

Productivity Loss in Brainstorming Groups: A Meta-Analytic Integration

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This article reports the results of a meta-analytic integration of previous research on productivity loss in brainstorming groups. The following patterns were observed: Generally, brainstorming groups are significantly less productive than nominal groups, in terms of both quantity and quality. Stronger productivity loss was demonstrated in the context of (a) larger groups, (b) experimenter presence, (c) tape-recorded vocalization of contributions (vs. writing of contributions), and (d) in comparison to a nominal group of truly Alone individuals (vs. a nominal group of Together individuals). These patterns are (a) highly consistent with predictions derived from social psychological explanatory mechanisms, and (b) only marginally consistent with procedural explanatory mechanisms, and (c) highly inconsistent with economic explanatory mechanisms. This article considers the implications of these patterns for the use of, and for future research on, brainstorming.

So loud each tongue, so empty was each head,
So much they talked, so very little said. (Churchill, 1761)

Osborn (1957) proposed *brainstorming* as an effective means of enhancing the quantity and quality of ideas generated in group settings. Typical brainstorming instructions prompt group members to generate as many ideas as possible, to evaluate uncritically their own ideas before expressing them, to evaluate uncritically other people's ideas when they are expressed, and to improve or combine ideas already suggested. Brainstorming carried the promise (cf. Osborn, 1957, p. 229) of leading the average person to generate twice as many ideas in a group as would be generated individually.

Since Osborn's (1957) formulation of brainstorming, a number of studies have examined the hypothesis that brainstorming groups could outperform individuals. Tests of the effectiveness of brainstorming compare the productivity of people interacting in real groups under brainstorming instructions with the productivity of people in "nominal groups" (i.e., people performing individually with no interaction, whose productivity is then combined). Generally, nominal groups tend to outperform brainstorming groups (e.g., Diehl & Stroebe, 1987; Taylor, Berry, & Block, 1958). This article presents a meta-analytic integration (Mullen, 1989a; Mullen & Rosenthal, 1985; Rosenthal, 1984) of research on productivity loss in brainstorming groups. This meta-analytic integration was developed to address a number of specific issues about brainstorming.

SIGNIFICANCE, MAGNITUDE, AND CONSISTENCY OF EFFECTS

There certainly seems to be a consensus on the part of researchers in this area that brainstorming groups produce fewer ideas than nominal groups (e.g., Casey, Gettys, & Pliske, 1984; Diehl & Stroebe, 1987). We do not have a clear gauge, however, of the extent of productivity loss engendered by the application of the brainstorming technique. Although brainstorming groups may generally produce significantly fewer ideas than nominal groups, the difference could be a small one that accounts for a trivial amount of variance. Moreover, there is the logical possibility (considered, albeit not supported, by Graham, 1977) that decrements in quantitative productivity could be compensated by a corresponding increase in the quality of ideas generated by brainstorming groups. The long-lived, if potentially misguided, popularity of brainstorming techniques highlights the importance of determining a clear and precise summary of the extent of productivity loss in brainstorming groups, for both quantity and quality of productivity.

MECHANISMS FOR PRODUCTIVITY LOSS

Although systematic theoretical development generally has not characterized the research literature on brainstorming, we can identify three independent plausible classes of explanatory mechanisms for productivity loss in brainstorming groups. "Procedural mechanisms" derive from the mundane concerns of parsing up a given amount of task performance time amongst a certain number of performers (e.g., production blocking; Lamm & Trommsdorf, 1973). "Social psychological mechanisms" are basic under-

lying processes engaged by the presence of the other people, and by the individual's membership in the group; for example, drive-arousal (Geen & Bushman, 1987; Zajonc, 1965) and self-attention (Carver & Scheier, 1981; Mullen, 1983, 1987; Mullen & Baumeister, 1987). Finally "economic mechanisms" represent a motivated, intentional withdrawal of effort; for example, social loafing (Latané, Williams, & Harkins, 1979) and free-riding (Kerr & Bruun, 1983).

In simpler terms, productivity loss in brainstorming groups has been explained as a result of people interrupting each other (procedural mechanisms), the effect of the group on the individual (social psychological mechanisms), or self-interested laziness (economic mechanisms). In a recent examination of productivity loss in brainstorming groups, Diehl & Stroebe (1987) argued that procedural mechanisms were the strongest contributors to productivity losses.¹ The relative contributions of these three general mechanisms for productivity loss can be examined using several methodological facets of the brainstorming research paradigm. These include group size, experimenter presence, response mode, and types of groups.

Group Size

Each of the three explanatory mechanisms would predict that productivity loss in brainstorming groups should increase as a function of group size. As group size increases, there are more people to interrupt the individual and take up more time talking, representing a productivity loss due to procedural mechanisms. As group size increases, there are more people whose presence should arouse the individual, or who can provide a deindividuating background in which the subject becomes perceptually immersed, representing a productivity loss due to social psychological mechanisms. Finally, as group size increases, there are more "suckers" upon whom the individual can "free-ride," or more co-actors among whom the individual can socially loaf, representing a productivity loss due to economic mechanisms.

The only study which directly examined the effects of group size on productivity loss in brainstorming groups (Bouchard & Hare, 1970) suggested that the difference in quantitative productivity between brainstorming groups and nominal groups increased as a function of group size. However, this study only reported a significant interaction effect, without statistically testing the trend across group sizes. Moreover, this pattern

¹Diehl and Stroebe (1987) presented a similar categorization of productivity loss mechanisms. For example, "procedural mechanisms" includes Diehl and Stroebe's "production blocking" (as well as cognitive interference). "Social psychological mechanisms" includes Diehl and Stroebe's "evaluation apprehension" (as well as self-attention, and the drive arousal underlying evaluation apprehension). "Economic mechanisms" includes Diehl and Stroebe's "free riding" (as well as social loafing).

derived for quantitative productivity in a single study does not indicate the strength or the generalizability of this proposed effect of group size on productivity loss. Therefore, in light of the pattern suggested by the proposed mechanisms previously detailed, productivity loss was expected to increase as a function of group size.

