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Individual and social determinants of shiftwork tolerance

by Friedhelm Nachreiner, DSc¹

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This paper reviews evidence published on individual and social determinants of shiftwork tolerance since 1993. In agreement with earlier reviews, individual differences show only some low and inconsistent concurrent covariation with shiftwork tolerance, and no predictive power for these measures has been found. It is thus not possible to predict future shiftwork tolerance from individual differences. Social conditions are also related to shiftwork tolerance, although again predictive power has not been demonstrated. An examination of the reasons for this state of the art suggested means of improving the relevance and usability of future research in this area.

Key terms individual differences, research strategies, selection, shift work, social conditions.

Interest in the individual and social determinants of shiftwork tolerance is usually based on 2 approaches to managing shift work. In the 1st approach suitable or shiftwork tolerant people could be selected for shift work — if this were possible — or, on the other hand, potentially unfit or intolerant workers should be prevented from entering shift work. In the other approach, shift workers are counseled on what to do and how to cope effectively with the problems of shift work according to the differences between those who are shiftwork tolerant and those who are not. Whereas selection is a genuine individual differences approach, looking for (relatively) stable personal characteristics that predict future shiftwork tolerance, counseling is much more a form of behavior modification aiming at changing behavior or changing conditions that influence behavior. Both approaches make sense, however, only if there are interindividual differences in shiftwork tolerance, if there is covariation between shiftwork tolerance and individual and social characteristics, if in the case of selection (especially in selecting tolerant shift workers) there are people who can be selected (ie, a greater number of applicants than open positions in shift work) and if the predictors do in fact *predict* and not just *covary* with shiftwork tolerance. Such predictive relationships have not been demonstrated, however. Therefore, Härmä (1), after a thorough review of the available evidence, concluded that “It seems thus unjustified to make any definitive selection of the future ‘good’ or ‘bad’ shiftworkers before experience in shiftwork” [p 107]. And, as the present review, roughly 5 years

later, shows, nothing has to be added to this statement. The question is “Why is the situation what it is and what should or could be done to improve it?” Some tentative answers are developed in this review after a short presentation of the new evidence on individual and social determinants of shiftwork tolerance.

Some remarks have to be made, however, before the results of this review and the conclusions drawn from it are considered. This is not a comprehensive review in several respects. First, it is based on Härmä’s (1); therefore no attempt has been made to review and report the literature presented by him and only the literature published since 1993 is covered, with some few exceptions. Second, no attempt has been made to cover all kinds of (theoretically possible or empirically analyzed) individual or social difference measures. Whether a “comprehensive” review in this respect, irrespective of the space available for publication, would be possible is questionable, since the (theoretically possible) number of individual difference measures is probably limited only by one’s imagination. Instead my effort has concentrated on the classical and more-promising newer individual and social difference measures with relevance to predicting shiftwork tolerance. Furthermore, no restrictions on methodological adequacy have been imposed on the reviewed literature, either published in conference proceedings, collections of abstracts for conferences (eg, in the *Shiftwork International Newsletter*), or in reviewed journals. Imposing rigid methodological standards would have reduced the literature to be reviewed dramatically,

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and therefore possible indications of a concurrent or predictive relationship between individual or social difference measures and shiftwork tolerance might have been underestimated, since the literature on individual and social differences and shiftwork tolerance indicates that the better controlled a study is the less support for a truly *predictive* relationship remains. Methodological flaws are widespread and range over the whole research process, from design problems (eg, collecting data for “predictors” time delayed after the dependent variables) and statistically inadequate treatment to the interpretation of predictive relationships from an analysis of statistically significant concurrent covariation (ie, taking the statistical term “coefficient of determination” literally) without due regard to the effect size. It should also be kept in mind that studies published in refereed journals are not methodologically unflawed as well. Therefore, conference abstracts have not been excluded from this review. Where possible, however, preference has been given to published papers.

Another intention of this review, which might well be considered a position paper based on a critical review of the available literature, is to provoke thought for future research in this field.

Individual differences

Gender

In an experimental study (2) no differences in the circadian adaptation process have been observed between men and women, and there are no other data to be reported currently on sex differences. Gender differences will be dealt with under social determinants.

