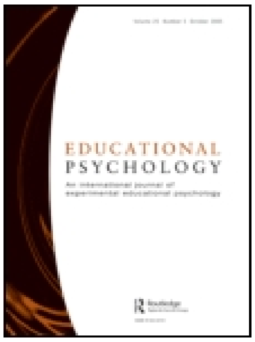

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Routledge

Combined Effects of Note-Taking/-Reviewing on Learning and the Enhancement through Interventions: A meta-analytic review

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Meta-analyses of 33 studies were conducted to examine (1) how much the combination of taking and reviewing notes contributes to school learning, and (2) whether interventions in the note-taking/-reviewing procedure enhance note-taking/-reviewing effects, and if so, how much and under what conditions. Syntheses of findings from note-taking/-reviewing versus no note-taking/-reviewing comparison studies indicated that the overall effects of note-taking/-reviewing were substantial. The advantage of note-taking with intervention over without intervention was modest but significantly greater than zero. This intervention effect was moderated by two variables: presence of provided notes and academic level of participants. Providing a framework or instructor's notes was more effective in the enhancement of note-taking/-reviewing effects than pre-training or verbal instruction only. The participants at lower academic levels gained greater benefits from interventions compared with the participants at a higher academic level.

Note-taking with paper and pen is very popular as a learning technology in school settings. Despite the recent diffusion of more advanced learning technologies such as personal computers, it remains valuable to ordinary students for achieving a variety of learning goals (Ryan, 2001; Van Meter, Yokoi, & Pressley, 1994). Considering the practical utility of paper and pen (e.g., inexpensive, speedy, versatile, easy to use), it seems unlikely that traditional note-taking will be completely replaced by electronic learning technologies in the near future. Rather, mixed use will continue (Haas, 1999). Examination of students' note-taking is still indispensable for understanding and improving their school learning.

In real academic situations, note-taking is closely related to note-reviewing. The majority of students take notes with the intention of reviewing the notes afterward.

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For example, Hartley and Davies (1978) reported that 98% of American students (n = 52) and 84% of British students (n = 71) answered "yes" to the questionnaire item, "I take notes to have review material for examination" (p. 208). In a study by Carrier and Newell (1984), 91.7% of dental hygiene students (n = 48) agreed to the idea, "Taking notes is important because I can review them" (p. 15). These findings suggest that ordinary students (can) benefit both from taking notes during class and from reviewing the notes after class. Therefore, from an educational point of view, it is legitimate and important to focus on the combination of note-taking and note-reviewing (Kiewra, 1985a). This article addressed the following questions: How much does note-taking/-reviewing (without any special intervention) enhance learning compared with no note-taking/-reviewing? Do interventions in students' spontaneous note-taking/-reviewing procedures increase the effects of note-taking/-reviewing, and if so, how much and under what conditions?

Estimate of Note-Taking/-Reviewing Effects

Theoretically, the combined effects of taking and reviewing notes consist of encoding and external storage effects. The encoding effects result from the note-taking process, while the external storage effects result from the activity of reviewing notes (Di Vesta & Gray, 1972). This is not to suggest, however, that the note-taking/-reviewing effects are the sum of independent encoding and external storage effects. For example, verbatim note-taking is likely to interfere with deeper processing of the presented information during class, thereby reducing encoding effects (Bretzing & Kulhavy, 1979). Nevertheless, verbatim notes can provide more complete information about the learning material, and therefore reviewing the notes after class may increase external storage effects. The combined effects of taking and reviewing notes should be estimated by the contrast between note-taking/-reviewing and no note-taking/-reviewing.

Ryan (1982) summarised the findings from 19 studies that compared the learning outcomes of note-taking (with or without later review) groups with those of no note-taking/-reviewing groups. For note-taking with later review, the mean unweighted effect size (d) was .34. It should be noted, however, that the estimate was calculated from only 19 of the 123 effect sizes included in the meta-analysis. The remaining 104 effect sizes were used for estimating the effects of note-taking without later review. This implies that the number of studies including note-taking/-reviewing versus no note-taking/-reviewing comparison was very small, although Ryan did not report it explicitly. Thus, it is still too early to conclude from his findings that the combined effects of taking and reviewing notes are modest. Fortunately, since Ryan's meta-analytic review, the number of studies available on the topic has increased. The present study sought to estimate the note-taking/-reviewing effects from a larger sample of studies.

Two types of note-taking/-reviewing versus no note-taking/-reviewing comparison were analysed. Learning outcomes of note-taking/-reviewing groups were compared with those of (1) listening or reading only groups and (2) listening or reading with later mental review groups. The note-taking/-reviewing effects were estimated separately for these group comparisons.

