

How knowledge worker teams deal effectively with task uncertainty: the impact of transformational leadership and group development

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Abstract

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The purpose of this paper is to clarify how leadership is able to improve team effectiveness, by means of its influence on group processes (i.e., increasing group development) and on the group task (i.e., decreasing task uncertainty). 408 members of 107 teams in a German research and development (R&D) organization completed a web-based survey; they provided measures of transformational leadership, group development, 2 aspects of task uncertainty, task interdependence, and team effectiveness. In 54 of these teams, the leaders answered a web-based survey on team effectiveness. We tested the model with the data from team members, using structural equations modelling. Group development and a task uncertainty measurement that refers to unstable demands from outside the team partially mediate the effect of transformational leadership on team effectiveness in R&D organizations ($p < .05$). Although transformational leaders reduce unclarity of goals ($p < .05$), this seems not to contribute to team effectiveness. The data provided by the leaders was used to assess common source bias, which did not affect the interpretability of the results. Limitations include cross-sectional data and a lower than expected variance of task uncertainty across different job types. This paper contributes to understanding how knowledge worker teams deal effectively with task uncertainty and confirms the importance of group development in this context. This is the first study to examine the effects of transformational leadership and team processes on team effectiveness considering the task characteristics uncertainty and interdependence.

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In review

How knowledge worker teams deal effectively with task uncertainty: the impact of transformational leadership and group development

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12 **Abstract**

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14 means of its influence on group processes (i.e., increasing group development) and on the group task
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16 (R&D) organization completed a web-based survey; they provided measures of transformational
17 leadership, group development, 2 aspects of task uncertainty, task interdependence, and team
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23 seems not to contribute to team effectiveness. The data provided by the leaders was used to assess
24 common source bias, which did not affect the interpretability of the results. Limitations include
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26 This paper contributes to understanding how knowledge worker teams deal effectively with task
27 uncertainty and confirms the importance of group development in this context. This is the first study
28 to examine the effects of transformational leadership and team processes on team effectiveness
29 considering the task characteristics uncertainty and interdependence.

30 **1 Introduction**

31 Uncertainty is growing in modern working contexts. Polyvalence, time pressure, unpredictable
32 environmental conditions, and the relevance of knowledge and distributed skills drive this
33 development (Navarro *et al.*, 2011). Knowledge workers are particularly exposed to uncertain tasks
34 and the relevance of knowledge work is rising in the developed economies (Spath and Hofmann,
35 2009): today's organizations need to constantly innovate (Reuveni and Vashdi, 2015), and they

36 increasingly rely on teams for this purpose (Edmondson and Nembhard, 2009). Consequently,
37 organizations need to enable their teams to deal with uncertainty and to create the synergies
38 necessary to innovate. Although the literature on leadership is extensive, the role of leadership with
39 respect to the demands of increasingly uncertain tasks has not been investigated, yet. We therefore
40 researched the role of leadership with respect to different types of task uncertainty, taking
41 interpersonal and structural coordination mechanisms into account and addressing limitations of
42 previous research. “Innovation is the multi-stage process whereby organizations transform ideas into
43 new/improved products, services or processes” (Baregheh *et al.*, 2009, p.1334). Creativity is defined
44 as the generation of such ideas (Cheung and Wong, 2011). Thus, innovation requires creativity. Work
45 meant to produce innovation as its primary outcome has been labelled knowledge work (Drucker,
46 1999; Willke, 1998). Definitions of knowledge work stress the continuous requirement for learning
47 (Drucker, 1999; Willke, 1998), unclear objectives, processes or outcomes (Spath and Hofmann,
48 2009), or the fact that knowledge is always connected to the unknown and always improvable
49 (Willke, 1998). The common characteristics across these definitions are uncertain objectives, a lack
50 of familiarity with the methods required to achieve the objective, or an unclear connection between
51 method and outcome of the work. This matches the operationalization of task uncertainty by Navarro
52 *et al.* (2011, p. 19). Knowledge work is characterized by uncertain tasks.

53 Consequently, two approaches are available to investigate the factors that help teams innovate: (1)
54 examining which factors influence outcomes such as team innovation or team creativity, and (2)
55 exploring which factors increase the effectiveness of teams working on uncertain tasks.

56 With respect to the first approach, research evidence is available. It indicates that transformational
57 leadership is particularly beneficial to the workers in teams focused on innovation: leaders should
58 serve as role models (idealized influence), communicate a positive vision (inspirational motivation),
59 take care of followers individually (individualized consideration), and encourage them to find their
60 own solutions (intellectual stimulation; Bass *et al.*, 2003). Thereby, they foster individual worker
61 creativity (de Jong and Den Hartog, 2007), individual employees’ engagement in idea management
62 (Pundt and Schyns, 2005), as well as group creativity (Eisenbeiß, 2009; Jung, 2001) and team
63 innovation (Paulsen *et al.*, 2009). Research indicates that the positive effect of transformational
64 leadership on team innovation and team creativity is mediated by group processes such as
65 cohesiveness (Eisenbeiß, 2009), team identity (Paulsen *et al.*, 2009), engagement and knowledge
66 sharing (Edmondson and Lei, 2014), or development of shared mental models (Reuveni and Vashdi,
67 2015). These findings integrate well into what is generally known about the effects of
68 transformational leadership on teams: transformational leadership augments the positive effects of
69 transactional leadership on team performance (Avolio *et al.*, 2009) and group processes such as
70 cohesiveness are mediators of this relationship (Bass *et al.*, 2003; Jung and Sosik, 2002).

71 However, existing research does not clarify whether transformational leadership plays a special role
72 in teams with high task uncertainty, such as teams of knowledge workers, compared to teams in other
73 types of work. Answering this question requires evidence based on the second approach, which is not
74 available as far as we know. Literature indicates that transformational leadership is more effective
75 when the organizational environment is uncertain (Bass and Riggio, 2006; Felfe, 2006) and the same
76 could apply to uncertain tasks: Frost *et al.* (2010) assumed that teams of knowledge workers require
77 transformational management solutions. To test these assumptions, we investigated a model of the
78 relationships between transformational leadership, group processes and task uncertainty. In contrast
79 to previous studies, we compared teams across different job types. Like other studies in this field
80 (e.g. Eisenbeiß, 2009; Reuveni and Vashdi, 2015), this research was focused on the team level.

81 The work presented here is, to our knowledge, the first study to investigate the relationships between
82 transformational leadership, task uncertainty, and team effectiveness. We tested assumptions derived
83 from Frost *et al.* (2010) and we addressed the limitations of previous studies resulting from the use of
84 homogeneous samples. In the model, we considered both, interpersonal (group development) and
85 structural (task interdependence) coordination mechanisms.

86 **2 Theoretical background and research model**

87 **2.1 Research model and independent variable: transformational leadership**

88 As argued above, there is exhaustive evidence that transformational leadership has positive effects on
89 team performance (Avolio *et al.*, 2009) and that group processes such as cohesiveness mediate this
90 relationship (Bass *et al.*, 2003; Jung and Sosik, 2002). While prior research relied on Input-Process-
91 Output Models (I-P-O, e.g. West and Hirst, 2003), Input-Mediator-Output-Input (IMOI) Models are
92 the most appropriate choice: I-P-O models assume the mediating variable to be a process, which is
93 inadequate in many cases; in IMOI, it can be an emergent state, too (Ilgen *et al.*, 2005). As
94 longitudinal data was not available, we integrated the aforementioned relationships into an Input-
95 Mediator-Output model and added measures of task uncertainty. In the following paragraphs, we
96 provide the reasoning for the choice of constructs and hypotheses.

