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Expressing Intrinsic Motivation Through Acts of Exploration and Facial Displays of Interest

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Intrinsically-motivated behavior has been defined through participants' task persistence during a free-choice interval. While fruitful, this operational definition assesses only the person's postperformance reaction to an activity. Presumably, people experience and express intrinsic motivation during task engagement as well. The need therefore exists for a supplemental in-performance behavioral measure of intrinsic motivation. To test the viability of constructing such a measure, we recorded the extent to which five acts of exploration and four facial displays of interest corresponded to self-reports of interest, self-determination, and competence for 60 undergraduates as they solved SOMA puzzles. Correlational and LISREL analyses confirmed the validity of three acts of exploration and two facial displays of interest. We concluded that just as task persistence is a valid postperformance indicator of intrinsic motivation, acts of exploration and facial displays of interest are valid in-performance indicators.

Intrinsic motivation arises from the organismic needs for competence and self-determination and energizes behavior for which the rewards are the experiences of effectance and autonomy (Deci & Ryan, 1985). This statement constitutes the conceptual, or psychological, definition of intrinsic motivation. In empirical study, researchers infer intrinsic motivation from a participant's extent of engagement with a target activity during a free-choice period in which there exists no extrinsic reward, pressure, or con-

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tingency to do so. To operationally define intrinsic motivation in this way, the experimenter informs the participant that the experiment has come to its conclusion and then offers a pretext for having to leave the participant alone with the task for a specified period of time, usually eight minutes. During this time, the participant has no extrinsic reason to re-engage the task, is unaware of being observed surreptitiously, has access to nearby and interesting alternative activities, and is free to do as he or she pleases. The extent of time the participant spends with the target activity serves as the operational definition of intrinsic motivation.

Well over 100 studies have used the free-choice persistence measure to operationalize intrinsic motivation (for reviews, see Cameron & Pierce, 1994; Deci & Ryan, 1985). Others have operationally defined intrinsic motivation through participants' self-reports of task interest (e.g., Harackiewicz, Sansone, & Manderlink, 1985) and willingness to volunteer for a future engagement with the activity (e.g., Weiner & Mander, 1978), but free-choice persistence is the only *behavioral* measure of intrinsic motivation. Despite its popularity and proven utility, the free-choice measure does possess the limitation of being a postperformance measure. Under some conditions, this can be a problem. For instance, teachers, parents, managers, and others sometimes seek to infer the intrinsic motivation of their students, children, and workers without the opportunity of a post-performance, free-choice interval. Sometimes the conditions are such that a teacher, parent, or manager wants to present a potentially interesting activity to another and look for the emergence of intrinsic motivation while doing the task. A teacher might, for instance, ask a student to read a book that may be interesting and then use that student's engagement behaviors as information about the book's competence and self-determination need-relevance for that reader. The goal of the present study, therefore, was to seek to identify a set of valid *in-performance* behaviors that express intrinsic motivation. In the present paper, we hypothesized that just as researchers have identified valid postperformance intrinsically-motivated behaviors during a free-choice interval, so too can in-performance intrinsically-motivated behaviors be identified during task engagement.

When a person encounters a new activity, an observer gains an impression of how intrinsically motivated he or she is by noting how quickly or gradually the person engages it, how active versus passive he or she handles it, how effortful and how detailed the investigation is, how wide open the eyes are, whether the person pulls the object close, whether he or she asks others for information about it, and so on (based on Berlyne, 1966; Harlow, 1953; Hunter, Ames, & Koopman, 1983; Langsdorf, Izard, Rayias, & Hembree, 1983; Renninger & Wozniak, 1985). Such investigatory behaviors seemingly reflect interest, but the free-choice persistence measure lacks the capacity to pick up on these acts of exploration.

Through exploration, a person becomes acquainted with a task. Specifically, exploration allows the person to investigate the task's complexity, assess its challenges, estimate its potential to produce positive and negative affect, identify which skills will be utilized, categorize it as a preferred activity or not, and so on. Berlyne (1963) classified such exploration behaviors in multiple ways (including diverse, specific, receptor-adjusting, locomotor, investigatory, extrinsic, and intrinsic), but we focused on those intrinsic, investigatory acts that allow the individual to diagnose (1) task affordances and (2) the extent of fit between those affordances and personal needs, preferences, and skills. Intrinsically-motivated exploration, therefore, constitutes investigatory behavior aimed at diagnosing the extent to which the task's affordances match and involve one's organismic needs, preferences, and valued skills (based on Deci, 1992). In the present study, we introduced participants to a SOMA puzzle (a task frequently used in studies of intrinsic motivation) and studied the following five acts of exploration: latency to initiate the task; comprehensiveness of investigation; richness (or quality) of investigation; manipulation speed of hands; and approach-avoidance orientation of the body.