Age

Härmä's (1) findings that shift-related problems tend to increase with increasing age have been supported, for both men and women, for example by Oginska et al (3). These authors also showed, however, that there is a decrease in complaints among women ≥ 50 years of age. Whether this increase in intolerance with age is associated with (or aggravated or caused by) the general increase in sleeping problems with age and the reported increase in morningness ($r=0.21$) (4) is still open to question, although some results by Brugère et al (5) would seem to indicate an additive effect for shift work and age, at least for sleeping problems, and no interaction. According to these results sleeping problems increase with age for both shift and nonshift workers, shift workers showing more problems in each age group but no higher increase with age than nonshift workers. For emotional reactions no increase with age was found in this study, either for shift or for nonshift workers.

Besides positive covariation, no covariation between age and morningness or health has been reported (6), but sometimes indirect or interactive rather than direct effects have been observed (7). The question thus is whether there are relevant circadian changes with age which would influence shiftwork tolerance (which then should apply to all people and, eg, not only to people without social support). However, as other results (8, 9) show, there is no reduction in circadian rhythmicity with age. Therefore, the question of how age influences shiftwork tolerance and whether the influence holds for all people or only for those with certain additional characteristics, which might then be the real cause of the (in)tolerance, remains open.

Neuroticism and extroversion

Neuroticism and extroversion continue to show their well known (low and inconsistent) correlations with shiftwork tolerance (10–15). Neuroticism tends to be the highest [if not the only significant (15)] predictor in multiple regressions. For example, Iskra-Golec et al (14) reported a correlation of 0.59 between neuroticism and shiftwork tolerance. This value is remarkably high, corresponding to as much as 35% of the variance explained. Usually the correlations are much lower, ranging from 0 to ≈ 0.20 [if the dependent variable is not too similar to neuroticism itself, eg, cognitive anxiety, for which correlations up to 0.57 can be found (15)]. Taking interactions with other variables into account does not seem to improve the proportion of variance explained, at least not substantially (14). In general, the correlations are inconsistent — in magnitude as well as in direction. (See, eg, reference 12.)

Testing the *predictive* power of several individual difference measures in one of the very few controlled longitudinal studies, Kaliterna et al (13) were able to demonstrate that neither neuroticism nor extroversion had any power to *predict* shiftwork intolerance.

In general, neuroticism seems to change or lose its status as a predictor or determinant of shiftwork tolerance and to become a confounding variable, whose effects have to be controlled for in the analysis of shift work and its effects (15), or to become an indicator of shiftwork tolerance, with increasing neuroticism considered as an *effect* of shift work (16, 17).

Morningness, eveningness and circadian type

Again, as with neuroticism, some significant correlations have been reported between morningness, eveningness, or circadian type scores (languidity, flexibility) and shiftwork tolerance (6, 18). One study (12) reports “satisfactory covariation”, which, of course, depends on what one is prepared to call satisfactory. As can be seen from an inspection of the results presented by Kaliterna et al (12) and Vidacek et al (10), the correlations are again low and

inconsistent. Härmä (1) already reported inconsistencies in the relations of these variables to shiftwork tolerance. In agreement with this pattern of inconsistency, Härmä et al (19) found no relation with attitudes towards shift work. Moog (20) reported better adaptation to shift work by evening types and suggested slowly rotating systems for these people. Brown (21) found some inconsistent covariation between shiftwork tolerance and scores on the Basic Language Morningness Scale. Therefore, again, there seems to be some association between these characteristics and intolerance, but, when tested in a *predictive* context, these characteristics show no validity to *predict* shiftwork tolerance (11, 13).

Circadian variation of body temperature or mood

There seems to be no validity associated with the ability of circadian parameters such as temperature rhythm or circadian variations in mood to predict shiftwork tolerance either. Vidacek et al (10, 11) showed that there is no association and no power for the amplitude, the mesor, or the acrophase of temperature rhythm to *predict* shiftwork tolerance, a finding that has been replicated recently in another longitudinal study — although of rather short duration — by Bohle (22). In fact, the only statistically significant prediction from circadian variables to scores of the General Health Questionnaire in this study (22) was opposed in direction to that hypothesized.

With regard to circadian variations in mood, Prizmic et al (23) found that, although there is some association between mood and circadian variation in mood and shiftwork tolerance in cross-sectional studies (24), *no predictive validity* could be demonstrated.

Newcomers

Hardiness has been introduced as a new personality variable associated with shiftwork tolerance (25), although no causal relationship was suggested. Since the concept is still undergoing development and the available evidence is limited, no conclusions can yet be drawn.