Experimenter Presence

The three different explanatory mechanisms generate distinct predictions regarding the effects of the presence of the experimenter. According to the procedural mechanisms, there can be no effect of the presence of the experimenter. If productivity loss in brainstorming groups results from group members interrupting each other and taking up "air time," this mechanism will influence group members' performances whether the experimenter is in the room or not. According to the social psychological mechanisms, the presence of the experimenter would be expected to increase the magnitude of productivity loss by virtue of the effect of the experimenter's presence on the underlying social psychological mechanisms. For example, the presence of the experimenter is likely to make the members of the brainstorming group slightly more self-attentive (enhancing their self-regulated performance to some degree) and the presence of the experimenter is likely to make the (lone) members of the nominal group considerably more self-attentive (enhancing their performance to a greater degree), yielding an increase in the overall relative productivity loss in brainstorming groups (cf. Mullen, 1983, 1987).² Finally, according to the economic mechanisms, the presence of the experimenter is likely to decrease the magnitude of productivity loss in brainstorming groups. If the difference between nominal groups and brainstorming groups is due to the free riding or social loafing of members of the brainstorming groups, then the presence of a potentially evaluative and performance-monitoring experimenter during the procedure would reduce the likelihood of free riding or social loafing, and thereby mitigate the productivity loss.

Although there has been variation across studies in the presence or absence of the experimenter during the procedure, no single study has directly manipulated this procedural element. In light of the different predictions derived from the proposed mechanisms, this facet of productivity loss should be examined carefully.

²As helpfully pointed out by two anonymous reviewers, the drive-arousal hypothesis might predict that the presence of the experimenter would arouse the lone performer more than the performers in groups. The resultant drive-induced performance impairment would be greater for the lone performer than for the group performers, producing a decrease in the relative productivity loss in brainstorming groups as a function of experimenter presence. This may be one instance in which the self-attention perspective and the drive-arousal perspective diverge in their formulation of productivity loss.

Response Mode

Two general modes of response have been commonly used in brainstorming research: subjects can speak their contributions aloud, while the group interaction is tape-recorded; or subjects can write their contributions down on paper. The procedural mechanisms would predict greater productivity loss for tape-recorded interactions than for individually written contributions. A tape-recorded group interaction presents greater opportunity for group members to interrupt one another. The social psychological mechanisms would also predict a greater productivity loss for tape-recorded interactions than for individually written contributions. A tape-recorded interaction, with group members talking to and interacting with each other, gives a greater opportunity for the presence of the other members of the group to engage the basic social psychological mechanisms (e.g., drive arousal or self-attention). Finally, the economic mechanisms would predict that productivity loss would not vary as a function of response mode. The chance of being identified by voice on the tape recording may be matched with the chances of being identified by handwriting on the written contributions. Similarly, the effort involved in writing down one's ideas may be the same as the effort involved in saying them aloud in front of a group.

Note, however, there is no indication in any previous study that response mode influences the magnitude of quantitative or qualitative productivity loss in brainstorming groups. In light of the different accounts which suggest the importance of response mode, this element of productivity loss in brainstorming groups should be scrutinized.

Types of Groups

We can identify two different types of brainstorming groups and two different types of nominal groups that have been used in past research. "Real brainstorming groups" comprise the standard face-to-face interacting group receiving the standard brainstorming instructions. "Variant brainstorming groups" comprise some variant on that basic theme (e.g., people interacting in some unusual or controlled way). "Alone nominal groups" comprise the standard nominal group, where individuals perform the task individually without any interaction. "Together nominal groups" comprise groups who sit together during individual performance. Thus, studies of productivity loss could report comparisons between Real versus Alone, Real versus Together, Variant versus Alone, and Variant versus Together groups. The critical issue is whether Alone and Together nominal groups lead to demonstrations of equivalent productivity loss in Real brainstorming groups (because the Variant brainstorming groups may represent odd or imperfect tests of the basic premise of the brainstorming hypothesis).

According to procedural mechanisms, comparisons between Real versus Alone must be equivalent to comparisons between Real versus Together, because both Alone nominal groups and Together nominal groups provide (equivalently) less opportunity for group members to interrupt one another than do brainstorming groups. According to the social psychological mechanisms, Together nominal groups may evoke some modicum of the operative social psychological mechanisms; perhaps not as much as the Real brainstorming groups, but more than the Alone nominal groups. For example, members of the Alone nominal groups would experience minimal levels of drive arousals and/or deindividuation, members of the Together nominal groups would experience some moderate increase in levels of drive arousal and/or deindividuation – by virtue of the mere presence of the other group members, and/or by the increased “entitativity” (Campbell, 1958) of the group produced by sitting together and working on the task at the same time – and members of the Real brainstorming groups would experience the maximum levels of drive arousal and/or deindividuation. According to economic mechanisms, there should be no difference between comparisons between Real versus Alone and those between Real versus Together because both types of nominal groups provide (equivalently) less opportunity to free ride or to socially loaf than do brainstorming groups.

Consider the predictions just described: If productivity loss in brainstorming groups is due to procedural mechanisms, then greater productivity losses should obtain as group sizes increases and when interactions are tape recorded; and, productivity losses cannot vary as a function of experimenter presence or type of group. If productivity loss is due to social psychological mechanisms, then greater productivity losses should obtain (a) as group size increases, (b) when the experimenter is present, (c) when interactions are tape recorded, and (d) when the nominal group is of the Alone type rather than the Together type. If productivity loss is due to economic mechanisms, then greater productivity losses should obtain as group size increases and when the experimenter is absent; also, productivity losses cannot vary as a function of response mode or type of group.