In addition to acts of exploration, we observed facial displays during SOMA-solving. When people encounter novel or information-bearing stimuli, they show two kinds of attentional responses (Berlyne, 1960)—a passive, involuntary orienting response and active, voluntary exploration. We focused on the latter, because they express the individual's intentional pursuit of diagnostic information about the activity. We borrowed from our previous work that showed the following facial displays both correlated with self-reported interest and varied in frequency following exposure to interesting versus uninteresting stimuli (Reeve, 1993)—eye contact, eyeball exposure, frequency of eyes closed, and duration of lips parted.

Our primary objective was to identify and validate two categories of in-performance behavioral expressions of intrinsic motivation—acts of exploration and facial displays of interest. To do so, we assessed participants' phenomenological states associated with intrinsic motivation—self-reported interest, perceived self-determination, and perceived competence—and tested whether these measures correlated with acts of exploration and facial expressions of interest. Our hypothesis was that these self-report measures of intrinsic motivation would correlate not only with the traditional free-choice persistence measure but would also correlate with each of the two clusters of in-performance measures.

METHOD

Participants

Sixty undergraduate students (36 females and 24 males) enrolled in an introductory psychology class at a private university in the northeast participated in exchange for partial fulfillment of a course requirement.

Materials

Experimental Task. The experimental task was a spatial-relations puzzle called SOMA. Past studies with college students solving SOMA puzzles indicate that participants find SOMA to be interesting and play with it when given a free-choice opportunity to do so (e.g., Zuckerman, Porac, Lathin, Smith, & Deci, 1978). SOMA features seven separate pieces that can be stacked and interlocked to form complex shapes. To provide the participant with complex shapes to solve, the experimenter provided a scaled drawing for three solutions (viz., skyscraper, T, mountain top). Drawings of three additional solutions not used during the performance phase of the study also rested on the tabletop so the participant would have the opportunity to engage novel, previously unencountered solutions during the free-choice interval.

Questionnaires. We included pre- and postperformance questionnaires to assess the phenomenology associated with intrinsic motivation. The preperformance questionnaire listed six items, such as "The puzzle is very interesting." and "The puzzle stimulates my curiosity without interruption." Each item had a 1–7 response scale that ranged from strongly disagree to strongly agree. A principal-components factor analysis on these six items showed that, as expected, a single-factor solution emerged, as evidenced by the following: only one eigenvalue exceeded 1.00; that factor accounted for more than half of the variance in the questionnaire (61.2%); and each item's factor loading exceeded .50 (actual range, .70 to .89). Scores for the six items were combined to form the scale for pretest intrinsic interest (alpha = .87). We administered the identical questionnaire at the conclusion of the puzzle-solving session to assess posttest intrinsic interest (alpha = .86). The postexperimental questionnaire further included items to assess perceptions of competence and self-determination. To assess these experiences, we used the activity feeling states (AFS) scale (Reeve & Sickenius, 1994). The AFS asks the extent to which SOMA-solving allows the person to feel a particular way—capable, competent, and achieving to assess perceived competence (3 items, alpha = .89); and free, offered choices what to do, I want to do this, and my participation is voluntary to assess perceived self-determination (4 items, alpha = .60). These reliability coeffcients correspond closely to those reported previously (alphas of .90 and .61 reported in Reeve & Sickenius, 1994).

Procedure

The experimenter escorted a single participant into the experimental room, seated him or her at a table, and announced that the purpose of the experiment was to investigate the strategies college students use to solve spatial puzzles. The participant's task was to attempt to assemble the seven individual SOMA pieces into a succession of three complex configurations, one at a time. The experimenter demonstrated how the SOMA pieces fit together by solving a sample problem and then outlining the logic underlying its discovery. The experimenter then pointed out a video camera (on the opposite side of the room) and announced that it would record the participant's puzzle-solving efforts, ostensibly so that the experimenter could use the videotape to later code how the participant solved each problem move-by-move. On the tabletop lay a 14 in × 11 in platform raised 9 in above the tabletop. The experimenter rested the solution drawings on this platform and asked the participant to solve each puzzle there so that the camera, SOMA pieces, and the participant's hands would all be aligned for the sake of the raters' later observations and codings. More importantly, this alignment provided the raters with a straight-on, forward view of the participant's facial movements.