Interventions in Note-Taking/-Reviewing Procedures

Prior research has indicated the incompleteness of information recorded in the ordinary student's notes. For example, Baker and Lombardi (1985) investigated the notes of college students enrolled in an introductory psychology course and found that most of them recorded less than 50% of lecture information relevant to the course examination. McDonald and Taylor (1980) reported that veterinary students often failed to draw important diagrams in their notes and missed main lecture points. According to Kiewra (1989), these findings suggest that many students are poor note-takers, and therefore they do not fully benefit from the process of taking notes or from the activity of reviewing notes.

To compensate for such a weakness in students' spontaneous note-taking procedures, some researchers (e.g., Collingwood & Hughes, 1978; Kiewra, 1985c; Morgan, Lilley, & Boreham, 1988) recommend that students should review the instructor's notes instead of taking and reviewing their own notes. In their views, instructors' notes are more useful for reprocessing the presented material than students' personal notes because the former notes generally surpass the latter notes in the completeness of information recorded. It should be noted, however, that personal notes have the advantage of containing personally meaningful information (Van Meter et al., 1994). Such information may serve as effective retrieval cues, whereby the students can recollect information they encoded in their own ways while taking notes (Carrier & Titus, 1979). Moreover, from an educational point of view, it is problematic that an instructor continues to provide his/her notes without giving the students with opportunities to take their own notes. Students' dependence on the instructor's notes may be an obstacle to their acquisition of the effective note-taking procedures necessary for becoming autonomous learners (Kiewra, 1989; Powers & Powers, 1978). Given these considerations, providing instructors' notes as substitutes for personal notes seems unlikely to be helpful in real academic situations.

An alternative means of making up for shortcomings in students' personal notes is to make some changes to their spontaneous note-taking and/or -reviewing procedures. Previous researchers have implemented various types of intervention for this purpose. They include: (1) pre-training of note-taking skills or strategies (e.g., Robin, Foxx, Martello, & Archable, 1977; Spires, 1993); (2) giving verbal instructions to employ a particular note-taking strategy (e.g., Bretzing & Kulhavy, 1979; Jonassen, 1984); (3) providing framework notes (e.g., outline notes, matrix notes) at the beginning of class (e.g., Kiewra, 1985b; Kiewra, Benton, Kim, Risch, & Christensen, 1995; Lazarus, 1991); (4) pre-training of note-reviewing skills or strategies (e.g., King, 1992; Stahl, King, & Henk, 1991); (5) giving verbal instructions to employ a particular note-reviewing strategy (e.g., Barnett, Di Vesta, & Rogozinski, 1981; Davis & Hult, 1997); and (6) complementing personal notes with instructors' notes at the time of later review (Kiewra, 1985b). Kobayashi's (2005) meta-analysis indicated that the first three types of intervention did not affect the encoding effects. Nevertheless, they may help students take more complete and well-structured notes, thereby enhancing the effects of reviewing personal notes. The fourth and fifth types of intervention aim at improving the activity of note-reviewing. Reviewing notes in a strategic way may promote reprocessing of information recorded in the notes or recollected. The sixth type of intervention gives students an opportunity to review the instructor's notes and their own notes at once. As a result, they may benefit from the advantages of both more complete notes and personally meaningful notes (Kiewra, 1985b).

Despite its practical importance, no attempt has been made quantitatively to synthesise prior findings about the effectiveness of note-taking/-reviewing intervention. The present meta-analysis examined the degree to which interventions in students' spontaneous note-taking/-reviewing procedures enhance the combined effects of taking and reviewing notes. Additionally, for exploratory purposes, the present meta-analysis investigated which factors influence the effectiveness of interventions. On the basis of a literature review, some factors were identified as possible moderator variables. They include two intervention characteristics (whether a set of notes as external aids was provided or not, and whether the interventions focused on note-taking/-reviewing or note-reviewing only), academic level of participants, three presentation characteristics (relevance of the presented material to the participants' course, presentation method of the material, and length of presentation), length of later review, and two publication characteristics (publication year and source).

Method

Literature Search and Inclusion Criteria

Relevant studies were collected from two sources. First, a computer search was conducted on PsycINFO, ERIC, and Dissertation Abstracts International. The keywords used to identify relevant studies were *note-taking*, *summarization*, *note-reviewing*, and variants on these terms. Second, the ancestry method was used for complementing the computer search. Studies were located from the references listed in review articles (e.g., Carrier & Titus, 1979; Ganske, 1981; Hartley & Davies, 1978; Kiewra, 1985a, 1985b, 1989; Ryan, 1982; Suritsky & Hughes, 1991), book chapters (e.g., Armbruster, 2000; Bligh, 2000; Caverly, Orlando, & Mullen, 2000), and collected empirical articles.

Studies were included in the meta-analysis if they met the following criteria. First, studies had to include: (1) comparison between outcomes for groups that were instructed or allowed to take notes as usual during class and review the notes before a test (NT+NR groups) and those for groups that were not allowed to take notes or to review others' notes (C groups); (2) comparison between outcomes for NT+NR groups and groups that were not allowed to take notes but could review the presented material mentally before a test (MR groups); or (3) comparison between outcomes for NT+NR groups that received interventions in note-taking and/or -reviewing procedures (intervention groups) and those of NT+NR groups that did not receive any special intervention (no-intervention groups). Second, studies had to measure how much the participants learned from a lecture or text. Studies focusing on non-academic measures (e.g., recall test of job interview events, liability decision in a civil trial, prospective memory performance) or writing measures as dependent variables were excluded from consideration. Finally, studies reporting the information necessary for the calculation of an effect size were examined.