This article reports the results of a meta-analytic integration of research examining productivity loss in brainstorming groups. This meta-analytic integration has five general goals: (a) to provide a precise summary of the combined significance, magnitude, and consistency of productivity loss in brainstorming groups, in terms of both the quantity and the quality of productivity; (b) to gauge the effects of group size on these productivity losses; (c) to gauge the influence of experimenter presence on these productivity losses; (d) to gauge the impact of response mode on these productivity losses; and (e) to determine the effects of the types of groups on the observed productivity loss in brainstorming groups. The latter four

goals converge to illuminate the relative efficacy of the three general mechanisms for productivity loss.

PROCEDURE

In accord with the procedures specified in Mullen (1989a), and Mullen and Rosenthal (1985), exhaustive manual and computer searches located studies using the “ancestry” approach, the “descendency” approach, and the “invisible college” approach, in addition to browsing through the past 25 years of major social psychological journals and regional and national psychology association proceedings. Studies were selected for inclusion in this meta-analysis if they reported (or intelligibly implied) a between-subjects statistical test of the comparison between productivity in some type of brainstorming group and productivity in some type of nominal group. Productivity was operationalized in two different ways. Quantity was generally gauged as the number of nonredundant ideas. Quality was generally gauged as some rating of the perceived quality of the ideas. Studies were eliminated from consideration (a) if the requisite statistical information was not retrievable (e.g., Bouchard, Drauden, & Barsaloux, 1974), (b) if the study failed to report a comparison between a (Real or Variant) brainstorming condition and a (Together or Alone) nominal condition (e.g., Diehl & Stroebe, 1987, Experiment 2), or (c) if a within-subjects design was employed (e.g., Dunnette, Campbell, & Jaastad, 1963).³ A total of 18 articles, with 20 separate studies, were located. These yielded a total of 34 hypothesis tests for quantity, representing the responses of 2,577 individuals in 844 groups. In addition, these yielded 9 hypothesis tests for quality, representing the responses of 638 individuals in 244 groups. Tests were coded as being in the expected direction if the nominal group out-performed the brainstorming group.

In addition to the basic statistical information (statistical test of the hypothesis, corresponding degrees of freedom, sample size, and direction of effect), each hypothesis test was coded for the predictors discussed earlier: group size, experimenter presence, response mode, and type of comparison. When reported, these predictors were simply tabulated from the procedure section of each study (with perfect agreement between two coders). The hypothesis tests included in this meta-analysis are presented in Table 1.

³Within-subjects designs have been demonstrated to “sensitize” subjects, making them respond more to the treatment than they otherwise would (Rosenthal & Rosnow, 1984; Rosnow & Suls, 1970). Substantial differences between within-subjects designs and between-subjects designs have been demonstrated in an earlier meta-analysis of the effects of source strength and immediacy in group contexts (Mullen, 1985).

TABLE 1
Studies Included in the Meta-Analysis

<i>Study</i>	<i>Measurement^a</i>	<i>Statistics^b</i>	<i>Z(significant)</i>	<i>r(effect)</i>	<i>G^c</i>	<i>RM^d</i>	<i>EP^e</i>	<i>TG^f</i>
Barkowski, Lamm, & Schwinger (1982)	QN	$t(76) = 2.44$ (=) [156]	2.39	.270	2	1	1	1
	QN	$t(76) = 4.12$ (+) [156]	3.90	.427	2	1	1	1
Bouchard & Hare (1970)	QN	$t(12) = 3.7096$ (=+) [40]	2.96	.731	5	1	1	1
	QN	$t(12) = 8.479$ (+) [56]	4.73	.926	7	1	1	1
	QN	$t(12) = 11.592$ (+) [72]	5.36	.958	9	1	1	1
Casey et al. (1984) Experiment 2	QN	$t(56) = 4.10$ (+) [80]	3.82	.480	2	2	0	1
	QL	$t(56) = 5.32$ (+) [80]	4.76	.579	2	2	0	1
	QN	$t(56) = 1.92$ (-) [80]	-1.88	-.249	2	3	0	3
	QL	$t(56) = 0.99$ (-) [80]	-0.98	-.131	2	3	0	3
Cohen et al. (1960)	QN	$F(1, 18) = .255$ (-) [48]	-0.50	-.118	2	1	0	1
	QN	$F(1, 18) = .005$ (-) [48]	-0.07	-.017	2	1	0	1
	QN	$F(1, 18) = .0006$ (+) [48]	0.02	.006	2	1	0	1
Diehl & Stroebe (1987) Experiment 1	QN	$F(1, 8) = 87.56$ (+) [48]	4.31	.957	4	1	1	1
	QL	$F(1, 8) = 10.38$ (+) [48]	2.50	.751	4	1	1	1
Diehl & Stroebe (1987) Experiment 3	QN	$F(1, 8) = 74.08$ (+) [64]	4.18	.950	4	1	2	1