97 **2.2 Dependent variable: team effectiveness**

98 To research the relationships between transformational leadership, group processes and task
99 uncertainty, the outcome variable must be applicable to any kind of team, no matter if such team is
100 meant to produce innovation or not. Therefore, we chose team effectiveness (Hackman, 1987) as our
101 outcome variable: a team is considered effective if (1) it meets the success criteria defined by
102 stakeholders, (2) the team members benefit from the outcomes of the team's work, and (3) the team's
103 ability of working together in the future is maintained. As a criterion of team performance, team
104 effectiveness has a long tradition in team research (e.g. Kozlowski and Bell, 2003).

105 **2.3 Mediator: group development**

106 In the majority of reported models, instead of other processes or emergent states, cohesion is
107 considered as the direct predictor of team effectiveness (Bass *et al.*, 2003; Jung and Sosik, 2002).
108 However, the concept of group cohesiveness, the different ways it is measured and how it is used in
109 research has been criticized (Hogg, 1993). Thus, we replaced cohesion by *group development* (GD;
110 Meneses *et al.*, 2008). This construct represents the degree to which a set of people functions as a real
111 team, defined by these characteristics of well-developed groups (Navarro *et al.*, 2015): (1) there are
112 regular personal interrelationships between the members; (2) the members are working or oriented
113 towards shared goals; (3) the members identify with the group; and (4) the group has a high level of
114 coordination. In contrast to group cohesion, GD refers to the group's goals and to the group's
115 coordination, which we considered highly relevant to explaining the effects of leadership on team
116 outcomes as mediated by group processes.

117 Theory further justifies the assumption that transformational leadership leads to increased group
118 development: transformational leadership is supposed to raise the acceptance of group goals
119 (Podsakoff *et al.*, 1996), which is a requirement of group development (Navarro *et al.*, 2015).
120 Additionally, individual consideration might reduce conflict among the team members and thus
121 positively affect their interpersonal relationships. Finally, individual consideration and intellectual
122 stimulation could make team members feel appreciated and their contributions valued, which may

123 strengthen their identification with the team. Based on this reasoning and literature (Bass *et al.*, 2003;
124 Jung and Sosik, 2002), we set the following hypothesis:

125 *H1. Group development will at least partially mediate the positive relationship between*
126 *transformational leadership and team effectiveness, with all variables being positively*
127 *interrelated.*

128 Despite its similarities to previous research, this model has, to our knowledge, never been tested.

129 **2.4 The role of task uncertainty**

130 The next step was adding task uncertainty to the model. Based on the literature, it could be mediator
131 or a moderator, depending on its operationalization. Sicotte and Bourgeault (2008), for example,
132 reported some dimensions of organizational and environmental uncertainty to directly predict a
133 decrease in team performance, while other dimensions of uncertainty moderated the effects of
134 organizational interventions on team performance. We intended to represent both potential roles in
135 the model by including *new situations* and *unclarity of goals* from the German version of the MITAG
136 instrument. We had previously validated this instrument in a German sample, which had resulted in a
137 reduced set of items and a new factor structure. From the three newly identified factors, we picked
138 new situations and unclarity of goals. For reasons of model parsimony, we disregarded the third
139 factor named *non-routine*, which on a theoretical level was more difficult to relate to the other
140 constructs.

141 Previous studies (Faraj and Yan, 2009; Gardner *et al.*, 2012) relied on short questionnaires that did
142 not distinguish between different types of uncertainty, although some were limited to specific work
143 settings. We decided to use measurements that are applicable across different job types while
144 specifying subordinate factors of task uncertainty.

145 **2.5 Task uncertainty as a moderator**

146 As task uncertainty is a necessary requirement of knowledge work (Spath and Hofmann, 2009), some
147 uncertain aspects of the team's task cannot be proactively reduced by the team itself. Variables that
148 measure these types of task uncertainty consequently qualify either as independent or as moderator
149 variables. The model by West and Hirst (2003) supports this perspective by restricting task
150 characteristics to the category of input variables.

151 There is evidence that transformational leadership is more likely to emerge and more effective, when
152 the environment is complex (Felfe, 2006; Wolfram and Mohr, 2009), unstable, uncertain or turbulent
153 (Bass and Riggio, 2006). This means that environmental complexity and uncertainty moderate the
154 relationship between transformational leadership and team outcomes (Wolfram and Mohr, 2009, p.
155 261). Consequently, uncertainty related to the team's task could also moderate this relationship. This
156 hypothesis is further supported by Frost *et al.* (2010): they argued that knowledge work requires
157 intrinsic motivation and voluntary contributions, which are fostered by transformational leadership.
158 Consequently, we argue that there should be an interaction effect between transformational
159 leadership and task uncertainty, which represents the characteristics of knowledge work.

160 If H1 were true, task uncertainty could moderate either the influence of leadership on group
161 processes, or the effect of group processes on team effectiveness. Literature suggests the latter:
162 Navarro *et al.* (2011, p. 20) argue that the social support and sense-making activities of group-work
163 are particularly beneficial when dealing with diverse, new, incompatible, and ambiguous tasks. And

164 evidence shows that boundary reinforcement, which refers to “sharpening team identity” (Faraj and
165 Yan, 2009, p. 607), and relational resources such as familiarity among team members (Gardner *et al.*,
166 2012) are more positively related to team performance when task uncertainty is high. Thus, we
167 assumed that task uncertainty would moderate the relationship between GD and team effectiveness.

168 To represent this type of externally caused task uncertainty, we used the factor new situations from
169 the German version of the MITAG questionnaire, as resulting from our previous validation study. It
170 refers to conflicting or fast changing short-term demands from outside the team. Thus, it is a type of
171 uncertainty that the team cannot avoid proactively. This type of task uncertainty requires
172 performance adaptations, which have been defined as “altering behavior to meet the demands of the
173 environment, an event or a new situation” (Pulakos *et al.*, 2002, p. 615). Team adaptation requires
174 coordination and information sharing (Maynard *et al.*, 2015), which corresponds to the characteristics
175 of well-developed teams, as measured by the GD instrument. So, we hypothesized that well-
176 developed teams adapt more efficiently to such changing short-term demands.

177 **2.6 Controlling for task interdependence**

178 To test the moderating effect of the factor new situations, we had to control for task interdependence.
179 “Team members are task interdependent when they must share materials, information, or expertise in
180 order to achieve the desired performance or output.” (Van der Vegt *et al.*, 2001, p. 52). The
181 commitment to a shared goal, group coordination, and strong interpersonal relationships can be
182 expected to be helpful in interdependent tasks (Mullen and Copper, 1994), even when uncertainty is
183 low. Consequently:

184 *H2. New situations will moderate the relationship between GD and team effectiveness,*
185 *while task interdependence will moderate this moderation effect: combinations of low*
186 *scores on new situations and task interdependence will be associated with weaker*
187 *relationships between group development and team effectiveness.*

188 **2.7 Task uncertainty as a mediator**

189 However, task uncertainty can be a mediator if team members or leader can actively reduce or
190 increase a certain aspect of task uncertainty. Weiss and Hoegl (2016) hypothesized that increased
191 task uncertainty will be detrimental to team performance. They argued that task uncertainty required
192 more planning and “more frequent nonroutine decision-making”, which would occupy additional
193 team resources such as time and effort (p.15). Such an effect may have led to Tatikonda and
194 Rosenthal (2000) finding higher task uncertainty to be related to higher costs in technology
195 innovation projects.

