels, 1990) to examine the potential mediating influence of perceived stress or depression on the significant associations between appraisal and belonging support and immune function. In each model, maximum likelihood estimates were used to derive the parameters estimates for each path.

Figure 2 depicts a hypothetical model with depression mediating the association between social support and immune function. According to Baron and Kenny (1986) three conditions must hold to infer mediation: (1) the independent variable should be significantly correlated with the presumed mediator (path a), (2) the presumed mediator should be significantly correlated with the dependent variable (path b), and (3) controlling for path a and b (the mediator) should render the direct path
Figure 2. Hypothetical path model depicting the mediational influence of depression on the association between social support and immune function.
FIGURE 2.
between social support and immune function nonsignificant (path c).

We first examined the potential mediating influence of perceived stress and depression on the associations between appraisal support and immune function. Results of the path analyses revealed that neither perceived stress nor depression was mediating the association between appraisal support and (1) the blastogenic response to Con A, (2) percent NK cells, (3) and percent of CD8$^+$ as the direct paths between appraisal support and immune function were significant in each path model (see Figures 3 and 4). In each of these models, the amount of variance in the immune measures accounted for ranged from .12 to .20, due primary to the influence of support appraisals. The amount of variance in the mediator accounted for, however, was small (.01 to .04).

In one path model involving the potential mediating influence of perceived stress, the direct path between appraisal support and the percent CD4$^+$ was non-significant when considering the influence of perceived stress (see Figure 3, bottom left panel). The amount of variance in the percent CD4$^+$ accounted for by the model was .20. However, evidence for mediation was inconclusive as (a) the path between support appraisal and perceived stress
Figure 3. Top left panel: Path analysis examining the potential mediational influence of perceived stress on the relationship between appraisal support and Con A (* p < .05). Top right panel: Path analysis examining the potential mediational influence of perceived stress on the relationship between appraisal support and percent NK cells (* p < .05). Bottom left panel: Path analysis examining the potential mediational influence of perceived stress on the relationship between appraisal support and percent CD4⁺ (* p < .05). Bottom right panel: Path analysis examining the potential mediational influence of perceived stress on the relationship between appraisal support and percent CD8⁺ (* p < .05).
FIGURE 3.

- Appraisal - Perceived - Support - Stress - Con A
  - .41*

- Appraisal - Perceived - Stress - Percent
  - .32*

- Appraisal - Perceived - Stress - CD4*
  - .30*

- Appraisal - Perceived - Stress - NK Cells
  - .19

- Appraisal - Perceived - Percent
  - .19

- Appraisal - Perceived - Percent - CD8*
  - .19

- Appraisal - Perceived - Percent
  - .19

- Appraisal - Perceived - Percent
  - .19
Figure 4. Top left panel: Path analysis examining the potential mediational influence of depression on the relationship between appraisal support and Con A (\(p < .05\)). Top right panel: Path analysis examining the potential mediational influence of depression on the relationship between appraisal support and percent NK cells (\(p < .05\)). Bottom left panel: Path analysis examining the potential mediational influence of depression on the relationship between appraisal support and percent CD4\(^+\) (\(p < .05\)). Bottom right panel: Path analysis examining the potential mediational influence of depression on the relationship between appraisal support and percent CD8\(^+\) (\(p < .05\)).
FIGURE 4.
was nonsignificant, and (b) the amount of variance in the mediator accounted for was small (.03).

Figure 5 depicts the path analyses for the associations between belonging support and immune function. The direct influence of belonging support on the blastogenic response to Con A (10 ug) and percent NK cells was unaffected when considering the mediating influence of depression. In addition, perceived stress did not influence the direct significant path between belonging support and percent NK cells. In each of these models, the amount of variance in the immune measures accounted for ranged from .10 to .15, due primary to the influence of support appraisals. The amount of variance in the mediator accounted for ranged from .05 to .18.