Once the procedure was explained, the participant completed the preperformance questionnaire. The experimenter seated himself or herself behind a room partition and watched the participant's puzzle-solving on a monitor connected to the video camera. The experimenter instructed the participant when to begin each trial, and he or she unobtrusively kept track of the time on a stopwatch, utilizing an eight-minute limit for each solution, when necessary. The experimenter did not tell the participant that each solution had a time limit because we did not want participants to feel pressured externally or to focus on performing quickly. On average, participants puzzle-solved for 15.5 minutes and solved 2.0 puzzles.

Following the third SOMA, the experimenter turned off and unambiguously put away the video camera. The experimenter retrieved the three solution drawings (i.e., previously solved versions of SOMA), and administered the postexperimental questionnaire. The experimenter then announced that the experiment had come to its conclusion, except that he or she needed to take the time necessary to walk down the hallway to another room and organize the participant's data. The experimenter left the room and promised to return after five minutes, saying, "While I'm gone, feel free to do whatever you want—read a magazine, solve some puzzles, sit and wait, or whatever. I'll return in five minutes." During this free-choice period, the experimenter recorded (through a one-way mirror) the duration of time the participant played with SOMA. A debriefing session followed the free-choice period.

Measures of Intrinsic Motivation

We measured three categories of intrinsically-motivated behavior. Our postperformance measure was free-choice persistence. The experimenter recorded each participant's persistence using a stopwatch while observing the free-choice interval. Our two in-performance measures were acts of exploration and facial displays of interest. The experimenter recorded these data on video tape while the participant puzzle-solved. Using the video tapes, two raters scored the five acts of exploration and four facial displays of interest. One rater coded and scored each measure for each participant on each of the three SOMA trials, while a second rater independently coded and scored a random sample of 20 (33%) of the video tapes. Interrater reliability scores were computed based on the 20 video tapes scored by both raters.

Free-Choice Persistence. Free-choice persistence is the traditional measure of intrinsically-motivated behavior, and past studies confirm that this measure correlates significantly with self-report measures of intrinsic motivation (e.g., Harackiewicz, 1979). In the present study, free-choice persistence was measured by the number of seconds each participant played with the novel, previously unencountered versions of SOMA during the free-choice interval (possible range, 0-300 seconds).

Acts of Exploration. We could not rely on previously validated measures of exploration and therefore constructed our own. We selected behaviors that captured the essence of attending to, investigating, manipulating, and experimenting with an activity in an effort to gain information about it. The operational definition and interrater reliability coefficient for each act of exploration were as follows: *latency to initiate* (r = .96)—number of seconds between the experimenter's announcement of the beginning of each trial until the participant first touched SOMA; *comprehensiveness of investigation* (r = .91)—number of different SOMA pieces handled on each trial with a possible range from 0 to 7 (actual range from 2 to 7); *richness of investigation* (r = .83)—number of rotations or permutations tried on each SOMA piece plus the number of interlocking combinations tried with two or more pieces (actual range 0 to 15); hand speed (r = .81)—manipulation speed of the hands scored on a 1-5 scale in which 1 represented passive and listless while 5 represented fast and continuous; and *approach-avoid-*

ance orientation (r = .75)—extent to which the participant drew his or her face near to SOMA as it lay on the platform rated on a 1–5 scale (higher numbers correspond to greater approach or nearness). Based on pilot test findings, we recorded each measure only during the first minute of each trial, because we expected everyone to take at least one minute to discover each solution but that exploratory behaviors might decline in a nonlinear fashion with extended exposure. (For instance, everyone's exploration should be comparable during the first minute, but a person who solves SOMA in the second minute works with a more novel activity than does the person who solves SOMA in the seventh minute.)

Facial Displays of Interest. For interest-associated facial displays, we selected facial behaviors previously validated as interest indicators (Reeve, 1993). For the facial displays, we recorded each participant's facial behavior for the full duration of each trial and then converted each either to a percentage score, a frequency of occurrence, or a duration length. The operational definition (based on Ekman & Friesen, 1978; Reeve, 1993; Tsubota & Nakamori, 1993) and interrater reliability coefficient for each facial display were as follows: *eye contact* (r = .82)—percentage of total time attending directly to SOMA calculated as seconds of puzzle-solving minus cumulative seconds of lateral eye glances away from SOMA; *eyeball exposure* (r = .85)—percentage visibility of the iris' outermost outline or boundary, which served as a proxy for exposed eyeball surface area; *eyes closed* (r = .88)—frequency per minute of eye blinks that extended in duration for at least a half-second; and *lips parted* (r = .72)—cumulative seconds of separated lips (about 2 mm) though jaw is not lowered or relaxed (as in a "jaw drop").