196 We chose the factor unclarity of goals from the German MITAG questionnaire, which represents the
197 extent to which general or long-term goals or objectives have not been well-defined by the team
198 leader.

199 Transformational leaders motivate their co-workers through a vision, and intellectual stimulation
200 means transformational leaders tell their followers rather what to achieve than how to do the job.
201 Both should reduce unclarity of goals in the team. Provided with a general vision and long-term
202 objectives, the team may achieve a higher level of coordination and emergence, increasing its
203 effectiveness. Thus, we assumed unclarity of goals to be negatively related to team effectiveness.

204 *H3. Unclarity of goals will partially mediate the relationship between transformational*
205 *leadership and team effectiveness, with higher scores in transformational leadership*
206 *associated to reduced unclarity of goals and thus to greater team effectiveness.*

207 Figure 1 gives an overview of model 1.

208 (Insert Figure 1 about here)

209 Hypotheses H1, H2, and H3 formed model 1. However, following Weiss and Hoegl (2016), new
210 situations could also increase the team's need to adapt and thus decrease its efficiency. Sicotte
211 and Bourgault (2008) found that fuzziness, which resembles the here used variable new
212 situations, correlated negatively to measures of performance. When a team scores high on new
213 situations, then the team needs to adapt. The adaptation process will consume time and resources
214 (Weiss and Hoegl, 2016), thus temporarily lowering performance. The more often a team needs
215 to adapt, the lower its efficiency will be. New situations may also be detrimental to the team
216 members' motivation, in case that the adaptation renders previously done work useless: the
217 expected reward for previous efforts is suddenly removed. This justifies an alternative hypothesis
218 that introduces new situations as a factor that has a direct influence on team performance.

219 Furthermore, new situations is a subjective measurement. Independently of the true amount of
220 changing demands, the team's appraisal may protect it from the respective negative
221 consequences. Transformational leaders who motivate team members through a long-term vision
222 may be able to buffer the supposed decrease in motivation that could result from frequently
223 adapting project plans to changing outside demands. Intellectual stimulation and individualized
224 consideration could further increase the team members' abilities to deal with disruptions quickly
225 and thus perceive them as less disturbing. A transformational leader's individually considerate
226 behaviors could empower team members (Dionne *et al.*, 2004). While research results at team
227 level are still missing, Maynard *et al.* (2015) suspect empowerment to foster team adaptation and
228 propose to further research this topic.

229 We assumed that transformational leadership could lead to a decrease in the measurement value
230 of new situations, which in turn would correlate negatively with team effectiveness. Thus, new
231 situations was also eligible as a mediator, and we created an alternative model 2 based on
232 hypotheses H1 and H3 and substituting H2 by H2a.

233 *H2a. New situations will partially mediate the relationship between transformational*
234 *leadership and team effectiveness, with higher scores in transformational leadership*
235 *being associated to a lower score in new situations and thus to greater team*
236 *effectiveness.*

237 Adapting to a new situation requires behavioral changes (Pulakos *et al.*, 2002). We assumed that
238 clearly defined interdependencies among the team members would speed up the adaptation process.
239 If interdependence is low, then the number of options is high, e.g. everybody might be eligible for a
240 new task. If, however, a task needs to be fit into a neatly organized set of interdependencies, then the
241 available options are limited and the decision will be made faster, which saves resources.
242 Additionally, we assumed that teams in which work was organized in a way that required team
243 members to frequently exchange outputs among each other, adaptation would be easier to achieve.
244 So, in teams experiencing new situations, we expected task interdependence to dampen the negative
245 impact of uncertainty on team effectiveness.

246 Therefore, assuming H2a to be true, we expected the structure of the team's work, as represented by
247 task interdependence, to moderate the effect of task uncertainty.

248 *H4. Task interdependence will moderate the relationship between new situations and*
249 *team effectiveness as stated in H2a, with greater task interdependence associated to a*
250 *weaker relationship between new situations and team effectiveness.*

251 Figure 2 depicts model 2.

252 (Insert Figure 2 about here).

253 **2.8 Topic delimitation: uncertainty avoidance**

254 Another variable that may determine how teams deal with uncertainty is uncertainty avoidance, e.g.
255 as measured by the Uncertainty Avoidance Index (UAI, Hofstede, *et al.*, 2010). Its origins are in
256 cross-cultural psychology and the following paragraphs explain why it was not included in our
257 model.

258 Uncertainty avoidance is “the extent to which the members of a culture feel threatened by ambiguous
259 or unknown situations. This feeling is [...] expressed through nervous stress and a need for
260 predictability” (Hofstede, *et al.*, 2010, p. 191). Some researchers have argued that high uncertainty
261 avoidance will hamper innovation (Shane, 1993). However, with regard to this assumption, research
262 has produced contradictory outcomes (Hofstede *et al.*, 2010, pp. 211): Studies at national level have
263 either found a negative relationship between uncertainty avoidance and innovation (Shane, 1993), or
264 no relationship at all (Rinne *et al.*, 2012). Hofstede *et al.* (2010) argued that cultures with low
265 uncertainty avoidance excelled at producing new ideas, while cultures with high uncertainty
266 avoidance were better at implementing such ideas into new processes or products.

267 This is interesting in the sense that depending on national culture, teams or individuals may apply
268 different strategies to cope with uncertainty, which may in turn have an impact on performance.
269 However, as the here-presented study is based on a sample from one national culture and from one
270 organization, we did not include uncertainty avoidance into our model. If any effects exist, they will
271 rather affect the international interpretability of the model.

272 Additionally to studies at national level, Hofstede's UAI can also measure individual differences:
273 Zhang and Zhou (2014) found that in followers with high uncertainty avoidance, empowering
274 leadership is related to higher creativity – but only if they trust their superior. This finding is likely to
275 apply to transformational leaders, as they are expected to empower followers through intellectual
276 stimulation (Bass *et al.*, 2003). However, we planned to test our model at group level, we refrained
277 from including individual level variables. Despite an individual's preference for avoiding or
278 embracing uncertainty, different types of task uncertainty may have different effects in teams of
279 knowledge workers. Such possible differences between sub-types of task uncertainty have been
280 disregarded in previous research (e.g. Faraj and Yan, 2009; Gardner *et al.*, 2012). From the
281 perspective of cross-cultural psychology, knowing the effects of different types of uncertainty on
282 work processes or outcomes may also aid in resolving the above mentioned dispute.

283 **3 Material and Methods**

284 **3.1 Participants and procedure**

285 501 team members from 226 teams and 104 team leaders from a German research organization
 286 completed an online-questionnaire (Table 1). Submitting the questionnaire required answering all
 287 items. Thus, there were not any empty fields in the data matrix. Each team had at least three
 288 members, in addition to the leader. Mean age was 34.3 years ($SD = 11.8$). 32.9% had worked 2 years
 289 or less on their team, 32.5% between 2 and 5 years, and 31.5% more than 5 years. The study design
 290 was approved by the organization's workers' council (German: Gesamtbetriebsrat). Section 3.3
 291 describes the data aggregation that resulted in (1) the final sample of 107 teams, composed by data
 292 from the team members, and (2) a sample of 54 of these teams, in which measurements of team
 293 effectiveness were provided by the leaders. We used the first sample for testing the model and the
 294 second sample to check for common source bias.