Dependent Learning Measures

Learning outcome measures served as dependent variables. Learning outcome was defined as knowledge acquisition (from a lecture or text) measured by a variety of post-tests such as free-recall, short-answer, completion, and multiple-choice tests. Although these tests may measure different aspects of knowledge acquisition, they were combined under the general construct because there were not enough studies to be subdivided into test types. Effect sizes calculated from multiple learning measures within a group comparison were averaged into an estimate. The present meta-analysis used these estimates as the primary data set.

Moderator Variables

All intervention versus no-intervention comparison studies were coded according to a set of eight continuous or discrete variables: (1) presence of provided notes (yes [e.g., providing outline notes, matrix notes, instructor's notes] or no); (2) focus of interventions (note-taking/-reviewing or note-reviewing only [see below]); (3) academic level of participants (higher [e.g., college students, second-year technical college students] or lower [e.g., post-secondary 11th- and 12th-grade students, academically unprepared college students]); (4) relevance of material (higher [e.g., lecture on memory given to the students enrolled in an educational psychology course] or lower [e.g., lecture on survival among sharks given to the students enrolled in an introductory psychology course]); (5) presentation method (live lecture, video, audio, IVD [interactive video disc]); (6) presentation length (length of a lecture or IVD lesson); (g) review length (time given to review notes); (7) publication year; and (8) publication source (journal article or dissertation/ERIC report).

The focus of interventions was coded as *note-taking/-reviewing* if the participants received interventions in their note-taking procedures (e.g., pre-training in a note-taking system) or in their note-taking/-reviewing procedures (e.g., providing outline notes at the beginning of class), and as *note-reviewing only* if the participants received interventions in their note-reviewing procedures only (e.g., pre-training in note-reviewing skills, giving instructions to summarise personal notes, providing instructor's notes at the time of later review). The reason why interventions in note-taking procedures were classified as note-taking/-reviewing was that the improvement of note-taking procedures affects the contents of notes available for later review. An independent coder was asked to code each variable from each of the studies included in the present meta-analysis. The percentage of agreement with the author was 92.9 %. Disagreements were resolved through discussion.

Meta-Analytic Procedures

The present meta-analysis used the *d* coefficient as the measure of effect size, which was corrected for sample size bias (Hedges & Olkin, 1985). Eight studies did not report the number of participants per group but the means and standard deviations. To make maximum use of the available data, effect sizes for these studies were estimated by assigning the averaged number of participants (the total number of participants divided by the number of groups) to each group. Effect sizes which fell below the first quartile or above the third quartile were identified as outliers. These outliers were winsorised: that is, each value was substituted for the value of the next maximum effect size in the relevant distribution.

Effect sizes from independent samples were combined into a mean effect size after weighting each effect size by sample size. For each mean weighted effect size, a 95% confidence interval (CI) and fail-safe *n* (i.e., the number of additional studies with a null result needed to negate the conclusion drawn from the analysis) were calculated. The homogeneity test statistic (Q) was also used to test whether the variance in effect sizes was homogeneous.

To examine the influence of possible moderator variables upon the variance in effect sizes, moderator analyses using between-groups Q_B and within-groups Q_W were conducted separately for each variable. Significant Q_B indicates that the variable significantly contributes to the variance in effect sizes. However, Q statistics become unreliable when individual moderator variables are interrelated with each other. Cramér's V was therefore calculated to examine possible interrelations among the variables. In addition, a multiple regression analysis was conducted to test the effect of multiple moderator variables. Each effect size used as the dependent variable was weighted by its inverse variance weight (Hedges & Olkin, 1985). All predictor variables (presence of provided notes, focus of interventions, academic level of participants, relevance of material, presentation method, presentation length, review length, publication year, and publication source) were simultaneously entered into the regression equation.

Results

A total of 33 studies met the inclusion criteria and were included in the present meta-analysis. Table 1 shows a summary of NT+NR groups versus C or MR groups comparison studies: sample size, number of effect sizes, and mean effect sizes. Table 2 shows a summary of intervention groups versus no-intervention groups comparison studies: publication year, sample size, intervention characteristics, academic level of participants, presentation characteristics, review length, publication source, number of effect sizes, and mean effect sizes.