RESULTS

Table I shows the means, standard deviations, and intercorrelation matrix for each of the 13 measures. Measure 1 reports the free-choice persistence behavioral measure; measures 2–4 report the phenomenological measures; measures 5–9 report the acts of exploration; and measures 10–13 report the facial displays of interest. Each measure, except 1, 3, and 4, represents a session-average score. For instance, the mean of 5.21 for self-reported interest represents the average of participants' preperformance (5.16) and postperformance (5.26) interest; similarly, the mean of 6.91 for latency to initiate represents participants' average latency on the first (6.40), second (7.33), and third (6.98) SOMA trials. Measures 1, 3, and 4 represent postperformance measures only.

Table I. Means, Standard Deviations, Range, and Intercorrelation Matrix for Free-Choice Persistence, Three Measures of the Phenomenology of Intrinsic Motivation, Five Acts of Exploration, and Four Facial Displays of Interest

Dependnet measure	*M*	SD	Range of scores	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Free-choice persistence (secs.)[a]	119.8	137.7	0.0 to 300.0		.45**	.41**	.18	.01	-.03	-.11	.06	.26*	.17	.19	-.20	.00
Phenomenology of intrinsic motivation[b]																
2. Self-reported interest	5.21	0.97	3.00 to 7.00			.67**	.44**	-.24	.26*	.27*	.45**	.29*	.32*	.16	-.24	.13
3. Perceived self-determination	4.65	0.97	3.00 to 6.75				.57**	-.06	.18	.21	.30*	.34**	.27*	-.11	-.23	.09
4. Perceived competence	4.38	1.48	1.00 to 7.00					-.14	.31*	.25*	.38**	.06	.06	.10	-.31**	.07
Acts of exploration[c]																
5. Latency to initiate (secs.)	6.91	3.64	2.33 to 17.3						-.52**	-.20	-.46**	-.04	-.03	-.04	.06	-.01
6. Comprehensiveness of investigation	5.06	0.75	3.00 to 6.67							.20	.60**	.14	.30*	-.07	-.15	-.01
7. Richness of investigation	4.72	2.40	1.00 to 8.67								.49**	.08	.04	-.11	-.10	.11
8. Hand speed	2.94	0.65	1.33 to 4.67									.20	.26*	-.20	-.16	.26*
9. Approach-avoidance orientation	2.89	0.52	1.33 to 4.00										.16	-.11	.05	.17
Facial displays of interest[d]																
10. Eye contact (%)	99.4	0.59	98 to 100											.08	-.19	.23
11. Eyeball exposure (%)	51.5	10.1	30.0 to 81.7												-.14	-.02
12. Eyes closed (frequency/min)	0.05	0.11	0.0 to 0.58													-.19
13. Lips parted (sec/min)	8.61	11.6	0.0 to 48.9													

Note. N = 60.
[a]Possible range for free-choice persistence, 0 to 300 seconds.
[b]Possible range, 1–7 with higher numbers representing higher endorsement of self-reported interest, self-determination, or competence.
[c]Possible ranges: latency, 0–60 secs; comprehensiveness, 0–7 SOMA pieces; richness, 0 to infinity SOMA pieces; hand speed and approach–avoidance, 1–5 rating.
[d]Possible range for eye contact and eyeball exposure, 0–100%; possible range for eyes closed and lips parted, 0 to 60 seconds.
*$p < .05$.
**$p < .01$.

Correlational Analyses

Intercorrelations Among Free-Choice Persistence and the Phenomenology of Intrinsic Motivation. Table I confirms that each of the three phenomenological measures of intrinsic motivation correlated with one another and that these measures generally correlated with free-choice persistence. That is, self-reported interest correlated with perceptions of self-determination and competence (r's = .67 and .44, p's < .01), and perceived self-determination and perceived competence were also correlated (r = .57, p < .01). Free-choice persistence correlated with self-reported interest and perceived self-determination (r's = .45 and .41, p's < .01), but not with perceived competence (r = .18, n.s.).