295 (Insert Table 1 about here)

296 **3.2 Measures**

297 **3.2.1 Transformational leadership**

298 Most research on transformational leadership relied on the MLQ (Bass and Avolio, 1995). Yet its
 299 dimensionality has been questioned (Bycio *et al.*, 1995), and Berger *et al.* (2012) showed that
 300 transformational leadership can be measured as a unidimensional construct. Thus, we used the
 301 German version of the HSA-TFL short-scale (8 items, Cronbach's $\alpha = .93$). The instrument had
 302 previously been validated successfully in a German sample by Berger and Guàrdia. Example item of
 303 the follower questionnaire: "Ich vertraue auf seine/ihre Fähigkeiten, Hindernisse jeder Art zu
 304 überwinden." ("I have trust in his/her ability to overcome any obstacle.").

305 **3.2.2 Group development**

306 We used the German translation of the group development questionnaire based on Navarro *et al.*,
 307 (2015), which we had previously validated in a German sample. In the validation study, the
 308 unidimensional structure was confirmed and the internal consistency was good (8 items, Cronbach's
 309 $\alpha = .87$). Example item: "In meiner Arbeitsgruppe teilen wir untereinander Instrumente, Ressourcen
 310 und Informationen" ("We share tools, resources and information.").

311 **3.2.3 Task uncertainty**

312 We used the German version of the MITAG model (Navarro *et al.*, 2011), as resulting from our
 313 previous validation study, to measure unclarity of goals (4 items, Cronbach's $\alpha = .78$), and new
 314 situations (3 items, Cronbach's $\alpha = .68$). Example item: "In meiner Arbeitsgruppe ist es für uns ganz
 315 klar was wir mit unserer Arbeit erreichen sollen." ("We are very clear on what we must achieve with
 316 our work").

317 **3.2.4 Task interdependence**

318 We translated the seven items developed by Van der Vegt *et al.*, (2001) into German, using a back-
 319 translation process to avoid translation errors based on cultural or linguistic differences (ITC, 2005).
 320 In our data, the internal consistency (Cronbach's α) of this one-dimensional measure was .76.

321 **3.2.5 Team effectiveness**

322 We translated the twelve-item effectiveness-scale presented by Navarro *et al.*, (2011) into German,
 323 following a back-translation process (ITC, 2005). These items are based on the normative model
 324 proposed by Hackman (1987). The internal consistency (Cronbach's α) of this one-factorial measure

325 was .89 in our sample. Example item: “In meiner Arbeitsgruppe arbeiten wir wirksam.” (“We are
326 efficient performing our tasks”).

327 Task Interdependence was measured using a seven-point Likert-scale, whereas all other instruments
328 were presented with a five-point Likert-scale.

329 3.3 Data aggregation

330 Team members answered all the above named instruments, while the team leaders answered only the
331 items measuring team effectiveness. The data collected from the team members were aggregated at
332 team level.

333 The wide-spread use of an equal distribution for calculating r_{wg} or $r_{wg(j)}$ has been criticized (LeBreton
334 and Senter, 2008), and it has been argued that .70 may be inadequate as a cut-off value for r_{wg} or $r_{wg(j)}$
335 (Biemann *et al.*, 2012). For ICC(1) and ICC(2), commonly accepted cut-off values do not exist,
336 either. Researchers are recommended to calculate different indicators, e.g. $r_{wg(j)}$, ICC(1) and ICC(2),
337 to carefully pick null distributions, and to consider the level of agreement expected or required for the
338 specific type of data, in comparison to other research in the area (Biemann *et al.*, 2012). Based on
339 these recommendations, we chose the following approach.

340 First, we calculated team means if at least two measurements were available from the same team,
341 resulting in a sample of 133 teams (408 individuals). Mean age in this reduced sample was 34.3 years
342 ($SD = 11.9$). Then, we calculated $r_{wg(j)}$ (Bliese, 2000) to delete the groups with the lowest agreement.
343 While Biemann *et al.* (2012) recommend not deleting groups with low agreement, in favor of test
344 power, we considered deleting such teams and thus sacrificing test power as the more conservative
345 approach. Despite the known criticism (LeBreton and Senter, 2008), in this case using an equal
346 distribution was justified by three reasons: (1), we only used $r_{wg(j)}$ for comparisons among teams,
347 which means that any bias introduced by a potentially inadequate null distribution would affect all
348 teams equally; (2) none of the restrictions mentioned by Meyer *et al.* (2014) seemed applicable to our
349 data and thus no other distribution was more favorable, and (3) the null distribution was frequently
350 used in recent leadership research (Biemann *et al.*, 2012), which increases the comparability among
351 studies. We deleted 26 teams in which either one $r_{wg(j)}$ value was below .40, or in which four $r_{wg(j)}$
352 values were below .70. The latter cut-off was chosen as, despite the mentioned criticism, it is the
353 most commonly used limit (Biemann *et al.*, 2012); the former was chosen at will. The coefficients
354 resulting after eliminating 26 teams are shown in Table 2.

355 In the resulting sample of 107 teams, we calculated ICC(1) and ICC(2) (Bliese, 2000). We required
356 ICC(1) to be above .10 and ICC(2) to be above .30. These values correspond to the indices obtained
357 in other leadership studies (Biemann *et al.*, 2012). As these criteria were met (Table 2), we assumed
358 that in the remaining sample, the aggregation was adequate.

359 (Insert Table 2 around here)

360 3.4 Datasets and missing data

361 We tested all hypotheses using the sample of 107 teams in which team effectiveness measures were
362 provided by the team members. There were not any empty cells in the final dataset, as participants
363 could only return completely answered questionnaires, and as the 26 teams with low agreement were
364 fully removed during the aggregation process. Procedures for dealing with missing data were thus
365 unnecessary. In 54 of the 133 aggregated teams, a measurement of team effectiveness by the team

366 leader was available. Thus, by replacing the effectiveness measure from the members by that
 367 obtained from the leaders, we obtained a second dataset of 54 teams. We used this second sample to
 368 check for common source bias.

369 3.5 Analysis of data

370 We used IBM SPSS Amos version 22 for structural equations modelling (SEM). We chose SEM for
 371 hypothesis testing (all hypotheses: models 1 and 2) for its benefit of correcting for measurement
 372 errors through the use of latent variables (Preacher and Hayes, 2008).

373 At individual level, we conducted separate confirmatory factor analyses (CFA) on the task
 374 interdependence measure and the team effectiveness measure. To assess the impact of common
 375 source variance, we applied Harman's test of common method bias (Podsakoff *et al.*, 2003). For the
 376 same purpose, we additionally substituted the team members' measures of team effectiveness by their
 377 leaders' judgements of team effectiveness and conducted a regression analysis on the resulting
 378 sample of 54 teams, using the PROCESS macro for mediation effects (H1), version 2.13 (Hayes,
 379 2015), and hierarchical regression analysis for moderation effects (H4).

380 We tested for the requirements of mediation (Baron and Kenny, 1986), and examined the
 381 significance of the indirect effect and the single predictors using the Amos 22 BC-bootstrapping
 382 procedure (Preacher and Hayes, 2008). Moderation (H2 and H4) was tested by including latent
 383 interaction variables. We followed the approach proposed by Marsh *et al.* (2004), and the additional
 384 recommendations by Foldnes and Hagtvet (2014). We used the following cut-off-criteria for the
 385 SEM: RMSEA (< 0.08), based on MacCallum *et al.* (1996) and $\chi^2/df (< 5)$, based on Schumacker and
 386 Lomax, (2004). In CFA, we additionally required TLI (> 0.95), following Hu and Bentler (1999). For
 387 model comparison, we used χ^2/df and RMSEA. For hypothesis testing, we set the Type I error at $\alpha =$
 388 .05.