Diehl & Stroebe (1987) Experiment 4	QN	$t(10) = 3.64$ (+) [12]	2.83	.755	4	1	2	1
Dillon et al. (1972)	QN	$F(1, 16) = 110.7$ (+) [96]	5.66	.935	4	3	0	2
Graham (1977)	QN	$p = .01$ (+) [128]	2.33	.206	4	1	0	1
Gurman (1968)	QN	$t(48) = 5.77$ (+) [54]	5.00	.640	3	3	2	2
	QL	$t(48) = 3.96$ (+) [54]	3.66	.496	3	3	2	2
Harari & Graham (1975)	QN	$F(1, 24) = 243.7$ (+) [128]	7.53	.954	4	0	0	1
Jablin, Seibold, & Sorenson (1977)	QN	$F(1, 25) = 0.20$ (-) [124]	-0.44	-.089	4	1	2	2
Jablin (1981)	QN	$F(1, 20) = 7.61$ (+) [104]	2.51	.525	4	1	1	2
Madsen & Finger (1978)	QN	$t(6) = .058$ (+) [32]	0.06	.024	4	3	1	2
	QN	$t(6) = .243$ (+) [32]	0.23	.009	4	3	1	4
	QN	$t(6) = 3.15$ (+) [32]	2.32	.789	4	3	1	2
	QN	$t(6) = .943$ (-) [32]	-0.87	-.359	4	3	1	4
Maginn & Harris (1980)	QN	$F(1, 26) = 16.23$ (+) [50]	3.52	.620	4	1	1	1
	QN	$F(1, 26) = .20$ (+) [125]	0.44	.087	4	1	2	3
Milton (1965)	QN	$p = .05$ (+) [48]	1.65	.237	4	1	0	1
	QL	$p = .05$ (+) [48]	1.65	.237	4	1	0	1

(continued)

TABLE 1 (Continued)

Study	Measurement ^a	Statistics ^b	Z(significant)	r(effect)	G ^c	RM ^d	EP ^e	TJ ^f
Pape & Bolle (1984)	QN	$t(44) = .62$	0.62	.093	2	1	1	1
		(+) [92]						
Rotter & Portugal (1969)	QN	$t(44) = .68$	0.67	.102	2	1	1	1
		(+) [92]						
		$t(16) = 3.87$	3.20	.695	4	3	1	1
		(+) [64]						
Taylor et al. (1958)	QN	$t(16) = 2.19$	2.02	.480	4	3	1	3
		(+) [96]						
		$t(44) = 8.96$	6.72	.804	4	1	2	1
		(+) [96]						
Torrance (1970)	QN	$F(1, 44) = 43.5$	5.47	.705	4	1	2	1
		(+) [96]						
		$t(44) = 9.38$	6.91	.816	4	1	2	1
		(+) [96]						
Torrance (1970)	QL	$F(1, 44) = 114.6$	7.47	.850	4	1	2	1
		(+) [96]						
		$t(44) = 9.26$	6.86	.813	4	1	2	1
		(+) [96]						
Torrance (1970)	QL	$F(1, 44) = 55.5$	5.96	.747	4	1	2	1
		(+) [96]						
		$t(38) = 1.002$	-0.99	-.160	2	3	0	3
		(-) [40]						
Torrance (1970)	QL	$t(38) = 4.326$	-3.88	-.574	2	3	0	3
		(-) [40]						

^aMeasurement: QN = Quantity, QL = Quality. ^b(+) indicates that nominal groups outperformed brainstorming groups, (-) indicates that brainstorming groups outperformed nominal groups, numbers in brackets represent sample size. ^cGroup size (GS). ^dResponse Mode (RM): 3 = individually written responses, 2 = responses written by a group secretary, 1 = tape recorded, 0 = don't know. ^eExperimenter Presence (EP): 2 = experimenter present, 1 = experimenter absent, 0 = don't know. ^fTypes of Groups (TG): 1 = Real brainstorming versus Alone nominal, 2 = Real brainstorming versus Together nominal, 3 = Variant brainstorming versus Alone nominal, 4 = Variant brainstorming versus Together nominal.

In the following analyses, tests for productivity loss involving quantity and those involving quality were separately subjected to the following meta-analytic procedures: combinations of significance levels and effect sizes, diffuse comparisons of significance levels and effect sizes, and focused comparisons of effect sizes. Formulae and computational procedures for these techniques are presented elsewhere (cf. Mullen, 1989a; Mullen & Rosenthal, 1985; Rosenthal, 1984).

RESULTS

General Effects

Table 2 presents the results of the combinations and diffuse comparisons of significance levels and effect sizes for the 34 hypothesis tests measuring quantitative productivity loss, and for the 9 hypothesis tests measuring qualitative productivity loss. These analyses reveal that the combined effects of these hypothesis tests are highly significant, of strong magnitude, and produce significantly heterogeneous results, in terms of both quantity and quality.

Group Size

For quantity, the correlation between Z_{Fisher} for effect size and the size of the group for each study was $r = .606$. The meta-analytic focused

TABLE 2
Results of Combinations and Diffuse Comparisons of
Significance Levels and Effect Sizes

	<i>k</i>	<i>Quantity</i>	<i>Quality</i>
		34	9
Combinations			
Significance levels	<i>Z</i>	15.324	10.592
	<i>p</i>	6.16E-35	1.25E-22
	<i>Nfs(p = .05)</i>	2827.3	252.7
Effect sizes	\bar{Z}_{Fisher}	0.650	0.630
	\bar{r}	.572	.558
	\bar{r}^2	.327	.311
	\bar{d}	1.395	1.344
Diffuse Comparisons			
Significance levels	χ^2	218.774	103.552
	<i>df</i>	33	8
	<i>p</i>	8.02E-29	2.03E-22
Effect sizes	χ^2	1111.210	170.991
	<i>df</i>	33	8
	<i>p</i>	0.01E-50	2.91E-33

comparison of effect sizes was $Z = 19.130$, $p = 4.13\text{E-}43$. For quality, the same pattern was demonstrated: $r = .715$, $Z = 9.528$, $p = 1.44\text{E-}19$. Thus, consistent with each of the mechanisms considered above, productivity loss increases as the size of the group increases.