Figure 5 (top left panel) depicts the path analysis between belonging support, perceived stress, and the blastogenic response to Con A. The direct path between belonging support and the blastogenic response to Con A was nonsignificant when considering the mediating effect of perceived stress. The amount of variance in Con A accounted for by the model was .15, whereas the amount of variance in perceived stress accounted for was .07. However, none of the paths were significant in the model.7
Figure 5. Top left panel: Path analysis examining the potential mediational influence of perceived stress on the relationship between belonging support and Con A (* p < .05). Top right panel: Path analysis examining the potential mediational influence of perceived stress on the relationship between belonging support and percent NK cells (* p < .05). Bottom left panel: Path analysis examining the potential mediational influence of depression on the relationship between belonging support and Con A (* p < .05). Bottom right panel: Path analysis examining the potential mediational influence of depression on the relationship between belonging support and percent NK cells (* p < .05).
FIGURE 5.
General Discussion

The results of Studies 1 and 2 suggest that social support is associated with increased immunocompetence. In particular, having someone to talk with about one's problems (i.e., appraisal support) was associated with (a) greater blastogenic response to Con A and PHA, (b) a lower ratio of helper T-cells to suppressor/cytotoxic T-cells and (c) lower percentages of helper T-cells, suppressor/cytotoxic T-cells, and NK cells. It is important to note that the associations between appraisal support and Con A, suppressor/cytotoxic T-cells, and NK cells proved replicable across gender.

The results of Study 1 and 2 are consistent with research emphasizing the importance of examining social support as a multi-dimensional construct (Cutrona & Russell, 1989). Many of the significant associations reported in both studies were evident only for a particular component of social support and not for the total scale. Therefore, theoretically important relationships may have been missed had we conceptualized social support as a unidimensional construct.

There are at least six a priori mechanisms that might explain the associations between appraisal support and cellular immune function. First, appraisal support may involve, in part, the exchange of information (Cohen &
McKay, 1984). Potential information may involve health-related knowledge (i.e., one should exercise or get adequate sleep) which in turn may have beneficial effects on immune function (Kiecolt-Glaser & Glaser, 1988b). Although health-related variables were able to decrease the significance of several correlations between appraisal support and immune function, by and large, it could only account for a small portion of the shared variance between appraisal support and immune function in both Studies 1 and 2.

It has been argued that measures of perceived social support may be confounded by personality measures such as neuroticism (Lakey & Cassady, 1990; Connell & D’Augelli, 1990; Bolger & Eckenrode, 1991; Kessler, Kendler, Heath, Neale, & Eaves, 1992). Bolger and Eckenrode (1991) suggest that neuroticism may lead to lower perceptions of social support via mood induced biases (e.g. negativity bias). Accordingly, social support may have an influence on immune function due to its association with personality variables. Contrary to this explanation, Study 1 and 2 demonstrated that the personality variables of neuroticism and extraversion were unable to explain away the associations between appraisal support and cellular immune function.
Depression has well-documented and reliable influences on immune function (Weisse, 1992; Herbert & Cohen, 1993). There are at least two potential ways in which depression may have contributed to our results. First, depression may have acted as a mechanism by which personality factors influence reports of perceived social support (i.e., negativity bias). Alternatively, high levels of appraisal support may act to reduce levels of depression. Contrary to these explanations, Study 2 found that (a) appraisal support was unrelated to depression, and (b) path models examining the influence of depression yielded little evidence for mediation. Consistent with Baron et al. (1988), therefore, depression does not appear to be mediating the associations between social support and immune function.

Life stress, like depression, appears to have reliable influences on cellular immune response (O'Leary, 1990; Herbert & Cohen, in press). According to Cohen and Wills (1985), social support may potentially impact on life stress at two points (see Figure 6). In the context of the present research, social support may act to prevent stress appraisals via provision of relevant information. For example, a friend might advise not to get involved in a relationship due to his or her past negative experiences with the person. In addition, appraisal support may act
Figure 6. Hypothetical model depicting the potential influence of social support on the stress response. Adapted from S. Cohen & T.A. Wills, Stress, social support and the buffering hypothesis. *Psychological Bulletin*, 98, p. 313.
FIGURE 6.
to reduce the perceived stressfulness of a situation once stress appraisals have occurred. For instance, a diagnosis of a serious heart condition might prove stressful, but information related to a good prognosis via a friend who may have had a similar condition may serve to reduce the stressfulness of the situation.