Locus of control, especially *shiftwork locus of control* (ie, the internal versus external attribution of control with regard to managing the problems of shift work) has been introduced as a determinant of shiftwork tolerance (26), again together with some (moderate) concurrent correlations indicating that an external locus of control is associated with more problems. A common feature in the attribution of control is, however, to attribute the causes of failure externally and those for success internally. This characteristic would be consistent with the reported findings, namely, those who report more problems, and thus are regarded as intolerant, would attribute their problems to external conditions while those who report fewer problems would tend to attribute a lack of problems to their own competence in managing with shift work.

Individual differences in strategies to cope with shift work have been analyzed (27) and would, at least theoretically, seem to be a promising candidate for predicting shiftwork tolerance, since coping behavior might directly influence shiftwork tolerance. The reported correlations were moderate again, and other researchers (7) have found only low correlations. But perhaps this result is due to the conceptualization and assessment in that reducing (possibly specific) coping *behavior* to coping *styles* goes again back to some stable personality dispositions, and their well known low and inconsistent correlations with shiftwork tolerance. Since predictive results have not been presented, the question of predictive power is open for speculation. Perhaps a closer view of the individual differences in *actual coping behavior* (instead of coping *styles*) might yield more promising results.

In summary, there is indeed not much new information on individual differences as determinants of shiftwork (in)tolerance, except that the Vidacek group has now shown empirically that *none of the parameters has any predictive value* and this finding has received support elsewhere.

Specific patterns of behavior

The results presented thus far could indicate that it may be more appropriate and efficient to consider specific *patterns of behavior* (eg, effective versus ineffective coping behavior) as determinants of shiftwork tolerance instead of *traits* or personality characteristics. There are a few studies which would seem to support this suggestion.

Physical fitness and exercising, which may be considered to be at the crossroads between traits and specific behavior, have again been argued for by Härmä (28, see also reference 1) as determinants of shiftwork tolerance, together with some empirical results supporting the position that physical fitness might work via a sleep connection (induced fatigue) and the timing of activities (zeitgeber) and also via enhanced fitness per se. Again more evidence (especially of a predictive nature) would seem to be required before firm conclusions can be drawn. And as physical fitness and exercising lend themselves to a behavior modification approach, well-controlled intervention studies like those by Härmä would seem appropriate.

Looking directly at a set of specific behavior, Greenwood (29) found remarkable differences in effective versus ineffective coping with shift work, and Härmä et al (19) reported that sleeping longer before the morning shifts, due to an interventive delay in the starting time of the morning shift, resulted in more favorable attitudes, with 65% of the variance explained by this change — a remarkably high proportion in comparison with the variance explained by personality traits.

Finally, Blood et al (30) found that the regularity of social behavior facilitated adaptation to shift work, which might be an indication that the regularity of the *actual behavior* might be more important than the self-assessment of flexibility as a *personality trait*.

Social determinants

Gender

It has been known for a long time that gender has an effect on coping with shift work (31) and that it works mainly via a social rather than a biological pathway. This finding has been supported in the meantime by much evidence. (See, eg, references 3, 32, and 33.) Oginska et al (3) found that women (from an industrial sample) showed more symptoms of intolerance than men — until the age of 50 years. Before 50 years of age symptoms increased with age and women of all age groups showed more symptoms than men, whereas women 50 or more years of age showed a decline in symptoms and no difference in comparison with their male colleagues. One possibility is that the change coincides with children having left the home, and therefore female shift workers experience a significant lessening of their double burden as taking care of dependents is reduced to taking care of the household and the husband. (Another reason for the decline among women after 50 years of age may, of course, be self-selection. Such a possibility would, however, have to rely on the assumption that self-selection works differently for men and women — which again would probably be best explained by differences in their social situations.)

The fact that this socially determined double burden makes the difference has been shown by Beermann (32), who found no differences in the effects of shift work on health between women and men but clear differences in domestic obligations and thus in work load and leisure-time activities. Although no differences in the frequency or severity of health complaints were found between women and men (33), Nachreiner et al (34) reported that women show an earlier development of a shiftwork-specific structure of health complaints than men, probably due to the socially determined role-specific behavior of men and women.

Spouses and partners

Much evidence (32, 33, 35—38) shows that the existence of a partner is a determinant of shiftwork tolerance — either in the form of social support (usually for men) or in the form of someone who has to be taken care of (usually for women). All this evidence tends to support the old saying that shift work is only tolerable with the support of a partner — which is exactly what is missing for women (32, 33).