Experimenter Presence

Table 3 presents the results of separate combinations of significance levels and effect sizes, and the corresponding focused comparisons, for hypothesis tests where the experimenter was present, and for hypothesis tests where the experimenter was absent. These results reveal a significantly greater quantitative productivity loss when the experimenter was present than when the experimenter was absent. This is consistent with the reasoning developed above for the social psychological mechanisms, and inconsistent with the reasoning for both the procedural mechanisms and the economic mechanisms.

Response Mode

Table 4 presents (a) separate combinations of significance levels and effect sizes and (b) the corresponding focused comparisons for hypothesis tests

TABLE 3
Results of Combinations and Focused Comparisons
Involving Experimenter Presence

		Quantity	Quality
Combinations			
Experimenter present			
	k	8	4
Significance levels	Z	9.998	11.507
	p	6.28E-21	3.40E-25
	$Nfs(p = .05)$	382.0	184.1
Effect sizes	\bar{Z}_{Fisher}	0.747	0.956
	\bar{r}	.633	.742
	\bar{r}^2	.401	.551
	\bar{d}	1.637	2.217
Experimenter absent			
	k	16	1
Significance levels	Z	9.004	2.498
	p	4.87E-18	.00625
	$Nfs(p = .05)$	515.0	—
Effect sizes	\bar{Z}_{Fisher}	0.623	0.976
	\bar{r}	.553	.751
	\bar{r}^2	.306	.565
	\bar{d}	1.328	2.278
Focused Comparisons			
	Z	3.375	0.410
	p	.00037	.34086

TABLE 4
Results of Combinations and Focused Comparisons
Involving Response Mode

		Quantity	Quality
Combinations			
Written responses	k	10	3
Significance levels	Z	5.561	-0.341
	p	1.51E-8	.63346
Effect sizes	$Nfs(p = .05)$	70.3	-
	\bar{Z}_{Fisher}	0.552	-0.042
	\bar{r}	.502	-0.042
	\bar{r}^2	.252	.0018
	\bar{d}	1.161	-0.084
Tape recorded			
Significance levels	k	22	5
	Z	12.176	11.207
Effect sizes	p	5.11E-27	2.32E-24
	$Nfs(p = .05)$	1394.1	191.1
	\bar{Z}_{Fisher}	0.600	0.927
	\bar{r}	.537	.729
	\bar{r}^2	.288	.532
	\bar{d}	1.273	2.130
Focused Comparisons			
	Z	4.770	9.590
	p	9.48E-7	9.56E-20

where responses were written, and for hypothesis tests where responses were tape recorded. These results indicate that tape recording contributions did increase the productivity loss, in terms of both quantity and quality. This is consistent with the reasoning for the procedural mechanisms and for the social psychological mechanisms, and inconsistent with the reasoning for the economic mechanisms.

Types of Groups

Table 5 presents separate combinations of significance levels and effect sizes for comparisons involving each of the four types of groups, along with corresponding focused comparisons. These analyses reveal that productivity loss is relatively stronger when the nominal group is of the Alone type than when it is of the Together type. This pattern was strongest for hypothesis tests involving quantitative productivity loss, and for comparisons involving real brainstorming groups. This is consistent with the reasoning developed earlier for the social psychological mechanisms, and inconsistent with the reasoning for both procedural mechanisms and economic mechanisms.

TABLE 5
Results of Combinations and Focused Comparisons
Involving Types of Groups

		<i>Quantity</i>	<i>Quality</i>
Combinations			
Real brainstorming versus alone nominal			
	<i>k</i>	22	6
Significance levels	<i>Z</i>	15.698	12.176
	<i>p</i>	8.33E-36	5.10E-27
Effect sizes	<i>Nfs(p = .05)</i>	1998.4	279.6
	\bar{Z}_{Fisher}	0.788	0.881
	\bar{r}	.657	.707
	\bar{r}^2	.432	.500
	\bar{d}	1.743	2.000
Real brainstorming versus together nominal			
	<i>k</i>	6	1
Significance levels	<i>Z</i>	5.453	3.664
	<i>p</i>	2.74E-8	.00012
Effect sizes	<i>Nfs(p = .05)</i>	78.3	—
	\bar{Z}_{Fisher}	0.652	0.544
	\bar{r}	.573	.496
	\bar{r}^2	.328	.246
	\bar{d}	1.398	1.143
Variant brainstorming versus alone nominal			
	<i>k</i>	4	2
Significance levels	<i>Z</i>	0.324	-2.611
	<i>p</i>	.37292	.99548
Effect sizes	<i>Nfs(p = .05)</i>	—	—
	\bar{Z}_{Fisher}	0.101	-0.306
	\bar{r}	.101	-.297
	\bar{r}^2	.010	.088
	\bar{d}	0.202	-0.622
Variant brainstorming versus together nominal			
	<i>k</i>	2	0
Significance levels	<i>Z</i>	-0.452	
	<i>p</i>	.67450	
Effect sizes	<i>Nfs(p = .05)</i>	—	
	\bar{Z}_{Fisher}	-0.139	
	\bar{r}	-.138	
	\bar{r}^2	.019	
	\bar{d}	-0.278	
Focused Comparisons			
(Real brainstorming versus alone nominal) versus (Real brainstorming versus together nominal)			
	<i>Z</i>	2.162	1.594
	<i>p</i>	.01530	.05545
(Variant brainstorming versus alone nominal) versus (Variant brainstorming versus together nominal)			
	<i>Z</i>	1.295	
	<i>p</i>	.09769	

Relative Contribution of the Three General Mechanisms

How can we gauge the relative contribution of the alternative mechanisms for productivity loss in brainstorming groups? A simple gauge would be to tally the correct and incorrect predictions derived for each of the three perspectives across the four predictors. This reveals (a) one correct and three incorrect predictions for the economic mechanisms, (b) two correct and two incorrect predictions for the procedural mechanisms, and (c) four correct and no incorrect predictions for the social psychological mechanisms.