389 4 Discussion

390 4.1 Confirmatory Factor Analysis

391 Both translated instruments, the task interdependence questionnaire (Figure 3) and the team
 392 effectiveness instrument (Figure 4), proved to be one-factorial (Table 3).

393 (Insert Figure 3 and Figure 4 around here)

394 4.2 Testing model 1

395 H1 was confirmed. The preconditions of mediation (Baron and Kenny, 1986) were fulfilled, as
 396 transformational leadership predicted team effectiveness significantly by $c = .78$ (standardized
 397 coefficient; $p < .001$) when no mediator was present. With group development present as mediator,
 398 this relationship dropped to $c' = .14$, while $a = .73$ ($p < .001$) and $b = .87$ ($p < .001$). The total
 399 interaction effect of transformational leadership on effectiveness was significant at $p < .01$ after BC-
 400 Bootstrapping (2-tailed).

401 H3 was rejected, as unclarity of goals showed a low and statistically insignificant relationship to team
 402 effectiveness. Transformational leadership was negatively related to unclarity of goals ($p < .01$).

403 Allowing for the residuals of group development and unclarity of goals to covary, as recommended
 404 by Preacher and Hayes (2008), did not alter the reported results: changes in standardized parameters
 405 were less or equal .01.

406 (Insert Table 3 about here)

407 The model including the latent interaction variable for testing H2 would not converge, due to
 408 discrepancies between product indicators. Therefore, we abandoned H2 and tested the alternative
 409 model 2.

410 **4.3 Testing model 2**

411 H2a was confirmed: with new situations present as a sole mediator, the effect of transformational
 412 leadership on team effectiveness dropped to $c' = .66$ ($p < .05$), while
 413 $a = -.50$ ($p < .05$) and $b = -.29$ ($p < .05$). With GD and unclarity of goals present (model 2 in table 3),
 414 the positive relationships were still significant ($p < .05$). The total interaction effect of
 415 transformational leadership on effectiveness was significant ($p < .05$) after BC-Bootstrapping (2-
 416 tailed). However, adding new situations as a third mediator did not further decrease the direct effect
 417 of transformational leadership on team effectiveness.

418 H4 was confirmed in the SEM with the estimate for the effect of the latent interaction variable on
 419 team effectiveness at .13 ($p < .05$): when task interdependence was high, the negative relationship
 420 between new situations and team effectiveness was weaker. Task interdependence was not a
 421 predictor of team effectiveness ($b = .04$, $p > .05$).

422 Comparing this model 2 to model 1 (Table 3) is difficult, as it contains two additional variables (new
 423 situations and task interdependence). However, with respect to χ^2/df and RMSEA, the loss of fit is
 424 minimal. Thus, model 2 can be accepted. Figure 5 summarizes the identified relationships.

425 (Insert Figure 5 about here)

426 **4.4 Assessment of common method bias**

427 Harman's single factor test identified a factor that accounted for 36.8 % of the entire variance of the
 428 variables: unclarity of goals, new situations, group development, team effectiveness, and
 429 transformational leadership. The regression analysis conducted with the sample of 54 teams that
 430 contained leader data confirmed the indirect effect of group development, with the 95% CI between
 431 0.19 and 0.56. As a consequence, the identified relationships would remain relevant after correcting
 432 for a possible common method bias. The moderation effect of task interdependence could not be
 433 confirmed in a hierarchical regression analysis using team effectiveness measures from leaders. In
 434 Table 4, we provide the Pearson-correlation coefficients between the mean scores of the variables in
 435 the model.

436 (Insert Table 4 around here).

437 **5 Findings**

438 **5.1 Main findings**

439 This work made three main contributions to the state of the art in leadership research: (1) it was, as
 440 far as we know, the first to investigate the role of leadership in the context of knowledge-work,

441 taking task characteristics (i.e., uncertainty and interdependence) into account; (2) with group
442 development and task interdependence, it considered both, interpersonal and structural coordination
443 mechanisms; and (3) it addressed methodological limitations of previous research, such as unspecific
444 measurements of uncertainty, issues related to the construct of group cohesion, and the restriction to
445 very homogeneous samples.

446 The main finding is that group development mediates the positive relationship between
447 transformational leadership and team effectiveness. Transformational leaders do not just create
448 cohesion, some sort of social attraction, in the team. They achieve higher acceptance of and
449 identification with group goals through visionary leadership, and their team members develop better
450 interpersonal relationships among each other, which leads to improved sharing of resources and
451 better coordination. This is why individual consideration and intellectual stimulation pay off beyond
452 performance improvements at the individual follower level.

453 The results also show that task uncertainty (i.e. new situations) is indeed a relevant phenomenon, as it
454 affected all groups of participants, to a greater extent than expected. New situations, the task
455 uncertainty factor relating to unstable environmental conditions or unpredictably changing outside
456 demands, is per se detrimental to team effectiveness, as the team's efforts to adjust consume
457 additional resources. Teams led by transformational leaders report to suffer less from such unstable
458 conditions and in turn show higher effectiveness. This mediation-effect of the factor new situations
459 does not explain any additional variance compared to the mediator group development. Thus, the
460 data shows that it is by fostering teamwork (i.e. developing the team better) and creating emergence
461 among team members, that transformational leaders achieve better team performance. The reduced
462 task uncertainty with respect to new situations is rather a byproduct of this effect.

463 Furthermore, the data indicates that the structural coordination mechanism of task interdependence
464 may help teams become less affected by such unstable environmental conditions: the negative effect
465 of unstable environments on team effectiveness was lower when task interdependence was high. This
466 means that beyond the improved sharing of resources among team members, which results from
467 improved group development, the way work is organized can have an additional effect. Supposedly,
468 teams adapt easier to new situations if cooperation mechanisms are well-defined.

469 Despite these mediating effects and contrary to what some authors have suggested, we did not find
470 any evidence of task uncertainty (i.e., new situations) moderating the influence of transformational
471 leadership on team effectiveness. Also, the mediating role of the task uncertainty factor unclarity of
472 goals was not confirmed. The data shows that transformational leaders, by definition expected to
473 motivate team members with a vision, reduce unclarity of goals in their teams. Nevertheless, this did
474 not positively affect team effectiveness. In research and development, unclear objectives may
475 diminish efficiency but they also allow for innovation. This is in line with other findings. Eisenbeiß
476 (2009), for example, reported that although transformational leadership had a positive effect on
477 follower creativity, it also increased the followers' dependence on the leader, which in turn had a
478 negative impact on creativity.

479 **5.2 Theoretical implications**

480 Apart from the described findings, this research has further theoretical implications. We did not
481 identify any moderating effect of task uncertainty, as we assumed based on previous literature (Bass
482 and Riggio, 2006; Frost et al., 2010). Some research questions came up: (1) subsequent studies could
483 investigate whether another here not represented aspect of task uncertainty fits the described role as a
484 moderator; (2) researching the role of the team members' appraisal of uncertainty may provide

485 helpful insights; and (3) studies to be conducted in other cultures could test the generalizability of the
486 results, e.g. across different levels of uncertainty avoidance. Of particular interest to researchers
487 might be the finding that different types of task uncertainty, such as new situations and unclarity of
488 goals, may play different roles in teams of knowledge workers. This is a first step towards refining
489 existing models that include effects of uncertainty, and towards specifying uncertainty aspects more
490 precisely in future studies, e.g. in research on team adaptation (see Maynard *et al.*, 2015).