Table 1. Summary of NT+NR groups versus C or MR groups comparison studies included in the meta-analyses

Study	NT+NR vs. C			NT+NR vs. MR		
	Sample size	*n* of *ES*	Mean *ES*	Sample size	*n* of *ES*	Mean *ES*
Annis & Davis (1975)	37	1	1.05	23	1	.65
Ash & Carlton (1953), sample 1[1]	105	1	–.09	–	–	–
Ash & Carlton (1953), sample 2[2]	97	1	–.09[b]	–	–	–
Catts (1987)	–	–	–	44	4	.06
Davis & Annis (1978), sample 1[3]	11	1	–.09[b]	–	–	–
Davis & Annis (1978), sample 2[4]	38	1	.60	–	–	–
Davis & Annis (1978), sample 3[5]	12	1	1.74[b]	–	–	–
Davis & Annis (1978), sample 4[6]	23	1	.70	–	–	–
Di Vesta & Gray (1972), sample 1[7]	30	1	.73	30	1	–.03
Di Vesta & Gray (1972), sample 2[8]	30	1	1.10	30	1	.27
Fisher & Harris (1973)	–	–	–	37[a]	3	.88
Frank (1984), sample 1[9]	–	–	–	26	1	1.04
Frank (1984), sample 2[10]	–	–	–	26	1	2.55
Freedman (1979), sample 1[11]	40	4	1.74[b]	40	4	2.10
Freedman (1979), sample 2[12]	40	4	1.74[b]	40	4	2.55[b]
Greene (1934)	91	1	1.74	–	–	–
Hertzbach (1981), pilot study	72	1	.59	–	–	–
Hertzbach (1981), dissertation study, sample 1[13]	18[a]	2	.72	18[a]	2	.63
Hertzbach (1981), dissertation study, sample 2[14]	18[a]	2	.45	18[a]	2	–.08
Jones (1993)	–	–	–	41	1	.07
Kiewra (1985c)	–	–	–	29	2	.27
Kiewra (1985d)	–	–	–	10[a]	2	.87
Knight & McKelvie (1986)	36	1	.76	–	–	–
Maqsud (1980), experiment 2, sample 1[15]	–	–	–	20	1	2.55[b]
Maqsud (1980), experiment 2, sample 2[16]	–	–	–	20	1	2.55[b]
Rickards et al. (1997), experiment 1, sample 1[17]	–	–	–	20[a]	2	.71
Rickards et al. (1997), experiment 1, sample 2[18]	–	–	–	20[a]	2	–.66

Table 1. *(Continued)*

Study	NT+NR vs. C			NT+NR vs. MR		
	Sample size	*n* of *ES*	Mean *ES*	Sample size	*n* of *ES*	Mean *ES*
Rickards et al. (1997), experiment 2, sample 1[19]	–	–	–	39[a]	2	1.26
Rickards et al. (1997), experiment 2, sample 2[20]	–	–	–	39[a]	2	1.28
Rickards et al. (1997), experiment 2, sample 3[21]	–	–	–	44[a]	2	.78
Rickards et al. (1997), experiment 2, sample 4[22]	–	–	–	44[a]	2	.81
Rickards & McCormick (1988)	22	1	.95	22	1	.38
Thomas (1978), sample 1[23]	–	–	–	24	1	1.25
Thomas (1978), sample 2[24]	–	–	–	24	1	1.40
Titsworth (2001), sample 1[25]	–	–	–	50[a]	4	.52
Titsworth (2001), sample 2[26]	–	–	–	50[a]	4	.59
Titsworth (2001), sample 3[27]	–	–	–	50[a]	4	.81
Titsworth (2001), sample 4[28]	–	–	–	50[a]	4	.60
Titsworth & Kiewra (2004), sample 1[29]	–	–	–	30[a]	2	1.33
Titsworth & Kiewra (2004), sample 2[30]	–	–	–	30[a]	2	.27
Wellington (1981), primary analysis	36	1	.57	–	–	–
Yu & Berliner (1988), sample 1[31]	12	2	.59	12	2	.37
Yu & Berliner (1988), sample 2[32]	12	2	–.09[b]	12	2	.34
Yu & Berliner (1988), sample 3[33]	12	2	.69	12	2	.77

Note. NT+NR = note-taking/-reviewing; C = listening or reading only; MR = listening or reading with mental reviewing; *ES* = effect size. Dashes indicate that data was not reported. [a]Averaged number of participants; [b]winsorised; [1]"High Altitude Flying" condition; [2]"Ocean Survival and Safety" condition; [3]familiar with reading topic and preferred study technique condition; [4]familiar with reading topic and unpreferred study technique condition; [5]unfamiliar with reading topic and preferred study technique condition; [6]unfamiliar with reading topic and unpreferred study technique condition; [7]testing condition; [8]no testing condition; [9]field-dependent group condition; [10]field-independent group condition; [11]objectives condition; [12]no objectives condition; [13]concrete passage condition; [14]abstract passage condition; [15]brief note-taker group condition; [16]detailed note-taker group condition; [17]signal condition; [18]no signal condition; [19]field-dependent group and signal condition; [20]field-dependent group and no signal condition; [21]field-independent and signal condition; [22]field-independent and no signal condition; [23]distributed notes condition; [24]parallel notes condition; [25]high immediacy and organisational cues condition; [26]high immediacy and no organisational cues condition; [27]low immediacy and organisational cues condition; [28]low immediacy and no organisational cues condition; [29]with organisational cue condition; [30]without organisational cue condition; [31]after-lecture review and before-test review condition; [32]after-lecture review condition; [33]before-test review condition.