In Study 2, we examined the potential influence of life stress on the association between appraisal support and immune function. According to contemporary models (see Cohen & Williamson, 1988) that focus on the importance of examining stress as a transaction between the person and environment (i.e., perceptions of stress), Study 2 would appear to provide a relatively strong test of the mediational effects of life stress on the associations between appraisal support and immune function. It should be noted that Baron et al. (1988) found that controlling for the number of negative life events did not alter the associations between social support and immune function in spouses of cancer patients. In Study 2, we also provide evidence that levels of perceived stress were not sufficient to explain the association between appraisal support and immune function.

One other potential mechanism by which appraisal support may be associated with increased immunocompetence emphasizes the beneficial influence of self-disclosure.
(Pennebaker & O’Heeron, 1984; Pennebaker & Beall, 1986; Pennebaker, Hughes, & O’Heeron, 1987; Greenberg & Stone, 1992). In an illustrative study, Pennebaker & O’Heeron reported that the more that spouses of suicides and accidental deaths discussed their spouses death with friends, the less the increase in health problems.

In a relevant study, Pennebaker, Kiecolt-Glaser, and Glaser (1988) examined the impact of self-disclosure (i.e., writing about a traumatic event) on the blastogenic response to PHA and Con A. Subjects were randomly assigned to write about either personally traumatic events or trivial events for 20 minutes on four consecutive days. Immune assessments were conducted prior to the start of the study, 1 hour after the final writing session, and 6 weeks after the conclusion of the study. Results revealed that subjects who self-disclosed personally traumatic events evidenced greater subsequent blastogenic response to PHA compared to subjects simply writing about trivial events. In addition, individuals who reportedly wrote about traumas that they had previously held back showed greater subsequent blastogenic response to Con A than control subjects and individuals who wrote about traumas that they had not held back. It is interesting to note that individuals who self-disclosed personally traumatic
events also evidenced fewer subsequent visits to the health center.

Pennebaker (1989) suggests that one reason self-disclosure may be beneficial is because it allows an individual to understand and assimilate traumatic events. Although we have not directly examined the influence of self-disclosure per se, it follows that appraisal support may have its effects on immune function because it provides an individual with the availability of others to disclose one’s personal problems. Consistent with this reasoning, Cohen et al. (1985) report that support appraisals were significantly correlated with a measure of self-disclosure (r = .40).

Given the lack of evidence for the mediational models, there are other variables not assessed in the current studies that might also mediate the relationship between appraisal support and immune function. For instance, controllability has been shown to alter immune function (Rodin, 1986; Sieber, Rodin, Larson, Ortega, Cummings, Levy, Whiteside, & Herberman, 1992). Accordingly, appraisal support may have its influence on immune function by increasing feelings of controllability. In order to explain the current results, however, one needs to assume that appraisal support, in particular, influences feelings of controllability as both studies
revealed that the appraisal component was consistently related to cellular immune function. Future research is needed to determine the plausibility of controllability as a mediator of the association between appraisal support and immune function.

There were several differences in the pattern of results across Studies 1 and 2 that warrant discussion. Study 2 suggested that belonging support and self-esteem support may be associated with increased immunocompetence in women. Collectively, belonging and self-esteem support comprise the component of emotional support (Cohen & McKay, 1984). Flaherty and Richman (1989) argue that women are more "affectively-connected" than men due to socialization factors. Consistent with this explanation, Flaherty and Richman (1989) found that emotional support was a strong predictor of depression in women but not men.

Based on the results of the current research, one might be tempted to conclude that belonging and self-esteem support may have emerged as predictors of several measures of immune function in Study 2 and not Study 1 because of the relative importance of emotional support for women compared to men. An examination of Table 3, however, revealed that the magnitude of the correlations between belonging/self-esteem support and immune function were comparable in Study 1 and Study 2. For example, the
correlation between belonging support and the blastogenic response to Con A (10 ug) was .33 in Study 1. It is important to note that Study 1 consisted of 22 subjects, resulting in relatively less statistical power compared to Study 2. The current research may instead implicate the relative importance of appraisal support for men compared to women as these relationships were considerable stronger in Study 1. We cannot determine in the present research, however, the extent to which distinct associations between Study 1 and Study 2 represent reliable gender differences. Potential gender differences in the association between specific support components and immune function is a matter for future research.