491 **5.3 Practical implications**

492 The results indicate that organizations should foster transformational leadership and remove barriers
493 that may hinder group development. Task interdependence among team members, which is
494 sometimes avoided as a possible source of problems, may also have positive effects on how the team
495 deals with uncertainty. Many teams in non-research jobs reported task uncertainty to be higher than
496 we had expected. For practitioners, this highlights the importance of group development and
497 transformational leadership in a broad spectrum of jobs.

498 **5.4 Limitations and implications for research**

499 This study has several limitations. First, it was cross-sectional and nonexperimental. Thus, our design
500 does not allow for causal interpretation. Following an experimental design was impossible, as we
501 could not manipulate transformational leadership long enough for groups to develop significantly. If
502 transformational leadership and group development are more stable over time than team
503 effectiveness, then the indirect effect may have been overestimated (Maxwell and Cole, 2007).
504 However, the causal effect of transformational leadership on team effectiveness has already been
505 demonstrated experimentally (Avolio *et al.*, 2009), and was replicated here. Assuming a reciprocal
506 relationship between transformational leadership and group development seems difficult to justify on
507 a theoretical level, such as a reciprocal relationship between transformational leadership and team
508 effectiveness. However, Mullen and Copper (1994) argued that the relationship between cohesion
509 and team effectiveness is reciprocal, with a stronger causal effect of the group process on the
510 outcomes. The same may apply to the relationship between team effectiveness and group
511 development: team success could, for example, foster identification with the team.

512 Second, our sample contained few responses from teams with low task interdependence or low task
513 uncertainty. This may, additionally to the mediation effects identified, have obscured potentially
514 existing moderation effects of task uncertainty. The findings thus represent R&D teams with rather
515 high task uncertainty.

516 Third, for reasons of model complexity, it was not possible to take into account to which extent the
517 team members worked on projects together with their teammates or in virtual teams outside the
518 official team structure. To overcome this limitation, we recommend researching the extent to which
519 resources provided by the core team can be carried over into the work on virtual teams, or limiting a
520 future studies to a context in which team members are not participating in virtual teams.

521 Fourth, while the mediation effects identified were maintained when checking for common method
522 bias, the moderation effect of task interdependence was not. Thus, this result has to be interpreted
523 with caution. For future work, we recommend collecting external outcome indicators, such as
524 financial figures, to reduce potential single source bias.

525 Fifth, the sample was unbalanced towards researchers and male participants, which was due to the
526 true distribution of genders (34% were women) and jobs (55% were researchers) in the organization

527 (based on HR data from the year 2014). Our data correctly represent today's R&D sector with its
528 limited gender diversity. Additionally, our sample was collected in only one organization and only in
529 Germany; therefore, possible cultural influences, such as effects caused by the level of uncertainty
530 avoidance, may lead to different results in other cultures.

531 With respect to future research, we also recommend exploring possible suppressor-effects on the
532 relationship between unclarity of goals and team effectiveness. Data should be collected from
533 samples with greater variability in task uncertainty and task interdependence. The findings may also
534 be relevant for cross-cultural psychology: different types of task uncertainty have a different impact
535 in the model. Researching the effects of uncertainty avoidance may thus require measuring the type
536 of uncertainty faced by the participants.

537 We recommend the GD instrument for research, as well as for practical application in organizations;
538 although caution is advised when comparing regression coefficients across studies, the strength of the
539 identified relationships justifies this choice.

540 **5.5 Summary**

541 In summary, task uncertainty affects a broad range of jobs in modern organizations, beyond the R&D
542 area. Transformational leadership fosters group development and thus leads to greater team
543 effectiveness. This goes along with turbulent situations being perceived less uncertain by team
544 members. Task interdependence further buffers the negative effect of turbulent situations on team
545 effectiveness.

546 **6 Conflict of Interest**

547 *The authors declare that the research was conducted in the absence of any commercial or financial*
548 *relationships that could be construed as a potential conflict of interest.*

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723 **9 Figure captions**

724 Figure 1. Model 1, representing the hypotheses H1, H2, and H3.

725 Figure 2. Model 2, representing the hypotheses H1, H2a, H3 and H4.

726 Figure 3. CFA of the Task Interdependence Questionnaire (standardized coefficients).

727 Figure 4. CFA of the Team Effectiveness measure (standardized coefficients).

728 Figure 5. Structural equation model 2 with standardized estimates. *** $p < .001$

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729 **10 Tables**

730 Table 1

731 *Sample description*

	All team members (<i>N</i> = 501)		107 selected teams (<i>N</i> = 408)	
	N	per cent	N	per cent
Male participants	343	68.5%	277	67.9%
Female participants	158	31.5%	131	32.1%
Job: Researcher	423	84.4%	346	84.8%
Job: Administration	42	9.6%	34	8.3%
Job: Facility Management / Workshop	23	4.6%	17	4.2%
Job: IT-Services / PR-Services	13	2.6%	11	2.7%
0-2 years on the team	165	32.9%	133	32.6%
2-5 years on the team	178	35.5%	144	35.3%
5+ years on the team	158	31.5%	130	31.9%

732 *Note.* *N* = Number of individuals.

733 Table 2
 734 *Intra-group agreement measures of 107 teams to undergo further analysis*

Measure	Number of items	Mean $r_{wg(j)}$	ICC(1)	ICC(2)
Unclarity of goals	4	.83	.36	.64
New situations	3	.79	.13	.64
Group development	8	.80	.17	.50
Team effectiveness	12	.83	.23	.38
Task interdependence	7	.78	.35	.49
Transformational leadership	8	.88	.19	.63

735 *Note.* Mean $r_{wg(j)}$ is the arithmetic mean of the $r_{wg(j)}$ score, a within-group interrater agreement, over
 736 107 teams (Bliese, 2000). ICC1 and ICC2 are the Intra-Class-Correlation Coefficients 1 and 2
 737 (Bliese, 2000).

738 Table 3
739 *Model fit parameters*

Model	χ^2	<i>df</i>	χ^2/df	<i>p</i> (χ^2)	TLI	RMSEA
CFA - task interdependence	25.92	11	2.36	.000	0.97	0.05
CFA - team effectiveness	96.31	38	2.53	.000	0.96	0.06
model 1	649.28	422	1.54	.000	0.89	0.07
model 2	1016,52	655	1.55	.000	0.85	0.07

740 *Note.* χ^2 is the Chi-Square represented by CMIN in Amos 22, and *df* is the respective number of
741 degrees of freedom. *p* (χ^2) is the significance level of the χ^2 statistic, named P in Amos 22. TLI =
742 Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation (Arbuckle, 2013).

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744 Table 4
 745 *Pearson correlations of mean scores*

	1	2	3	4	5	6
1 Transf. leadership	(.93)					
2 GD	.64**	(.87)				
3 MITAG (new sit.)	-.50**	-.51**	(.68)			
4 MITAG (unclar. goals)	-.32**	-.33**	.65**	(.78)		
5 Task interdependence	.72**	.86**	-.57**	-.50**	(.76)	
6 Team effectiveness	.37**	.47**	-.23*	-.03	.40**	(.89)

746 *Note.* $N = 107$ teams. ** indicates significance at $p < .01$. * indicates significance at $p < .05$. The main
 747 diagonal contains Cronbach's α .