Children

Children add to domestic obligations and thus to the problems of coping with shift work, especially for women, but also for men (33). The evidence seems to be convincing in this respect (30, 35, 38—40). Grzech-Šukalo & Nachreiner (37) have shown that the statistical relationships among the relevant variables become much more complex with the presence of children in the home (indicating higher complexities in the management of the social situation of the shift worker) and that different characteristics of the shift system become relevant or effective with the presence of children (indicating the importance of *interactions* between individual, social, and work conditions as determinants of shiftwork tolerance).

It becomes clear from the published literature as well that children and spouses are not only determinants of shiftwork tolerance, they also add additional dimensions to it (ie, the relationships with spouses and children, the social interactions with them, and the resulting satisfaction).

Domestic obligations

It has already been argued that domestic obligations play a major role as determinants of shiftwork tolerance, and in fact all the references under the headings of gender, spouses and children could be repeated in this section, since domestic obligations seem to be the mechanism by which these conditions become effective. Support for the validity of this conclusion has been provided by Beermann (32), who analyzed the differential work load and social support of men and women.

Social support

The importance of social support, whether at home from family members or at work from colleagues and superiors, as a determinant of shiftwork tolerance has been shown recently (7, 16, 35, 38, 40, 41), in addition to domestic obligations. This evidence is consistent with the results of (older) sociological studies (42) showing role changes in shiftworker families in which women take over roles (and duties) of a shiftworking spouse in order to support the family and the shift worker in coping with shift work.

Shiftwork tradition and culture

There are some old sayings about the effects of shiftwork tradition within a community. For example, within the old coal and steel communities, where shift work was common (and supported by the surroundings) and not abnormal, shift work was more tolerable than in communities or areas where shift work is definitely “abnormal”. However, there seems to be no systematic research into this problem within the last few years. The same is true if one broadens the perspective from the neighborhood, residential area, or community to greater social

systems like societies, for example, in the United States with its "rock around the clock" culture, where everything goes all the time, as compared with more time-structured societies like the European countries (eg, Germany, where more flexibility in scheduling workhours is argued for — especially for economic reasons). We simply do not know anything about this phenomenon (ie, whether destroying social rhythms or socially induced time structures for behavior will have any effect on shiftwork tolerance). It would seem important, however, for present and future discussions to have some evidence on the effects of the social system on shiftwork tolerance.

Again, as with individual differences, the question remains of how big the effects of social determinants are on shiftwork tolerance. There is covariation between social conditions and shiftwork tolerance, and there are some estimates about the (relative) strength of the relationships. But again, whether these are predictive is open to question, although, with some variables, an inverse causal relationship seems less probable.

Considering the results on the individual and social determinants of shiftwork tolerance together raises the question of why so little is known about *determinants* of shiftwork tolerance after all these years of intense research and effort. Reviewing the literature leads to the following problems and possible reasons.

Problems in determining determinants of shiftwork tolerance

Concepts and constructs

One of the reasons for the state of the art might be the definition and explication of the concepts involved. What, for example, does shiftwork tolerance mean exactly? According to Härmä (1), who adopted the concept from Reinberg et al (43), it is the absence of complaints with regard to sleep, digestive and nervous disorders, or psychological well-being, usually measured by some questionnaire (eg, the General Health Questionnaire). The question is (i) whether this definition is a good explication (and operationalization) of the concept of shiftwork tolerance and (ii) whether it is comprehensive enough. What about psychosocial problems, problems with spouses, children and friends, or work-nonwork conflicts, changes in personality (eg, towards increased neuroticism or introversion), or changes in the value structure [eg, towards more solitary activities (16, 17)]? And what about negative effects on spouses or children due to ineffective coping with shift work, partially without complaints from shift workers because they might not even note these problems themselves?

Shiftwork tolerance, as the term is used today, is clearly an ill-defined concept that shows a biologically restricted perspective of "tolerance". It obscures relations

between the biological and social consequences of shift work — and their possible interactions. This concept should thus be either clearly and adequately defined for future use or abandoned.

What is morningness? Is it the chronometric position of the temperature minimum (under unmasked conditions!) or the length of the circadian period (under free running conditions!) or is it a behavioral concept (eg, the preferred times for certain activities) or is it lack of adaptability to changing time structures? Is it a uni- or a multidimensional physiological or behavioral concept (and it should be remembered that a correlation is not a very convincing argument)? Morningness has been found to be multidimensional (44), yielding 2 to 3 orthogonal factors, which, nevertheless, have been combined into 1 single score. The rationale for such a procedure is difficult to understand, but it can be observed with other instruments as well.

A clear explication and definition of the concept would seem required, since such conceptual weaknesses are clearly not very promising for developing valid measuring instruments.