One of our interests in examining cellular immune function was as a potential window through which to investigate the potential long-term health consequences of social relations. An important issue must be considered in evaluating the significance of immune alterations. First, although evidence is beginning to emerge, relatively little is known about the health consequences of both functional and quantitative cellular immune measures (Borysenko, 1987). Blastogenesis, however, is one of the few immune measures reliably related to relevant health outcomes (Pennebaker, Kiecolt-Glaser, & Glaser, 1988). For example, decreased blastogenesis has
been associated with the following conditions: (a) acquired immune-deficiency syndrome (Fletcher, Baron, Ashman, Fischl, & Klimas, 1987), (b) infectious mononucleosis (Lumio, Welin, & Weber, 1983), (c) acute necrotizing ulcerative gingivitis (Cogen, Stevens, Cohen-Cole, Kirk, & Freeman, 1983), and (d) mortality (Murasko, Weiner, & Kaye, 1988). Importantly, therefore, individuals higher in appraisal support had greater blastogenic responses in both Study 1 and Study 2.

To our knowledge, this is one of a few studies to demonstrate increased immunocompetence as a function of social support in young, healthy adults (also see Jemmott et al., 1988; Glaser et al., 1992). Aging is typically associated with a down-regulation of the immune system (Roberts-Thomson, Whittingham, Youngchaiyud, & MacKay, 1974; Goodwin, Searles, & Tung, 1982; Goidl, 1987); and respiratory illnesses, in which the immune system is involved, is the fourth leading cause of death in the elderly (Effros & Walford, 1987). Therefore, the associations reported in this paper are likely to be greater consequence when examining social support and cellular immune function across the life-span. As noted by Kiecolt-Glaser and Glaser (1988, p. 202):

While immunological changes are only infrequently associated with increased illness in our young and
healthy medical students, such changes may have important consequences in individuals whose health is already impaired, in individuals who are exposed to an infectious agent or carcinogen, in individuals who already have undetected tumor cells, or in older (predominantly female) populations with decreased immunocompetence.

According to House et al. (1988), the evidence linking social relationships to health and mortality is stronger than the evidence that led to the certification of Type A personality as a risk factor for cardiovascular disorders, and approaches the evidence from the Surgeon General's Report that led to the status of cigarette smoking as a risk factor for mortality. The authors admittedly noted that the specificity of the relationship between social relationships and mortality is not as clear as other risk factors (e.g., smoking and lung cancer).

In the present research, we have potentially addressed two questions to clarify the specificity of the relationship between social relationships and health. First, our results implicate the immune system as one potential physiological mechanism linking social support and health. Second, appraisal support may be an especially important component of social support to consider.
The results of the current studies further highlight the importance of several programs of research. It is clear that appraisal support is itself a multidimensional construct and contains at least two components: (1) the provision of information, and (2) the availability of others for self-disclosure. Research should be aimed at an examination of such components and its specificity to morbidity and mortality. Second, the health implications of immune measures typically employed in PNI research need further examination to clarify the implications of related research. Finally, associations between social support and immune function cannot be assumed in the elderly, especially in light of evidence that the relationship between social support and mortality may be more complicated in elderly women (Shumaker & Hill, 1992). Therefore, a developmental perspective is needed to establish the importance and replicability of such results across the life-span. Admittedly, the research agenda is inherently interdisciplinary, requiring the expertise of scientists in fields such as social and developmental psychology, immunology and physiology, and epidemiology. Such an interdisciplinary approach is critical, however, if future inquiry is to clarify the complex association between social relationships and health.
NOTES

1 It is important to note that the internal consistency of each subscale in Study 1 was comparable. The Cronbach's alphas were .77 for appraisal support, .80 for belonging support, .81 for tangible support, and .80 for self-esteem support. Therefore, the associations between specific support components and immune function do not appear to be a result of differential scale reliability.