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Figure 1.JPEG

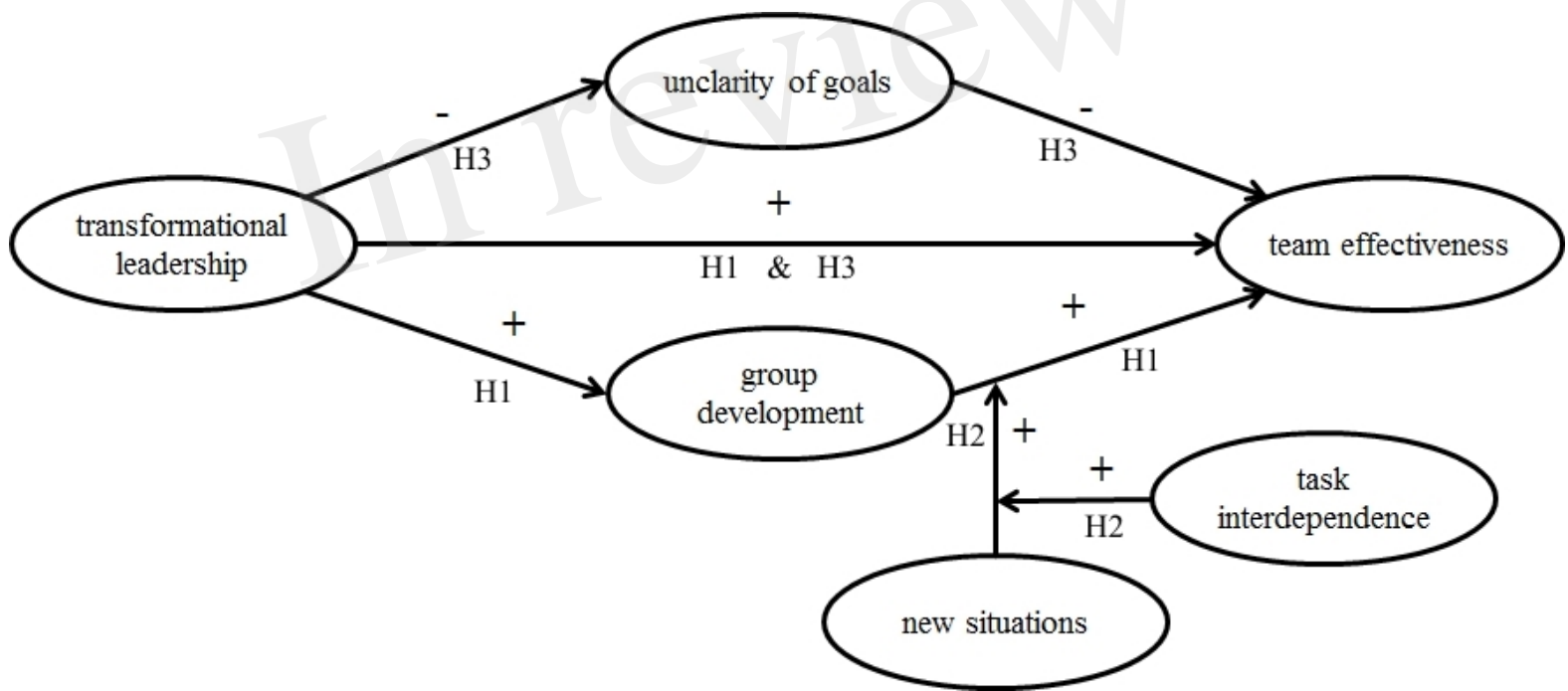


Figure 2.JPEG

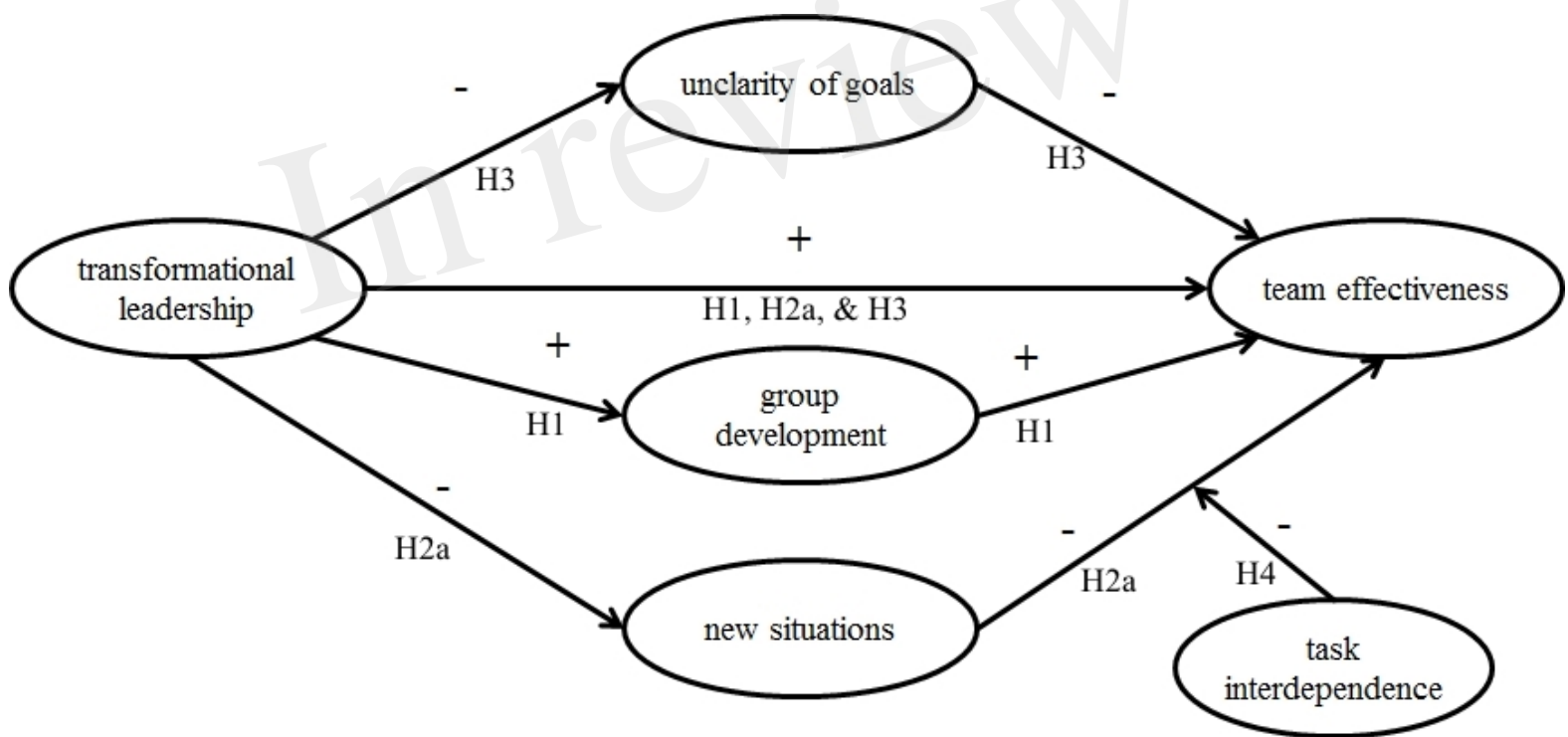