Table 2. Summary of intervention groups versus no-intervention groups comparison studies included in the meta-analyses

Study	Sample size	Intervention characteristics[a]	Academic level[b]	Presentation characteristics[c]	Review length[d]	Publication source[e]	*n* of *ES*	Mean *ES*
Annis & Davis (1975)	20	1/0	H	1/0/40	10	J	1	.22
Berndt (1997), sample 1[1]	78	1/1	L	0/1/11	12	D/E	2	.90
Berndt (1997), sample 2[2]	78	1/1	L	0/1/11	12	D/E	2	1.33
Berndt (1997), sample 3[3]	78	0/0	L	0/1/11	12	D/E	2	.29
Carrier & Titus (1981), sample 1[4]	34[f]	0/1	L	0/0/20	14	J	2	.62
Carrier & Titus (1981), sample 2[5]	34[f]	0/1	L	0/0/20	14	J	2	–.51
Carrier & Titus (1981), sample 3[6]	34[f]	0/1	L	0/0/20	14	J	2	–.46
Catts (1987)	43	0/1	L	0/1/24	6	D/E	4	.09
Davis & Hult (1997)	49	0/0	H	1/1/21	12	J	3	.15
Frank (1984), sample 1[7]	26	1/1	H	1/2/15	10	J	1	.92
Frank (1984), sample 2[8]	26	1/1	H	1/2/15	10	J	1	–.33
Frank (1984), sample 3[9]	26	1/1	H	1/2/15	10	J	1	1.48
Frank (1984), sample 4[10]	26	1/1	H	1/2/15	10	J	1	–.24
Jones (1993)	43	1/0	H	1/3/92.5[g]	30	J	1	.23
Keller (1994), sample 1[11]	17[f]	1/1	H	1/1/22.5[g]	20	D/E	4	1.14
Keller (1994), sample 2[12]	22[f]	1/1	H	1/1/22.5[g]	20	D/E	4	1.17
Keller (1994), sample 3[13]	22[f]	1/1	H	1/1/22.5[g]	20	D/E	4	.42
Keller (1994), sample 4[14]	20[f]	1/1	H	1/1/22.5[g]	20	D/E	4	.77
Kiewra (1985c)	31	1/0	H	1/1/20	25	J	2	.51
Kiewra et al. (1995), experiment 1, sample 1[15]	18	1/1	H	0/1/19	25	J	2	–.82
Kiewra et al. (1995), experiment 1, sample 2[16]	19	1/1	H	0/1/19	25	J	2	.77
Kiewra et al. (1995), experiment 1, sample 3[17]	19	0/0	H	0/1/19	25	J	2	–.82[h]
Kiewra et al. (1995), experiment 1, sample 4[18]	17	1/1	H	0/1/19	25	J	2	–.82[h]

Table 2. *(Continued)*

Study	Sample size	Intervention characteristics[a]	Academic level[b]	Presentation characteristics[c]	Review length[d]	Publication source[e]	*n* of *ES*	Mean *ES*
Kiewra et al. (1995), experiment 1, sample 5[19]	17	1/1	H	0/1/19	25	J	2	1.37
Kiewra & Frank (1988), sample 1[20]	78	1/1	H	1/1/20	25	J	2	.06
Kiewra & Frank (1988), sample 2[21]	81	1/1	H	1/1/20	25	J	2	.31
King (1992), sample 1[22]	37	0/0	L	0/1/25[g]	15	J	2	.84
King (1992), sample 2[23]	37	0/0	L	0/1/25[g]	15	J	2	.90
Lacroix (1987), sample 1[24]	53	1/1	H	0/0/50	15	D/E	1	.11
Lacroix (1987), sample 2[25]	43	1/1	H	0/0/50	15	D/E	1	.34
Lacroix (1987), sample 3[26]	66	1/1	H	0/0/50	15	D/E	1	.12
Lacroix (1987), sample 4[27]	56	1/1	H	0/0/50	15	D/E	1	.03
Lacroix (1987), sample 5[28]	31	1/1	H	0/0/50	15	D/E	1	.48
Lacroix (1987), sample 6[29]	65	1/1	H	0/0/50	15	D/E	1	−.03
Maqsud (1980), experiment 2, sample 1[30]	20	1/0	H	1/2/-	30	J	1	1.48[h]
Maqsud (1980), experiment 2, sample 2[31]	20	1/0	H	1/2/-	30	J	1	1.21
Thomas (1978), sample 1[32]	24	1/1	H	0/2/16	10	J	1	.12
Thomas (1978), sample 2[33]	24	1/1	H	0/2/16	10	J	1	.36
Thomas (1978), sample 3[34]	24	1/0	H	0/2/16	10	J	1	.54
Ward & Clark (1987), sample 1[35]	34	1/1	H	0/1/20	10	J	6	.31