2 For the current analyses, the blastogenic response to Con A and PHA were averaged across the two middle concentrations to reduce variability in the data.

3 We also conducted a series of hierarchical regression analyses in which alcohol and hours of exercise were partialled from the significant associations found in Study 1. Results of the hierarchical regressions were consistent with the simple correlational analyses and revealed the same significant associations reported in the text for PHA, number of NK cells, number of CD8\(^+\) cells, and the ratio of CD4\(^+\) to CD8\(^+\).

4 In Study 2, we used the percent of CD4\(^+\), CD8\(^+\), and NK cells instead of the absolute number. Calculations of absolute number requires a count of total white blood cells and percent lymphocytes. Unfortunately, six subjects had missing data for total white blood cell counts or percent lymphocytes. To maximize the statistical power of the analyses, we therefore chose to focus on percentages. The choice of metric, however, did not affect the results as the same relationships were found when examining the association between appraisal support and absolute numbers of CD4\(^+\), CD8\(^+\), and NK cells. For example, the correlation between appraisal support and absolute number of CD4\(^+\) was -.34 (p < .05).

5 As in Study 1, differences in scale reliability could not explain the associations between social support components and immune function. The Cronbach's alphas were .50 for appraisal support, .76 for belonging support, .67 for tangible support, and .72 for self-esteem support.

6 A psychometric analysis was first performed on the perceived stress scale (PSS). The internal consistency of the 14 item scale was adequate (.71). Further analyses revealed, however, that four items correlated poorly with the total score (r's -.20 to .16). Deletion of these
items increased the internal consistency of the PSS to .82. We thus decided to use a 10 item version of the PSS based on the results of the psychometric analyses. It is important to note, however, that three out of the four items are also deleted on a shorter 10 item version of the PSS (see Cohen & Williamson, 1987).

The path models considered the potential mediating influence of perceived stress on social support and immune function. Alternatively, the buffering model predicts an interaction between stress and social support such that social support is mainly effective during periods of high stress (Cohen & Wills, 1985). The moderational approach represented by the buffering model is conceptually distinct from mediational analyses. Thus, we examined the potential interaction between social support and perceived stress in predicting cellular immune response.

Results of the moderational analyses revealed a significant interaction between tangible support and perceived stress on the blastogenic response to PHA, $F(1,40) = 10.01$, $p < .01$. Contrary to the buffering hypothesis, the interaction revealed that under conditions of low stress, higher tangible support was associated with a lower blastogenic response to PHA, whereas no effect of tangible support was evident for subjects high in perceived stress. A similar interaction was found between total social support and perceived stress. The two significant interactions, however, may be due to chance given the large number of statistical test that were performed. All in all, results were not supportive of the buffering model.
APPENDIX A