Figure 3.JPEG

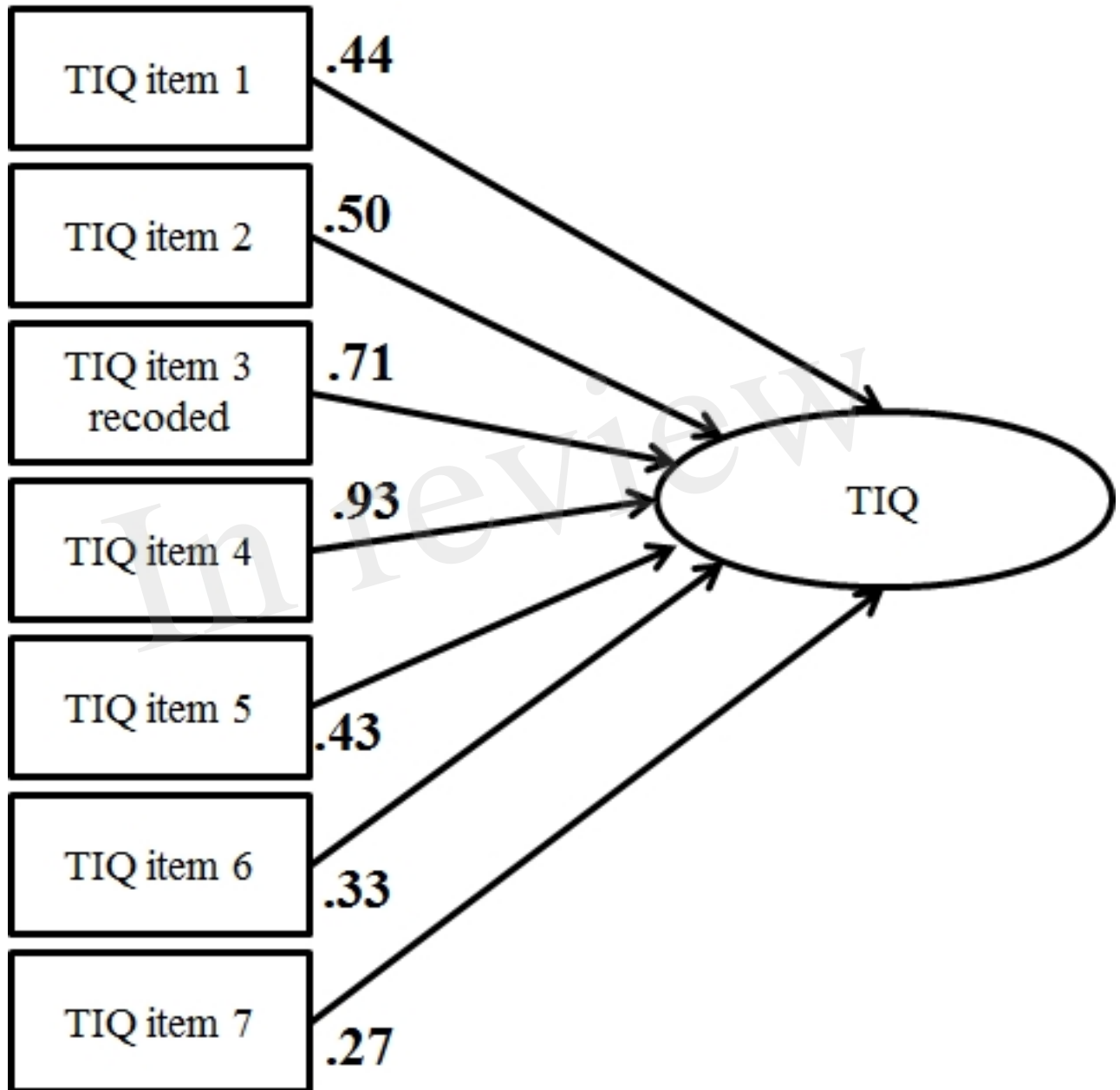


Figure 4.JPEG

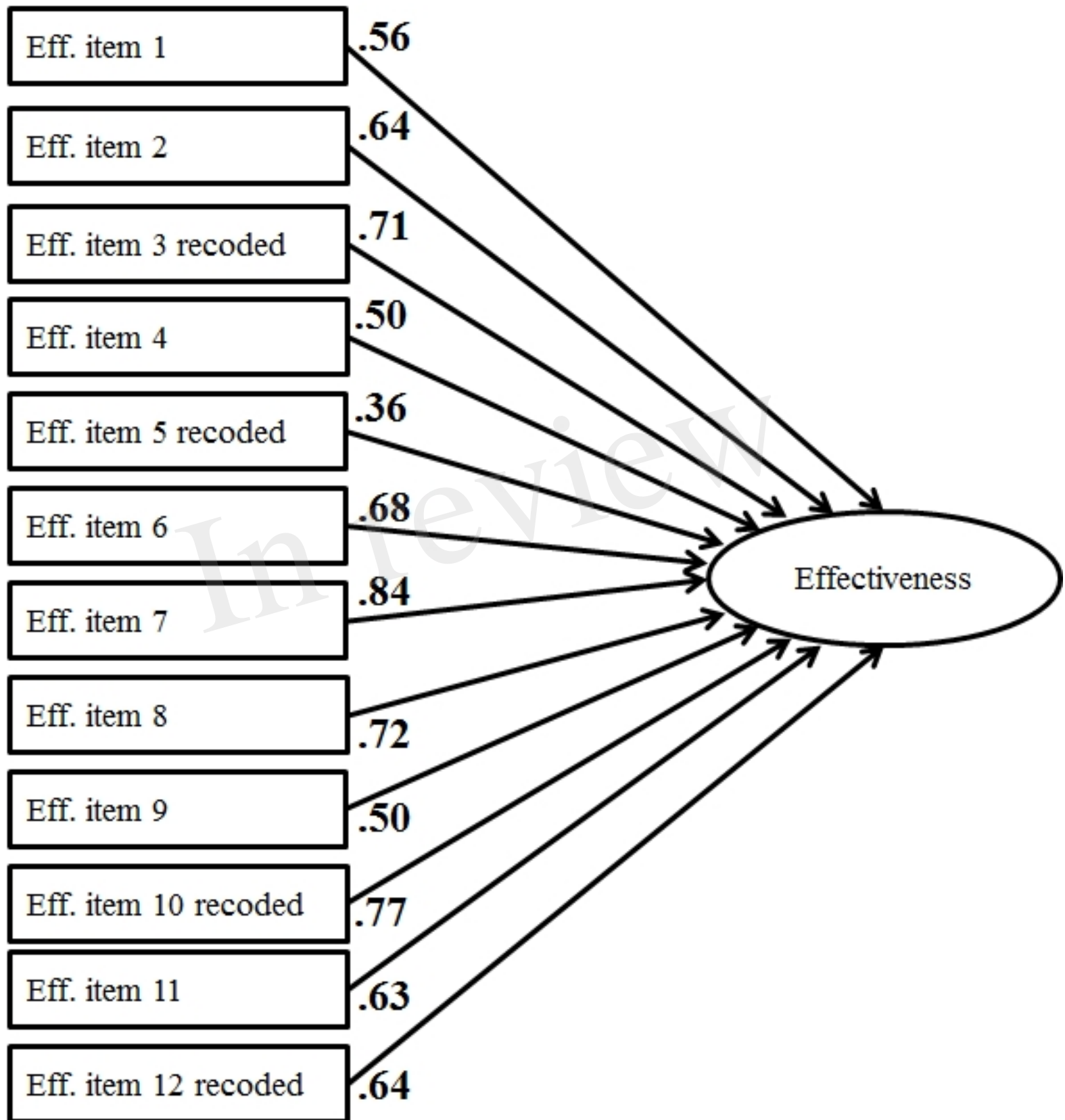


Figure 5.JPEG