How stable is morningness over time? If it were to be used to predict (a well-defined) shiftwork tolerance, it should be a relatively stable personality trait, independent of external conditions. Moog (20, 45) has reported satisfactory short-term stability ($r=0.84$) among students and, as expected, definitely lower long-term stability over 7 years ($r=0.46$), corresponding to a drop from 65% to 21% in systematic variance, which is clearly not very promising for predictive purposes — especially if one considers that these students probably did not have too many transitions in life circumstances and that correlations indicate only *relative*, not absolute, stability. There have been reports on changes in — or more precisely covariations of — morningness with age (44), although rather low ($r=0.20$, corresponding to 4% of common variance), and an age-related phase advance of temperature rhythm among older people under normal conditions. The latter was not present, however, under constant routine conditions (9), indicating behavioral dependency. Personal experience would lead one to believe that temporal preferences for certain activities, as asked for in morningness-eveningness questionnaires, change with transitions across life phases — and thus change according to external conditions. It is not clear whether the temperature minimum (under unmasked conditions) changes correspondingly — but behavior does change, as can be easily observed. Why should morningness change with age (if it does)? Could it be due to the effect of a third variable? The answer is not available at the moment. Why does morningness change with the seasons, a definitely external condition, as Pokorski et al (46) showed? The question thus is what morningness really means. Is it a relatively stable personality disposition, dimension, or

trait with the possibility to *predict* shiftwork tolerance? — “Probably not” would be the most appropriate conclusion after a critical review of the literature.

Psychometric properties of measuring instruments

Since it is difficult to construct well-designed instruments for badly defined constructs, one would not expect too much with respect of the “determinants” of shiftwork tolerance. In fact, there are remarkable weaknesses in the instruments used. In a factor analysis of the Circadian Type Inventory, Silvério et al (47) found only 23% of the variance explained by the 2 factors, and Smith et al (48) demonstrated that the psychometric properties of the Circadian Type Inventory are definitely not adequate. The problem of combining items belonging to *orthogonal factors* in a single score on a *unidimensional scale* has already been mentioned in the context of morningness-eveningness. If 4 loci of (shiftwork) control can be differentiated, why should they then be combined into a single score — especially if they refer to different areas

of impairment and the correlations are higher for the specific scales with their respective area of impairment (26)?

Statistical treatment

The statistical problems of the measuring instruments lead directly to problems of the statistical treatment of the relations between dependent and independent variables. What one usually finds are multiple dependent (eg, those making up shiftwork tolerance) and multiple independent (eg, neuroticism, morningness, flexibility) variables. However, instead of using adequate statistical methods (eg, canonical correlation) these variables are generally treated by simple bivariate correlational analyses, multiple regressions (or multiple multiple regressions), or (multiple) factor analyses or combinations thereof. The use of these techniques leaves interesting covariation unobserved and leads to repeated tests of the same hypothesis on the same data.

That an adequate statistical treatment offers some interesting insights into the relationships between the variables has been demonstrated earlier (49), where it could be shown that the evaluative component of the attitude towards shift work could be separated from its conative (behavioral) component and that both components are determined by different independent variables, the behavioral component (eg, manifest trials to get out of shift work) being less influenced by personality characteristics (eg, neuroticism) than the evaluative component. The behavioral component on the other hand is much more influenced by motivational and situational variables.

Some improvements, however, have to be noted as well. There is a tendency to use more appropriate and more sophisticated statistics, for example, structural modeling (38, 40, 50), during the last few years.

Design problems

A severe problem is the common cross-sectional design of studies. Longitudinal studies are rare, but offer remarkable insight, as can be seen from the studies of Vidacek et al (11) and Kaliterna et al (13). On the other hand, if longitudinal studies are used, why not repeat the measurement of the predictors as well, not only to estimate their stability but to be able to use cross-lagged analysis techniques to detect complex recursive relations (eg, neuroticism influencing tolerance, which influences neuroticism). Such more-complex approaches, combined with more complex, adequate statistical techniques like structural modeling, may improve the understanding of what really happens in shift work.