SUMMARY OF STUDIES EXAMINING SOCIAL RELATIONSHIPS 
AND IMMUNE FUNCTION

72
Table 7. Social relationships and immune function.

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas et al. (1985)</td>
<td>265 older adults</td>
<td>Social support: Number of frank and confiding relationships</td>
<td>Social support related to inc. blastogenic response to PHA and total lymphocyte count for women only.</td>
</tr>
<tr>
<td>Jemmott et al. (1988)</td>
<td>8 men, 7 women</td>
<td>Social support: Adequacy of support (Need for support partialed from amount of support)</td>
<td>Subjects high in social support had higher S-IgA concentrations than subjects low in social support.</td>
</tr>
<tr>
<td>Theorell et al. (1990)</td>
<td>39 men, 10 women</td>
<td>Social support: Availability and adequacy of support</td>
<td>Adequacy of social support related to dec. serum IgG concentrations at high levels of job stress.</td>
</tr>
<tr>
<td>Baron et al. (1988)</td>
<td>23 spouses of cancer patients</td>
<td>Social support: Perceptions of functional support components</td>
<td>High social support related to inc. blastogenic response to PHA, &amp; inc. NKCA (all support components). No difference in Con A, % T-lymphocytes, % total lymphocytes.</td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiecolt-Glaser</td>
<td>69 family caregivers, 69 matched controls</td>
<td>Caregiving responsibilities for a family member with AD. Social support: Helpfulness of important others (emotional and tangible support).</td>
<td>Caregivers had greater dec. in blastogenic response to PHA &amp; Con A from year 1 to year 2 (esp. at higher concentrations), inc. antibody levels of EBV from year 1 to year 2 than controls. No difference in % helper T-cells, suppressor T-cells, B-cells, NK cells. Caregivers low in helpful social support had greater negative changes in functional immune response (i.e., PHA, Con A, EBV) from year 1 to year 2 than controls.</td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>McNaughton et al. (1990)</td>
<td>33 elderly women</td>
<td>Social support: Social network, satisfaction with emotional and informational support</td>
<td>Women higher in perceived emotional support had lower number of CD8⁺. No difference on CD4⁺ or ratio of CD4⁺/CD8⁺ on any support measure.</td>
</tr>
<tr>
<td>Levy et al. (1990)</td>
<td>61 women (stage 1 &amp; 2 breast cancer patients)</td>
<td>Social support: Perceived emotional support of spouse (or intimate other), family members, friends, nurses, and physician.</td>
<td>Patients higher in perceived emotional support from spouse (or intimate other) and physician had greater NKCA.</td>
</tr>
<tr>
<td>Glaser et al. (1992)</td>
<td>25 men and 23 women (2nd year medical students)</td>
<td>Social support: Aggregate perceived social support</td>
<td>Higher social support associated with greater immune response to Hep B surface antigen and blastogenic response to a Hep B surface antigen peptide (SAg).</td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schlesinger et al. (1991)</td>
<td>46 married couples with children</td>
<td>Social support</td>
<td>Social support not related to NKCA, number of CD57 and CD16 cells.</td>
</tr>
<tr>
<td>Bartrop et al. (1977)</td>
<td>26 spouses/26 matched controls</td>
<td>Marital bereavement</td>
<td>Bereaved spouses had dec. blastogenic response to PHA &amp; Con A than controls. No difference in T &amp; B cell numbers.</td>
</tr>
<tr>
<td>Schleifer et al. (1983)</td>
<td>15 spouses</td>
<td>Marital bereavement</td>
<td>Bereaved spouses had dec. blastogenic response to PHA, Con A, &amp; PWM two months after bereavement compared to pre-bereavement baseline. No difference in total lymphocytes, T or B cell numbers.</td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spratt &amp; Denney (1991)</td>
<td>9 suddenly bereaved parents and 9 controls</td>
<td>Bereavement of child</td>
<td>Bereaved parents had inc. CD4⁺, and ratio of CD4⁺/CD8⁺, dec. CD8⁺, and inc. blastogenesis to PHA at 6 ug only (overall ANOVA n.s., however) than controls. No group differences in cortisol, WBC, and monocytes.</td>
</tr>
<tr>
<td>Irwin et al. (1986)</td>
<td>12 bereaved women, 16 women (spouses w/ cancer), 11 women (healthy spouses)</td>
<td>Marital bereavement</td>