Intercorrelations Among Acts of Exploration and the Phenomenology of Intrinsic Motivation. Four of the five acts of exploration correlated with the phenomenology of intrinsic motivation. Comprehensiveness of investigation correlated with self-reported interest and perceived competence (r's = .26 and .31, p's < .05), as did richness of investigation (r's = .27 and .25, p's < .05); hand speed correlated with self-reported interest, perceived self-determination, and perceived competence (r's = .45, .30, and .38, p's < .05), and approach–avoidance correlated with self-reported interest and perceived self-determination (r's = .29 and .34, p's < .05). As to the intercorrelations among the acts of exploration, 4 of the 10 possible correlations were significant. Hand speed correlated with three of the other four acts of exploration; both latency to initiate and comprehensiveness of investigation intercorrelated with two other measures; richness of investigation intercorrelated with one other measure, while approach–avoidance orientation did not correlate with any other act of exploration (see Table I).

Intercorrelations Among Facial Displays and the Phenomenology of Intrinsic Motivation. Eye contact and eyes closed generally correlated with the phenomenology of intrinsic motivation, while eyeball exposure and lips parted did not. That is, eye contact correlated with self-reported interest and perceived self-determination (r's = .32 and .27, p's < .05), and eyes closed correlated with competence (r = .31, p < .01). Among the four facial displays of interest, no measure intercorrelated significantly with any of the other three.

Actual Performance. We also assessed the correlations between actual performance and each measure listed in Table I. Actual performance constituted the average number of seconds each participant took to solve the three SOMA puzzles (M = 310.3 seconds, SD = 100.1 seconds). Out of the possible 13 correlations, actual performance correlated only with perceived competence (r = .40, p < .01). The absence of correlations between actual performance and the remaining measures suggests that the results in Table I are not confounded by participants' puzzle-solving performances.

LISREL Analyses

The correlations shown in Table I suggest that the phenomenology of intrinsic motivation correlated with (1) free-choice persistence, (2) four acts of exploration, and (3) two facial displays of interest. In a final analysis, we aggregated these 10 measures into a hypothesized model to illustrate the relationship between the subjective experience of intrinsic motivation and each category of intrinsically motivated behavior. To construct a LISREL model, we constrained each measure to load only on the latent factor it was intended to measure (4 latent variables, 10 indicators) and arranged for the phenomenology of intrinsic motivation to predict each category of intrinsically motivated behavior (using LISREL8; Joreskog & Sorbom, 1993). The hypothesized model fit the data well, $\chi^2(31) = 36.55$, n.s. (GFI = .90, AGFI = . 82), and each individual parameter estimate was statistically significant ($p < .05$), except approach-avoidance orientation.

While the data nicely fit the model, a conceptual problem emerged from using eye contact and eyes closed as uncorrelated indicators of the latent construct of facial displays of interest (i.e., $r = -.19$, n.s.; see Table I). Because these two measures were uncorrelated, it did not make conceptual sense to treat them as indicators of the same construct. In a second analysis, we used eye contact as a single indicator of facial expression of interest. This 9-item model fit the data well, $\chi^2(24) = 32.31$, n.s (GFI = .90, AGFI = .81), and each individual parameter estimate was statistically significant ($p < .01$), except approach-avoidance orientation. (Results using eyes closed only rather than eye contact produced virtually identical results.) Figure 1 shows the standardized solution for the 9-term model.

DISCUSSION

The data indicate that, as predicted, valid in-performance intrinsically-motivated exploration behaviors can be identified. We began with the assumption that intrinsic motivation expresses itself during an encounter with an activity through investigatory acts that serve purposes such as gathering information about the activity's characteristics and affordances. Four of our five acts of exploration—comprehensiveness of investigation, richness of investigation, hand speed, and approach-avoidance orientation—correlated significantly with the self-report ratings. Approach-avoidance orientation did not, however, intercorrelate with the other measures of exploration.