Table 2. *(Continued)*

Study	Sample size	Intervention characteristics[a]	Academic level[b]	Presentation characteristics[c]	Review length[d]	Publication source[e]	*n* of *ES*	Mean *ES*
Ward & Clark (1987), sample 2[36]	34	1/1	H	0/1/20	10	J	6	.28
Yu & Berliner (1988), sample 1[37]	12	1/1	H	1/0/35	20	D/E	2	.82
Yu & Berliner (1988), sample 2[38]	12	1/1	H	1/0/35	10	D/E	2	.97
Yu & Berliner (1988), sample 3[39]	12	1/1	H	1/0/35	10	D/E	2	.38

Note. *ES* = effect size; [a]the first variable is presence of provided notes (0 = no, 1 = yes) and the second variable is focus of interventions (0 = interventions in note-reviewing only, 1 = interventions in note-taking/-reviewing); [b]L = lower academic level of participants, H = higher academic level of participants; [c]the first variable is relevance of material (0 = lower, 1 = higher), the second variable is presentation method (0 = live lecture, 1 = video, 2 = audio, 3 = IVD), and the third variable is presentation length (in minutes); [d]in minutes; [e]J = journal article, D/E = dissertation or ERIC report; [f]averaged number of participants; [g]mean length of presentation; [h]winsorised; [1]matrix and example condition; [2]matrix only condition; [3]example only condition; [4]multiple-choice test expectation condition; [5]essay test expectation condition; [6]nonspecific test expectation condition; [7]outline framework plus student's notes and field-dependent group condition; [8]outline framework plus student's notes and field-independent group condition; [9]complete outline plus student's notes and field-dependent group condition; [10]complete outline plus student's notes and field-independent group condition; [11]matrix training and matrix form lecture condition; [12]matrix training and hierarchy form lecture condition; [13]hierarchical training and matrix form lecture condition; [14]hierarchical training and hierarchy form lecture condition; [15]matrix and review condition; [16]outline and review condition; [17]conventional and essay condition; [18]matrix and essay condition; [19]outline and essay condition; [20]skeletal notes condition; [21]detailed notes condition; [22]self-questioning condition; [23]summarising condition; [24]field-dependent and brief outline condition; [25]field-neutral and brief outline condition; [26]field-independent and brief outline condition; [27]field-dependent and detailed outline condition; [28]field-neutral and detailed outline condition; [29]field-independent and detailed outline condition; [30]brief note-taker group condition; [31]detailed note-taker group condition; [32]distributed notes on outline, review notes condition; [33]parallel notes on outline, review notes condition; [34]parallel notes, review notes and summary condition; [35]field-dependent group condition; [36]field-independent group condition; [37]after-lecture review and before-test review condition; [38]after-lecture review condition; [39]before-test review condition.

NT+NR vs. C or MR

Twelve NT+NR groups versus C groups comparison studies yielded 21 independent samples, and 18 NT+NR groups versus MR groups comparison studies yielded 34 independent samples. Six effect sizes were identified as outliers for NT+NR versus C (*ES* = −1.08, −.75, −.52, 1.78, 3.18, and 3.48) and there were three for NT+NR versus MR (*ES* = 3.27, 8.74, and 9.45). Results of the meta-analyses are summarised in Table 3. When the outcomes of the NT+NR groups were compared with those of the C groups, the mean weighted effect size was .75 (95% CI = .61, .89); when compared with those of the MR groups, the mean weighted effect size was .77 (95% CI = .64, .90). The magnitude of both effect sizes was in the range of medium to large, according to Cohen's (1988) criteria.

Intervention vs. No Intervention

For comparing intervention groups with no-intervention groups, 17 studies yielded 44 independent samples. Three effect sizes (*ES* = −2.84, −1.50, and 2.13) were identified as outliers. The mean weighted effect size was .36 (95% CI = .26, .46), in the range of small to medium magnitude. The fail-safe *n* was 1,486, indicating high tolerance for future null results. The homogeneity test showed that the effect sizes were significantly heterogeneous ($Q[4] = 97.70$, $p < .001$).

Moderator analyses using the *Q* statistic were conducted separately for nine possible moderator variables: presence of provided notes, focus of interventions, academic level of participants, relevance of material, presentation method, presentation length (≤ 20 min, > 20 min, or unreported), review length (< 15 min or ≥ 15 min), publication year (1970s, 1980s, or 1990s), and publication source. Results are shown in Table 4. Between-groups statistics were significant for the following four variables: academic level of participants (*ES* = .29 for higher and .53 for lower; $Q_B[1] = 4.33$, $p < .05$); presentation method (*ES* = .13 for live lecture, .46 for video, .53 for audio, and .23 for IVD; $Q_B[3] = 9.87$, $p < .05$); presentation length (*ES* = .34 for ≤ 20 min, .33 for > 20 min, and 1.34 for unreported; $Q_B[3] = 8.08$, $p < .05$); and publication year (*ES* = .31 for 1970s, .23 for 1980s, and .57 for 1990s; $Q_B[2] = 9.33$, $p < .05$). For the other variables, between-group statistics did not reach significance.