A more precise gauge of the relative contributions of alternative perspectives can be derived from a Z for Standard Theoretical Comparisons, or ZSTC (Mullen, 1989b). The ZSTC is essentially a weighted average of the Z s for focused comparison of effect sizes for each of the predictors included in a meta-analysis.⁴ This ZSTC becomes large and positive for a given perspective if that perspective is able to formulate uniquely more accurate predictions about the phenomenon; this ZSTC becomes large and negative for a given perspective if it formulates a larger number of uniquely inaccurate predictions. The ZSTC for procedural, social psychological, and economic perspectives, respectively, were 1.497, 3.556, and -0.292 for quantity, and 1.741, 2.140, and -1.701 for quality. These ZSTCs indicate that the social psychological mechanisms provide the most accurate predictions, that the procedural mechanisms provide marginally accurate predictions, and that economic mechanisms generally yield erroneous predictions.⁵

⁴The formula for the ZSTC is:

$$Z_{stc} = \frac{\sum w_p z_p - \sum w_{np} z_{np}}{j}$$

In this formula, w_p represents the weight assigned to Z for focused comparison of effect sizes for each predictor on which the perspective does formulate a directional prediction; this w_p is positive if the theory's directional prediction was accurate, negative if inaccurate. The w_{np} represents the weight assigned to the Z for focused comparison of effect sizes for predictors on which the perspective predicts that there should be no difference or no effect; this w_{np} is positive. The magnitude of these weights is defined as the inverse of the number of theoretical perspectives formulating that particular directional prediction (for w_p), or as the inverse of the number of theoretical perspectives predicting no difference or effect (for w_{np}). Z_p and Z_{np} represent the Z s for focused comparison of effect sizes for predictors which that theoretical perspective predicts will, or will not (respectively), have an effect. Finally, j represents the number of predictors included in the theoretical comparisons.

⁵The possibility exists that the results for experimenter presence, response mode, and group size may represent confounds among these variables. Therefore, supplementary analyses were performed on the 24 hypothesis tests for quantity which explicitly reported information for experimenter presence, response mode, and group size (there were too few hypothesis tests for

DISCUSSION

The general combinations reveal that, for both quantitative and qualitative operationalizations, productivity loss in brainstorming groups is highly significant and of strong magnitude. Thus, the quantitative productivity loss engendered by brainstorming groups is not trivially small; also, contrary to the position considered by Graham (1977) and others, quantitative productivity loss is not compensated for by an increase in the quality of productivity in brainstorming groups. It appears to be particularly difficult to justify brainstorming techniques in terms of any performance outcomes, and the long-lived popularity of brainstorming techniques is unequivocally and substantively misguided.

These meta-analytic results represent the first demonstration of the effects of experimenter presence and types of groups on the magnitude of productivity loss in brainstorming groups. In addition, these meta-analytic

quality to perform analogous analyses). These analyses reproduced the basic results for combinations of significance levels and effect sizes, as well as the predictions for group size, experimenter presence, and response mode. Moreover, these analyses provide little support for a confound interpretation of these results. For example, effects were stronger when the experimenter was present compared to when the experimenter was absent for written responses ($\bar{r} = .640$ vs. $.427$, $Z = 2.519$, $p = .0059$) and for taped responses ($\bar{r} = .633$ vs. $.591$, $Z = 0.382$, $p = .3511$). Effects were stronger for taped vs. written responses when the experimenter was absent ($\bar{r} = .633$ vs. $.427$, $Z = 6.370$, $p = 1.38E-10$) but not when the experimenter was present ($\bar{r} = .633$ vs. $.640$, $Z = 0.867$, $p = .1929$). Finally, the mean group size across the various combinations of response mode and experimenter presence ranged between 4.0 and 4.5, indicating that the effects of experimenter presence and response mode are not likely to be attributed to, or to account for, the group size effects.

It is entirely possible that the effects of experimenter presence and taped responses may be limited at the extreme by a ceiling effect. For example, the combined effects of taped responses and experimenter presence render a mean effect size of $\bar{r} = .633$. Expressed in terms of Cohen's d , this represents the mean of the nominal group's performance falling 1.634 SD units above the mean of the brainstorming group's performance (or, at the 94.9 percentile of the brainstorming performance distribution). It may simply not be possible to produce a much greater difference in performance between nominal groups and brainstorming groups.

Finally, to examine the possibility that the effect of the type of group was really a confound of response mode, additional analyses were conducted on the 32 hypothesis tests for quantity that reported response mode (the type of brainstorming group—Real vs. Variant—was collapsed across in these analyses, in order to have enough data points to compare the Alone nominal group hypothesis tests with Together nominal group hypothesis tests). The difference between Alone and Together nominal groups was not significant for written responses ($\bar{r} = .353$ vs. $\bar{r} = .273$, $Z = 0.717$, $p = .2368$), but it was significant for taped responses ($\bar{r} = .575$ vs. $\bar{r} = .214$, $Z = 6.620$, $p = 2.99E-11$). Note that this represented a highly significant additive combination of response mode and type of nominal group, $Z = 6.657$, $p = 2.37E-11$, and a nonsignificant interactive combination, $Z = 0.677$, $p = .2492$. Thus, the differences between Alone nominal group effects and Together nominal group effects do not seem attributable to some hidden confound of response mode.

results clarify and extend limited previous considerations of the effects of group size and response mode. These patterns highlight the conditions under which brainstorming is likely to be most counterproductive. Specifically, productivity losses will be greatest (a) when the brainstorming group is relatively large in size, (b) when the experimenter (or some authoritative observer) is present, (c) when group members vocalize their contributions (rather than writing them down), and (d) when the point of comparison is a nominal group of truly Alone individuals, rather than a nominal group of individuals performing Together. Researchers studying other parameters of productivity loss in brainstorming groups may wish to utilize just this constellation of situational parameters in an effort to maximize the creation of robust productivity losses. Practitioners who still implement brainstorming techniques (in spite of the general failure of these techniques to enhance the quantity or quality of performance) may wish to utilize the opposite configuration (i.e., smaller groups, "experimenter" absent, written contributions) in an effort to minimize the (inevitable) productivity losses engendered by brainstorming techniques.

