**Figure 5.14** Mechanisms leading to a successful search for solutions (+) in 28 critical situations of this type. The figure 139% in the box "experience" is caused by the fact that high experience in one critical situation may serve both as a source for communication as well as a cause for the availability of information, so that we have to take "experience" into account twice in one critical situation. Thus, a percentage of over 100% can only result if one factor is related to more than one other factor.

of course, many other aspects that contribute to the quality of a solution search, but regarding the group, "group climate" is more important than has been assumed in recent studies undertaken in the context of social psychology (Witte and Lecher 1998).

Another important group-related factor supporting the main design representation "communication" is group organization. In situations of positive solution search, however, group organization proved to be less relevant and occurred in only 14% of all situations of positive solution search. (For example, the informal discussion between designer C and designer B in Table 5.4 did not take place because of group organization; rather, it was based on the trustful relationship between the colleagues C and B.)

Achieving adequate group organization, together with good group climate, is among the major responsibilities of the group leader. The optimization of important external conditions, such as spatial distance between colleagues and the division of work, is more or less the responsibility of the management. This makes the quality of leadership a major prerequisite in the background of successful communication in solution search situations, and thus group creativity. But we have to consider that the individual designer with his or her experience and knowledge has an impact, too: information transfer is mostly based on the experience of designers. Moreover, the open-mindedness of the individual designer, a readiness to accept new ideas and a high demand for quality, leads to an intensive search for solutions (see also Badke-Schaub and Buerschaper 2000). These findings are corroborated by other studies (Perkins 1988; Sternberg 1988) that have shown that domain-specific knowledge is not sufficient for successful problem solving because the adaptation

Frequency of occurrence [%]
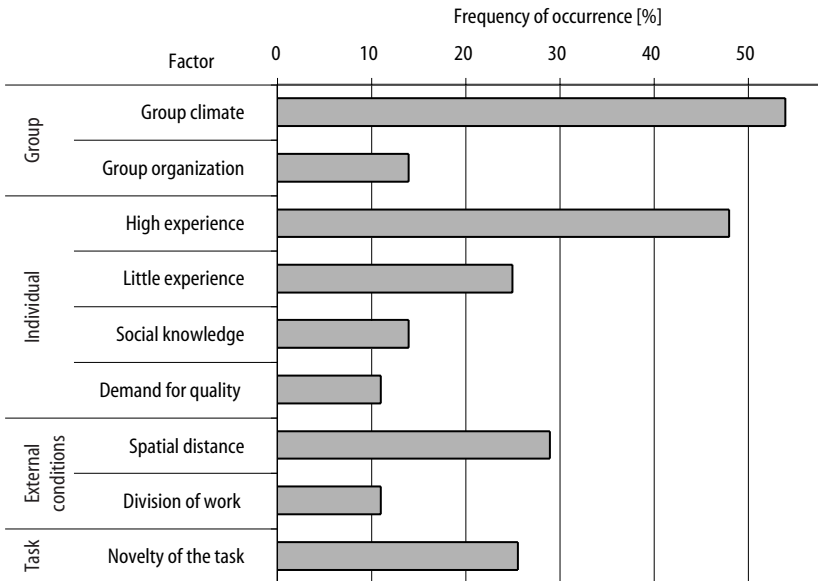
Figure 5.15 Factors influencing communication in situations of successful solution search.

and restructuring of knowledge is also related to personality characteristics such as open-mindedness and tolerance for ambiguity.

Figure 5.15 illustrates how frequently different factors support verbal information transfer in critical situations of successful solution search.

Conclusions

Thinking about external design representations we instantly associate design representations with artefacts such as sketches, drawings, or models. But whereas sketches are a basic design representation for every routine work in product development, critical situations in the design process underlie other representational conditions. In critical situations communication between colleagues is the most important design representation: engineering designers contact colleagues in nearly 90% of the critical situations identified along the design process. Therefore, the appropriateness of communication in different types of critical design situations turns out to be an important prerequisite for successful design work. Whereas routine work can be supported adequately and quickly by computer-based information tools, social information transfer in critical situations must be emphasized and supported.

Usually, designers prefer to search for information by asking their colleagues because, in doing so, they receive much additional information, including a rough sense of the quality of their own idea, solution, or decision. The study suggests that it is important for group members to know the rules and mechanism to enforce adequate information transfer during these situations. We know that it is important to encourage designers (and all people, for that matter) to preserve the individual's feeling of competence. Negative