Variance explained and linearity of relationships

When one looks at (usually cross-sectional) covariation, another question concerns the amount of variance explained. The amount explained usually varies from very low to low (4 — 10%), 35% being already a rare

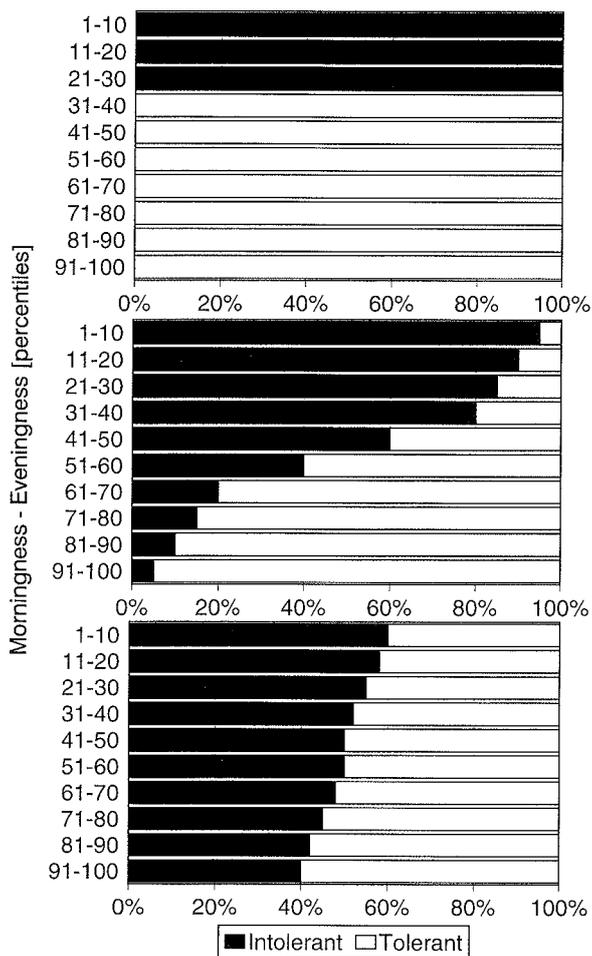


Figure 1. Expectancy charts for different predictor-criterion relationships (theoretical examples).

exception. Considered together with the inconsistencies (in magnitude and direction), the low amount of covariation casts severe doubts on the chances of effective selection.

Usually linear relationships are (tacitly) assumed (eg, as in correlation) without further inspection. Could nonlinearities or stepfunctions be one of the reasons for the low correlations? For circadian type variables, extreme groups are usually compared. But what happens in between? Or do such comparisons imply tacitly favoring a model with a bimodal distribution, quite in contrast to the empirical distributions? If selection is really wanted and if it is to be done in a responsible way, with some estimates of effectiveness, then expectancy charts, giving the odds of correct decisions for different scores on the predictor, may be much more informative than correlation coefficients or extreme group comparisons.

Figure 1 shows 3 theoretical examples of such expectancy charts, all of which would yield a correlation between the predictor and the criterion (partially substantial, eg, 0.80, 0.68 and 0.12 on an individual level and 0.80, 0.97 and 0.99 on the group level from top to bottom). These expectancy charts would show immediately what the chances for an effective selection would be under the particular conditions given. Error-free selection decisions would only be possible with top chart conditions, if the assessment of the predictor were highly reliable, and more than 30% could be rejected from entering shift work. However, such a predictor-criterion relationship has never been observed.

Factors influencing selection efficiency

As figure 1 shows, selection will always yield errors, depending on more variables than merely a substantial predictor-criterion relationship, since there are more factors which influence the efficiency of selection, eg, the base rate (ie, the proportion showing the criterion, eg, shiftwork tolerance, in the unselected population), and the selection rate (ie, the proportion that has to be selected from the population to fill the jobs), which will influence the proportion of false positives, false negatives, true positives, and true negatives with different "costs" associated with each group. But what would be the base rate of shiftwork tolerance (whatever it means) in an unselected population? The fairest answer would seem to be "unknown". And what are realistic selection rates, if there are any at all, in practice?

Concluding remarks

When the facts presented in this review are taken into account, the chances for an effective selection strategy

with regard to shiftwork tolerance would appear to be minimal, at least for the time being, and therefore it would not seem to be a professionally serious and responsible activity.

The problem remains, however, with regard to counseling. Intervention studies would appear to be the most helpful in testing hypotheses about determinants of shiftwork tolerance or effective coping with shift work. In this context a concentration on specific patterns of behavior and its hypothesized determinants would seem appropriate and promising.

Nor should oversimplified models for underlying mechanisms or relations be used. If behavior is taken seriously as a function of the person, the environment (including the job and the task), and especially the interaction between the person and the environment, more consideration should be given to a more thorough explanation of the underlying constructs, to more complex, for example, recursive, models of the relationships between them, and to the use of adequate instruments and methodologies to improve the applicability of shiftwork research.

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