<td>No group differences in NKCA. Life change and depression associated with dec. NKCA.</td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irwin et al. (1988)</td>
<td>10 bereaved women, 8 control</td>
<td>Marital bereavement</td>
<td>Bereaved group had dec. NKCA than controls.</td>
</tr>
<tr>
<td>(Study 1)</td>
<td>women (healthy spouses)</td>
<td></td>
<td>No group differences in absolute number of lymphocytes.</td>
</tr>
<tr>
<td>(Study 2)</td>
<td>6 recently bereaved women</td>
<td>Marital bereavement</td>
<td>Change in depression from anticipatory bereavement to bereavement correlated -.89 with change in NKCA during same period.</td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiecolt-Glaser</td>
<td>38 divorced or separated</td>
<td>Marital quality and marital disruption</td>
<td>Poor marital quality related to lower blastogenic response to PHA (esp. at higher concentrations), Con A, &amp; higher antibody levels of EBV. Length of marital disruption related to inc. % suppressor T-cells, dec % NK cells. Marital disruption in women separated 1 year or less related to lower blastogenic response to Con A (esp. at higher concentrations), PHA, inc. antibody levels of EBV, lower % NK cells, lower % helper T-cells than married women. Marital disruption related to lower blastogenic response to PHA (esp. at higher concentrations), inc. antibody levels of EBV, lower % NK cells than married women.</td>
</tr>
<tr>
<td>et al. (1987)</td>
<td>women, 38 married women control group</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiecolt-Glaser et al.</td>
<td>32 divorced or separated men, 32 married men controls</td>
<td>Marital quality and marital disruption</td>
<td>Poor marital quality related to higher antibody levels of EBV, lower % suppressor T-cells, lower helper/suppressor ratio. Marital disruption related to higher antibody levels of EBV &amp; HSV-1 only than married controls. Initiators of marital disruption had lower antibody levels of EBV. No effect for time of separation.</td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiecolt-Glaser et al.</td>
<td>90 newly-wed</td>
<td>Marital interactions: Marital</td>
<td>Subjects who were high in negative behaviors had dec. blastogenic response to PHA, Con A, T3, dec. NKCA, inc. in total T-lymphocytes, helper</td>
</tr>
<tr>
<td>(in press)</td>
<td>couples</td>
<td>conflict discussion task.</td>
<td>cells, helper/suppressor ratio, dec. in % macrophages at 24 hour than baseline assessment. Subjects high in negative behavior had higher antibody levels of EBV, higher</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>% neutrophils than subjects low in negative behavior.</td>
</tr>
</tbody>
</table>
Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiecolt-Glaser et al. (1987)</td>
<td>34 family caregivers, 34 matched controls</td>
<td>Caregiving responsibilities for a family member with AD</td>
<td>Caregivers had higher antibody levels of EBV, lower % total lymphocytes, lower helper T-cells, &amp; lower helper/suppressor ratio than controls. No differences in suppressor T-cells or % NK cells. Caregivers attending support groups had inc. % NK cells.</td>
</tr>
<tr>
<td>Kiecolt-Glaser et al. (1984)</td>
<td>50 men, 26 women (Med students)</td>
<td>Loneliness</td>
<td>Lonely subjects had lower levels of NKCA.</td>
</tr>
<tr>
<td>Glaser et al. (1985)</td>
<td>33 men, 16 women (Med students)</td>
<td>Loneliness</td>
<td>Lonely subjects had inc. antibody levels of EBV.</td>
</tr>
<tr>
<td>STUDY</td>
<td>SAMPLE</td>
<td>SOCIAL RELATIONSHIP</td>
<td>IMMUNE CHANGES</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>---------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Kiecolt-Glaser et al. (1984)</td>
<td>12 men and 21 women (psychiatric patients)</td>
<td>Loneliness</td>
<td>Lonely subjects had lower blastogenic response to PHA, lower NKCA, and higher urinary cortisol. No group differences in blastogenic response to PWM.</td>
</tr>
<tr>
<td>Kiecolt-Glaser et al. (1984)</td>
<td>47 men and 23 women (Med students)</td>
<td>Loneliness</td>
<td>Lonely subjects had lower transformation levels of B-lymphocytes from the EBV, reflecting the need for more virus.</td>
</tr>
</tbody>
</table>
### Table 7 (Continued).