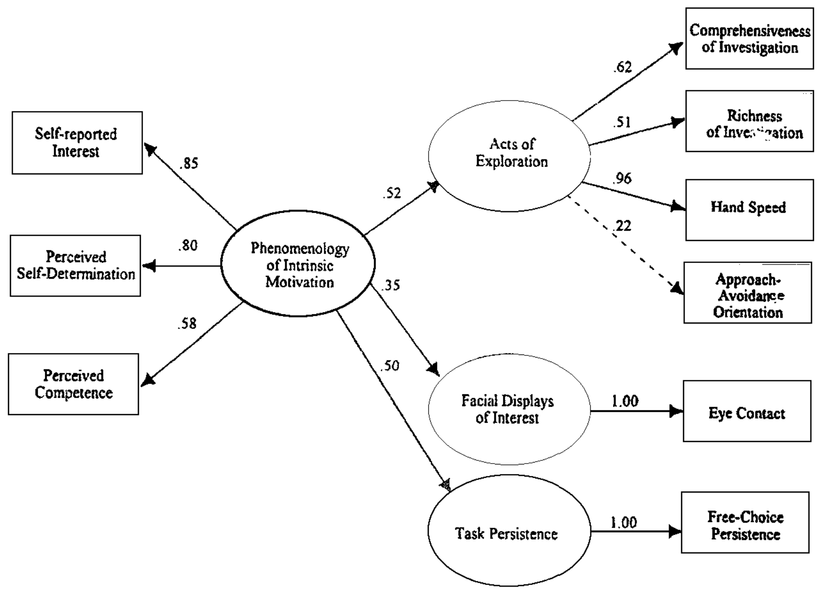

Fig. 1. Path diagram to estimate three categories of intrinsically-motivated behavior.

Thus, hand speed, comprehensiveness of investigation, and richness of investigation emerged as the coherent cluster of exploration behaviors that constituted the essence of intrinsically-motivated exploration.

The data also suggest that valid in-performance facial displays of interest can be identified, though the data supporting facial displays were not as strong as the data supporting acts of exploration. Eye contact and eyes closed correlated adequately with the phenomenological measures, but the two facial displays did not correlate with one another, which suggests that a coherent cluster of interest-associated facial displays might not exist. Instead, the LISREL analysis showed that the use of eye contact *or* eyes closed provides the observer with the data necessary to infer in-performance facial displays of interest. In deciding between the two, eye contact seemed to be the preferred indicator, because it, unlike eyes closed, correlated with self-reported interest, perceived self-determination, and the cluster of exploratory behaviors (see Table I).

The status of approach–avoidance orientation as an intrinsically-motivated act of exploration and the status of eyes closed as an intrinsically-motivated facial display of interest remain, unfortunately, ambiguous. Both measures correlated impressively with the self-report measures; the problem was that neither correlated with its related in-performance indicators.

Approach–avoidance might serve as an equivalent or compensating act of exploration to comprehensiveness (or richness) of investigation, and eyes closed might serve as an equivalent or compensating facial display to eyes closed.[2] That is, one might explore with close visual inspection (approach–avoidance orientation) or with a comprehensive and rich manual investigation, just as one might display visual disengaging by decreasing eye contact or by closing one's eyes. So, while further research is needed to determine the status of approach–avoidance and eyes closed, the data do rather convincingly support the status of hand speed, comprehensiveness of investigation, and richness of investigation as intrinsically-motivated acts of exploration and the status of eye contact as an intrinsically-motivated facial display of interest.

Two criticisms, at first glance, cast a shadow of interpretive caution over our findings and methods. A possible criticism of our findings might be to argue that participants puzzle-solved mentally in their mind's eye, rather than physically with their hands. While we recognize this limitation, we also point out that our participants showed little delay or withholding of their manual exploration in lieu of covert exploration, as evidenced by brief latencies (M = 6.91 secs.) and constant task-focused attention (eye contact > 99%). A possible criticism of our method might be that it required video taping participants, a condition shown previously to decrease intrinsic motivation (Lepper & Greene, 1975; Plant & Ryan, 1985). It is not, however, the presence of a videocamera or even surveillance that decreases intrinsic motivation; rather, it is the *functional significance* of the videocamera that determines its affect on intrinsic motivation (Deci & Ryan, 1985). Knowing this, our cover story presented the video camera in a nonpressuring way. Participants' high interest, self-determination, and free-choice persistence (and the high intercorrelations among these measures; Ryan, Koestner, & Deci, 1991) support our interpretation.

Our research suggests the following conclusion: Just as free-choice persistence represents one valid category of intrinsically-motivated behavior, specific acts of exploration and facial displays of interest represent a second valid category. That is, people who feel effective and autonomous not only persist freely when free to do or not to do a task, they also show predictable acts of exploration and facial displays of interest when asked to try that task. These acts of exploration and facial displays of interest therefore provide observers with nonintrusive behavioral markers to infer organism-need involvement as people engage tasks in the absence of external contingencies. Thus, a teacher might introduce a student to a microscope or computer and observe the student's hand speed as an indicator of the task's need-relevance for that

[2]We thank an anonymous reviewer for this interpretation.

student. The teacher interested in supporting intrinsic motivation could then tailor his or her instructional decisions accordingly.

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