At a broader level, our results regarding group size, response mode, experimenter presence, and type of group illuminate the relative contributions of the three types of explanatory mechanisms. The demonstration of stronger productivity losses in the context of larger groups, experimenter presence, tape-recorded vocalization of contributions, and Alone (rather than Together) nominal groups is (a) highly consistent with basic social psychological mechanisms, (b) moderately inconsistent with the procedural mechanisms, and (c) highly inconsistent with the economic mechanisms. Three implications of these patterns should be highlighted. First, the demarcation between the specific facets of the social psychological mechanisms (e.g., self-attention vs. drive arousal) should be the focus of future research. Second, these results contradict the interpretation of productivity loss suggested by Diehl and Stroebe (1987) as being largely attributable to the mechanics of parsing up a given amount of time amongst a certain number of group members. Certainly, when blocking is experimentally manipulated (as in Diehl & Stroebe, 1987, Experiment 4), it can yield a productivity loss. However, simply because productivity loss can occur after a manipulation of blocking, this does not mean that all instances of productivity loss must result from production blocking. Our results indicate that procedural mechanisms might contribute to productivity loss in brainstorming groups, but that their influence is likely to be secondary to that of the more predictive social psychological mechanisms. Third, interestingly, the only account which portrays productivity loss as a divisive, intentional reduction of effort is the account which received the least empirical support (i.e., economic mechanisms). Thus, although the general

results of these analyses provide a damning indictment of the efficacy of the brainstorming technique, at least it does not seem to be the case that people in brainstorming groups are underproductive on purpose.

Several authors (e.g., Diehl & Stroebe, 1987; Lamm & Trommsdorff, 1973) suggested that the deleterious effects of brainstorming might be overcome by having group members generate their ideas individually, and then bringing the individuals together as a group to evaluate the ideas. This recommendation is based on two implicit assumptions, both of which are contradicted by the results of these analyses. First, this recommendation assumes that productivity loss in brainstorming groups is predominately a result of procedural mechanisms, and is thereby most directly alleviated by tinkering with procedural facets of the brainstorming technique. The patterns revealed by our analyses suggest that the procedural mechanisms for productivity loss in brainstorming groups play a secondary role. Second, this recommendation assumes that productivity loss in brainstorming groups is limited to quantitative outcomes. Therefore, if the group members could generate a lot of ideas individually, the beneficial effects of group brainstorming could be employed on the more qualitative task of evaluating those ideas in the context of the group. Again, the patterns revealed by our analyses indicate that qualitative outcomes suffer just as badly from brainstorming as quantitative outcomes.

If there is a prescriptive recommendation to be distilled from this meta-analytic integration, it is this: In attempts to glean some benefit from a brainstorming procedure, it is not at all likely to be effective to exhort people to stop being lazy (economic mechanisms). Nor is it likely to be ultimately effective to try to orchestrate the session so that people stop interrupting or distracting each other (procedural mechanisms). It is possible that it may be effective to encourage people to adapt to and to compensate for some of the basic social-psychological mechanisms engaged by group membership and the presence of other people: For example, anxiety reduction (drive arousal), or verbal inductions of self-focus (deindividuation). Although there is little or no evidence regarding whether such adaptive or compensatory strategies can mitigate drive arousal or deindividuation (cf. Mullen & Baumeister, 1987), this recommendation would at least be directed toward what appears to be the more compelling operative mechanisms for productivity loss.

In conclusion, as always, patterns identified at the level of a meta-analysis should be examined at the level of experimental studies where spurious influences can be better controlled. It should be recognized that other factors not examined in this meta-analytic integration may contribute to productivity loss in brainstorming groups. For example, special training techniques have produced mixed results (Cohen, Whitmyre, & Funk, 1960; Dillon, Graham, & Aidells, 1972). In addition, the importance of the

brainstorming problems have sometimes influenced performance (Dillon et al., 1972; Graham, 1977). We do not wish to convey the impression that the variables examined in our analyses are the only interesting influences on the effects of brainstorming. Future research might continue to chart additional contributions to productivity loss in brainstorming groups. However, the point of the present analyses has been to cast into sharp relief the relative contributions of procedural, social psychological, and economic mechanisms on productivity losses. It becomes clear that future research should be directed toward social psychological contributions to productivity loss, at least to the degree that previous research has already examined procedural contributions (cf. Diehl & Stroebe, 1987).