Table 3. Meta-analytic results of NT+NR groups versus C or M groups comparison studies

Category	Number of studies	*k*	Weighted mean *ES*	95% CI	*Q*	Fail-safe *n*
NT+NR vs. C	12	21	.75	.61, .89	92.72***	800
NT+NR vs. MR	18	34	.77	.64, .90	104.68***	1,928

Note. *k* = number of independent samples; CI = confidence interval; *Q* = homogeneity statistic; ***$p < .001$.

Table 4. Results of moderator analyses

Category	Q_B	k	Weighted mean *ES*	95% CI	Q_W
Presence of provided notes	3.29				
Yes		35	.41	.29, .53	72.90***
No		9	.19	−.02, .40	21.51**
Focus of interventions	.90				
Note-taking/-reviewing		12	.33	.21, .45	77.66***
Note-reviewing only		32	.45	.24, .65	19.13
Academic level of participants	4.33*				
Higher		35	.29	.17, .41	58.74**
Lower		9	.53	.34, .72	34.62***
Relevance of material	1.24				
Higher		19	.44	.27, .61	31.20*
Lower		25	.32	.19, .44	62.26***
Presentation method	9.87*				
Live lecture		12	.13	−.06, .31	13.43
Video		21	.46	.32, .60	53.65***
Audio		9	.53	.25, .81	20.75**
IVD		1	.23	−.38, .83	–
Presentation length	8.08*				
≤ 20 min		23	.34	.20, .48	70.06***
> 20 min		19	.33	.17, .49	19.41
Unreported		2	1.34	.66, 2.03	.15
Review length	.56				
< 15 min		20	.40	.25, .55	48.83***
≥ 15 min		24	.32	.18, .46	48.31**
Publication year	9.33*				
70s		4	.31	−.10, .73	.57
80s		24	.23	.10, .37	40.67*
90s		16	.57	.40, .74	47.13**
Publication source	2.52				
Journal article		27	.28	.15, .42	61.88***
Dissertation/ERIC		17	.45	.30, .60	33.29**

Note. Q_B = between-groups homogeneity statistic; k = number of independent samples; CI = confidence interval; Q_W = within-groups homogeneity statistic; * $p < .05$; ** $p < .01$; *** $p < .001$.

It should be noted, however, that Cramér's V statistics revealed some significant interrelations among possible moderator variables: presence of provided notes × focus of interventions ($V = .36$), academic level of participants ($V = .72$), and relevance of material ($V = .33$); focus of interventions × publication source ($V = .35$); academic level of participants × relevance of material ($V = .44$) and review length ($V = .33$); presentation method × presentation length ($V = .43$), publication year ($V = .51$), and publication source ($V = .41$); presentation length × review length ($V = .39$)

and publication source (V = .62); and review length × publication year (V = .42). These interrelations may have confounded the result of each moderator analysis using the Q statistic.

To test the independent effect of each variable, a weighted multiple regression analysis was conducted. The predictor variables were presence of provided notes (yes = 1, no = 0), focus of interventions (note-taking/-reviewing = 1, note-reviewing only = 0), academic level of participants (higher = 1, lower = 0), relevance of material (higher = 1, lower = 0), video or audio versus live lecture or IVD (video or audio = 1, live lecture or IVD = 0), presentation length (in minutes), review length (in minutes), publication year (in chronological year), and publication source (journal article = 1, dissertation/ERIC report = 0). Overall, these variables accounted for 41.7 % of the variance in effect sizes ($F[9, 32] = 2.54$, $p < .05$). As shown in Table 5, significant variables ($p < .05$) were presence of provided notes ($b = .82$, $SE = .28$) and academic level of participants ($b = -.70$, $SE = .25$). Other variables did not significantly contribute to the regression.

Discussion

The meta-analyses comparing learning outcomes of NT+NR groups with those of C or MR groups indicated that the overall effects of note-taking/-reviewing were highly positive. The mean weighted effect sizes were .75 (mean unweighted ES = .77) for NT+NR versus C and .77 (mean unweighted ES = .88) for NT+NR versus MR. These findings are inconsistent with Ryan's (1982) mean unweighted effect size of .34. Remember, however, that Ryan's meta-analysis was based on a smaller sample of studies. He calculated the mean effect size from only 19 effect sizes, whereas the present meta-analysis used 32 effect sizes for NT+NR versus C and 72 effect sizes for NT+NR versus MR. Therefore, the present findings probably gave more accurate estimates of note-taking/-reviewing effects.