<table>
<thead>
<tr>
<th>STUDY</th>
<th>SAMPLE</th>
<th>SOCIAL RELATIONSHIP</th>
<th>IMMUNE CHANGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiecolt-Glaser et al. (1985)</td>
<td>9 men and 36 women (Geriatric residents).</td>
<td>Social contact</td>
<td>Social contact not associated with changes in blastogenic response to PHA &amp; PWM; NKCA; and antibody levels of HSV.</td>
</tr>
<tr>
<td></td>
<td>3 men and 12 women per group (relaxation, social contact, &amp; control).</td>
<td></td>
<td>Relaxation associated with inc. NKCA, decreased antibody levels of HSV.</td>
</tr>
</tbody>
</table>

**Note.** PHA = Phytohemmaglutinin, Con A = Concanavalin A, S-IgA = Salivary IgA, NKCA = Natural killer cell activity, NK cells = Natural killer cells, EBV = Epstein-Barr virus, Hep B = Hepatitis B, PWM = Pokeweed mitogen, WBC = White blood cells, HSV = Herpes simplex virus.
APPENDIX B

EXPERIMENTAL QUESTIONNAIRES IN STUDIES 1 AND 2
CRITERIA FORM

CODE: ___________  DATE: ___________

1. In an average week, how many hours do you spend exercising?  _____ Hours
   How many times a week do you exercise? _____ Times

2. In an average week, how many alcoholic beverages do you consume?  _____ Alcoholic beverages

3. What is your current height? _____ Ft. _____ In.

4. What is your current weight? _____ Pounds

5. Are you an offspring of a hypertensive parent?  _____ Yes  _____ No

6. Do you have any history of a psychological disorder?  _____ Yes  _____ No

7. Do you use tobacco products?  _____ Yes  _____ No

8. Do you have a chronic illness?  _____ Yes  _____ No

9. Are you on chronic medication? (including birth control pills)  _____ Yes  _____ No

10. Do you use recreational drugs?  _____ Yes  _____ No

11. Are you in good health?  _____ Yes  _____ No

12. Do you experience speech anxiety?  _____ Yes  _____ No

13. Do you experience math anxiety?  _____ Yes  _____ No

14. Are you needle phobic?  _____ Yes  _____ No

15. Are you willing to participate, if selected, in a follow-up study at the Clinical Research Center?  _____ Yes  _____ No

16. Do you have either Monday or Tuesday mornings (8am to 1 pm) free for the potential participation at the Clinical Research Center?  _____ Yes  _____ No
BACKGROUND INFORMATION

Your age: __________________ Marital Status: __________________ Sex: ___ Female ___ Male

Medications taken in the last week, both prescription and nonprescription:

If you have taken any aspirin (not tylenol) in the last four days, please indicate the number and the day on which you took them:

___ this morning; ___ yesterday; ___ 2 days ago; ___ 3 days ago

Number of cold sores in the last month? ___

Do you have a cold sore at present? ___ yes ___ no

If there has been any change in your weight in the last week, please indicate ____ pounds lost or ____ pounds gained

Compare the amount of sleep you have had in the last three days with the amount you feel you optimally need:

___ I have had as much sleep as I need in the last three days.
___ I have had ___ hours less sleep than I feel I need.
___ I have had ___ hours more sleep than I feel I need.

How many hours did you sleep last night? ____ hours.

How many hours have you spent in vigorous physical activity in the last week?

____ total hours

____ hours jogging and ____ number of miles/week
____ hours biking and ____ number of miles/week
____ hours swimming and ____ number of miles/week
____ hours playing tennis or
____ hours playing other racket sports
____ hours playing basketball
____ hours lifting weights
____ hours in aerobics

Other: please describe type and duration ________________________________

How much alcohol have you drunk in the last 48 hours (12 oz. beer equivalents)? ________

in the last 24 hours? ________

in the last 12 hours? ________

How many caffeinated beverages (coffee, tea, soda pop) have you had in the last 48 hours? ________

Have you taken caffeine in any other form in the last 48 hours? ________ (e.g. No Dox, Dexatrim)

For women - current phase of menstrual cycle:

___ currently menstruating ___ first week after period ___ second week after period
___ third week after period ___ fourth week after period
PLEASE NOTE

Copyrighted materials in this document have not been filmed at the request of the author. They are available for consultation, however, in the author's university library.

88-91, ISEL
92, PSS
93-95, BECK INVENTORY

University Microfilms International
REFERENCES


96


Rodin, J. (1986). Health, control, and aging. In M.M. Baltes & P.B. Baltes (Eds.), *The psychology of control and aging* (pp. 139-165). Hillsdale, New Jersey: Lawrence Erlbaum.