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REFERENCES

- Barkowski, D., Lamm, H., & Schwinger, T. (1982). Einfallsproduktion von Individuen und Dyaden unter "Brainstorming"-bedingungen [Brainstorming in group (dyadic) and individual conditions]. *Psychologische Beiträge*, *24*, 39-46.
- Bouchard, T. J., Drauden, G., & Barsaloux, J. (1974). A comparison of individual subgroup and total group methods of problem solving. *Journal of Applied Psychology*, *59*, 226-227.
- Bouchard, T. J., & Hare, M. (1970). Size, performance, and potential in brainstorming groups. *Journal of Applied Psychology*, *54*, 51-55.
- Campbell, D. T. (1958). Common fate, similarity, and other indices of the status of aggregates of persons as social entities. *Behavioral Science*, *3*, 14-25.
- Carver, C. S., & Scheier, M. F. (1981). *Attention and self-regulation: A control theory approach to human behavior*. New York: Springer-Verlag.
- Casey, J. T., Gettys, C. F., & Pliske, R. M. (1984). A partition of small group predecision performance into informational and social components. *Organizational Behavior and Human Performance*, *34*, 112-139.
- Cohen, D., Whitmyre, J. W., & Funk, D. W. (1960). Effect of group cohesiveness and training upon creative thinking. *Journal of Applied Psychology*, *44*, 319-322.
- Diehl, M., & Stroebe, W. (1987). Productivity loss in brainstorming groups: Toward the solution of a riddle. *Journal of Personality and Social Psychology*, *53*, 497-509.
- Dillon, P. C., Graham, W. K., & Aidells, A. L. (1972). Brainstorming on a "hot" problem: Effects of training and practice on individual and group performance. *Journal of Applied Psychology*, *47*, 30-37.

- Dunnette, M. D., Campbell, J., & Jaastad, K. (1963). The effect of group participation on brainstorming effectiveness for two industrial samples. *Journal of Applied Psychology, 47*, 30-37.
- Geen, R. G., & Bushman, B. J. (1987). Drive theory: Effects of socially engendered arousal. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior* (pp. 89-109). New York: Springer-Verlag.
- Graham, W. K. (1977). Acceptance of ideas generated through individual and group brainstorming. *Journal of Social Psychology, 101*, 231-234.
- Gurman, E. B. (1968). Creativity as a function of orientation and group participation. *Psychological Reports, 22*, 471-478.
- Harari, O., & Graham, W. K. (1975). Tasks and task consequences as factors in individual and group brainstorming. *Journal of Social Psychology, 95*, 61-65.
- Jablin, F. M. (1981). Cultivating imagination: Factors that enhance and inhibit creativity in brainstorming groups. *Human Communication Research, 7*, 245-258.
- Jablin, F. M., Seibold, D. R., & Sorenson, R. L. (1977). Potential inhibitory effects of group participation on brainstorming performance. *Central States Speech Journal, 28*, 113-121.
- Kerr, N. L., & Bruun, S. E. (1983). Dispensability of member effort and group motivation losses: Free-rider effects. *Journal of Personality and Social Psychology, 44*, 78-94.
- Lamm, H., & Trommsdorf, G. (1973). Group versus individual performance on tasks requiring ideational proficiency (brainstorming). *European Journal of Social Psychology, 3*, 361-387.
- Latané, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology, 37*, 822-832.
- Madsen, D. B., & Finger, J. R. (1978). Comparison of a written feedback procedure, group brainstorming, and individual brainstorming. *Journal of Applied Psychology, 63*, 120-123.
- Maginn, B. K., & Harris, R. J. (1980). Effects of anticipated evaluation on individual brainstorming performance. *Journal of Applied Psychology, 65*, 219-225.
- Milton, G. A. (1965). Enthusiasm vs. effectiveness in group and individual problem-solving. *Psychological Reports, 16*, 1197-1202.
- Mullen, B. (1983). Operationalizing the effect of the group on the individual: A self-attention perspective. *Journal of Experimental Social Psychology, 19*, 295-322.
- Mullen, B. (1985). Strength and immediacy of sources: A meta-analysis of the forgotten elements of Social Impact Theory. *Journal of Personality and Social Psychology, 48*, 1458-1466.
- Mullen, B. (1987). Self-attention theory. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior* (pp. 125-146). New York: Springer-Verlag.
- Mullen, B. (1989a). *Advanced BASIC meta-analysis*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Mullen, B. (1989b). *Z for standard theoretical comparison: A meta-analytic gauge of relative contribution of different theoretical perspectives*. Manuscript submitted for publication.
- Mullen, B., & Baumeister, R. F. (1987). Group effects on self-attention and performance: Social loafing, social facilitation, and social impairment. In C. Hendrick (Ed.), *Review of personality and social psychology* (pp. 189-206). Beverly Hills: Sage.
- Mullen, B., & Rosenthal, R. (1985). *BASIC Meta-analysis: Procedures and programs*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Osborn, A. F. (1957). *Applied imagination*. New York: Scribner.
- Pape, T., & Bolle, I. (1984). Einfallproduktion von Individuen und dyaden unter "brainstorming"-bedingungen [Brainstorming in group (dyadic) and individual conditions]. *Psychologische Beiträge, 26*, 459-468.

- Rosenthal, R. (1984). *Meta-analytic procedures for social research*. Beverly Hills: Sage.
- Rosenthal, R., & Rosnow, R. (1984). *Essentials of behavioral research: Methods and data analysis*. New York: McGraw-Hill.
- Rosnow, R., & Suls, J. (1970). Reactive effects of pretesting in attitude research. *Journal of Personality and Social Psychology*, *15*, 338-343.
- Rotter, G. S., & Portugal, S. M. (1969). Group and individual effects in problem solving. *Journal of Applied Psychology*, *53*, 338-341.
- Taylor, D. W., Berry, P. C., & Block, C. H. (1958). Does group participation when using brainstorming facilitate or inhibit creative thinking? *Administrative Science Quarterly*, *3*, 23-47.
- Torrence, E. P. (1970). Influence of dyadic interaction on creative functioning. *Psychological Reports*, *26*, 391-394.
- Zajonc, R. B. (1965). Social facilitation. *Science*, *149*, 269-274.

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