It is important to note that the present estimates of note-taking/-reviewing effects were far larger than the mean weighted effect size of .26 (k = 66) found for note-taking

Table 5. Results of multiple regression analysis

Predictor variables	b	95% CI for b
Presence of provided notes	.82	.39, 1.24
Focus of interventions	−.26	−.61, .10
Academic level of participants	−.70	−1.08, −.32
Relevance of material	.27	−.01, .56
Video or audio vs. live lecture or IVD	.15	−.40, .69
Presentation length	.00	−.01, .02
Review length	−.02	−.04, .01
Publication year	.01	−.02, .05
Publication source	−.09	−.42, .24

(without any special intervention) versus no note-taking comparison studies in Kobayashi's (2005) meta-analytic review. This contrast gives support to the idea that later review of notes substantially heightens the value of note-taking as a learning technology (Kiewra et al., 1991). Fortunately, in real academic situations, the majority of students do not only take notes during class, but also review the notes afterward (e.g., Carrier & Newell, 1984; Hartley & Davies, 1978; Van Meter et al., 1994). From the present findings, it seems that students benefit greatly from using notes.

The present study also examined the degree to which interventions in the students' spontaneous note-taking and/or -reviewing procedures increase the effects of note-taking/-reviewing. Meta-analysis of studies comparing outcomes of intervention groups with those of no-intervention groups revealed that the overall intervention effect was modest (mean weighted $ES = .36$) but significantly greater than zero. This result suggests that there is still room for improvement in the students' spontaneous note-taking/-reviewing procedures, even though their note-taking/-reviewing substantially enhances learning without any special intervention.

Furthermore, the present study explored which factors influence the effectiveness of interventions. Nine possible moderator variables were included in the analysis: presence of provided notes, focus of interventions, academic level of participants, relevance of material, presentation method, presentation length, review length, publication year, and publication source. However, the results of moderator analyses using the Q statistic were inconsistent with those of multiple regression analysis. As stated earlier, this inconsistency is probably due to interrelations among the possible moderator variables that may have confounded the former results. For this reason, my discussion concentrates on the results of multiple regression analysis.

Multiple regression analysis indicated that presence of provided notes significantly contributed to the regression. That is, providing instructor's notes enhanced the effects of note-taking/-reviewing more than pre-training or verbal instructions only. One potential reason for the difference is that the two types of intervention vary in how they modify students' spontaneous note-taking procedures. Instructor's notes are an external resource that help students take and/or review notes in a particular way. For example, structured information in the framework notes directs the note-takers' attention to what they should write down in their notes (Kiewra et al., 1991, 1995). With the aid of external resources, the participants may have been able to take and review effective notes easily. In contrast, interventions without provided notes require that, after pre-training or verbal instructions, students follow the imposed note-taking/-reviewing procedures only by their own efforts. This seems difficult once they establish their own styles (Thornton, Bohlmeyer, Dickson, & Kulhavy, 1990). As a consequence, pre-training or verbal instructions only may have been less effective in changing note-taking/-reviewing procedures.

Another significant predictor variable was academic level of participants. The benefits of interventions for participants at a lower academic level were greater than those for participants at a higher academic level. This finding is not surprising; the former participants probably had more "room left" to improve their note-taking/-reviewing procedures than the latter participants. In the present meta-analysis, those classified as at a lower academic level were high-school students (Berndt, 1997; Carrier & Titus, 1981) and academically unprepared undergraduates (Catts, 1987; King, 1992). It is highly likely that the average high-school student is inferior to the average post-high-school student in note-taking/-reviewing skills because these skills develop as one gains educational experience (e.g., Hartley & Davies, 1978; Hidi & Klaiman, 1983). Also, the participants diagnosed as academically unprepared had been enrolled on a "study skills course" (Catts, 1987) or "remedial reading and study skills course" (King, 1992), suggesting that they were lacking in the fundamental skills necessary for taking and reviewing notes in effective ways.

At least two limitations of the present findings must be mentioned. First, the samples of participants included in the present meta-analysis were confined within narrow limits. For example, the majority of them were high-school or college students without learning disabilities in Western countries. Therefore, extensive generalisation of these findings may not be possible. Second, the meta-analysis of intervention groups versus no-intervention groups comparison studies could not examine some potentially important variables, such as length of pre-training and type of provided notes (e.g., instructor's notes, outline notes, matrix notes). This was because the number of samples classified into subcategories for each variable was too small to conduct a meaningful analysis of effect sizes. It will be necessary to accumulate empirical studies including these variables in the future.

In conclusion, the present meta-analysis reveals that the overall effects on learning of students' spontaneous note-taking/-reviewing are substantially positive. The results also show that interventions in note-taking and/or -reviewing procedures can increase the benefits of note-taking/-reviewing. In particular, larger intervention effects tend to occur when framework or instructor's notes are provided and when students are at a lower academic level. These findings highlight the importance and potential of note-taking/-reviewing for school learning.

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