Teaching Tacting of Private Events Based on Public Accompaniments: Effects of Contingencies, Audience Control, and Stimulus Complexity

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Abstract Our current understanding of the role of private events in the science of behavior is based largely on Skinner's natural science interpretation of private events. Skinner described public accompaniments as one source of control for a verbal community to differentially reinforce verbal behavior regarding private events. In this study, we developed an experimental analogue to study variables influencing tacting of private events. The participant had exclusive access to one set of stimuli (the private stimuli), and the experimenter attempted to teach tacts for private stimuli based on their correspondence with public stimuli accessible to both the experimenter and participant. Results of experiments 1 and 2 demonstrated that reports of private stimuli were a function of degree of public-private correspondence, reinforcement contingency, and audience control. In some cases, we encountered reports controlled exclusively by public stimuli. Results of experiment 3 showed that public control was less likely when public stimuli were more complex and the experimenter

had a unique behavioral history with respect to those stimuli that was not shared by the learner. The orderly patterns of data obtained suggest that analogue arrangements might be a useful, and even necessary, starting point for experimental investigations of how private events may enter into the analysis of behavior.

Keywords Audience control · Private events · Public accompaniments · Verbal behavior

Skinner's account of language was unlike traditional approaches (Skinner 1957). Traditional accounts of language focus on its structural properties (e.g., grammar or syntax) and commonly assume that words and sentences convey "meaning" to a listener. In contrast, Skinner focused on the functional properties of language and suggested that "meaning" is found in the antecedents and consequences (i.e., contingencies) that control verbal responses.¹ Though Skinner emphasized a functional account, he did not neglect the important contributions of a structural approach. He did, however, highlight that a functional account achieves a level of prediction and control of verbal responses that is missing from other accounts.

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¹ We acknowledge that Skinner's account of language is similar to other philosophical approaches. Day (1969) summarized the philosophical similarities between Skinnerian and Wittgensteinian approaches to language. For example, both Skinner and Wittgenstein focused on the function of language.

Though Skinner's approach to language was unlike traditional approaches to language, it was no different than his approach to all other behavior. That is, Skinner's account is rooted in behavioral principles (e.g., reinforcement) uncovered through research on nonverbal behavior.

Chomsky (1959) criticized Skinner's approach as a nonscientific, untested hypothesis. At the time *Verbal Behavior* was published, it was true that Skinner's account of language was untested, but extending experimental data to other phenomena is the business of scientific interpretation (see MacCorquodale 1970 and Palmer 2006, for rebuttals to Chomsky's criticisms), which differs from speculation that is not rooted in scientific evidence. Palmer (2003) distinguished between experimentation and interpretation, and he elaborated on the role each plays in the science of human behavior. Experimentation is the process through which the laws of nature are uncovered; interpretation is an extension of laws uncovered through experimentation to provide a plausible explanation of how nature might work. Interpretation plays an important role in the science of human behavior, but it should not be an end point. Palmer emphasized the value of interpretation in progressing science but also highlighted the important role of experimentation in filling out the frame built through interpretation. Since the publication of *Verbal Behavior*, many studies have provided experimental contributions to Skinner's interpretation that add to the scientific understanding of language and the development of behavioral technology that addresses problems of social significance (for reviews, see, e.g., Oah and Dickinson 1989; Sautter and LeBlanc 2006; Sundberg and Michael 2001). Nevertheless, much of Skinner's interpretative framework still lacks experimental support.

How we learn to talk about private events is one problem addressed by Skinner's interpretation that still requires empirical support (Skinner 1945, 1957). Private events are stimuli (sensations or feelings) or responses that are accessible to only one individual (e.g., stimulation related to a headache, hunger, or fatigue). Given the private nature of these events, it is really quite remarkable that we learn to talk about them at all. A key point of Skinner's interpretation was that verbal responses

develop as a result of listener behavior² explicitly taught by the verbal community. Verbal reports primarily controlled by antecedent nonverbal stimuli (i.e., tacts) develop as a result of differential reinforcement provided by listeners of a particular verbal community. However, because private nonverbal stimuli are not accessible to others, members of the verbal community are faced with a unique challenge when delivering consequences for reports of private sensations and feelings. For example, imagine your 3-year-old son tells you before preschool that he has a stomachache. Given that you do not have direct access to his sensations and feelings, you cannot provide the appropriate consequences for his reports based on direct contact with the desirable source of control (i.e., a stomachache); this is the problem of privacy.

According to Skinner, the problem of privacy is a problem only of accessibility. Because private events are accessible to only one person, measurement has proven difficult. However, privacy is conditional in that given the proper instruments, what is private one minute can be public the next. Brain-imaging studies, for example, provide evidence that supplement a behavioral interpretation of a listener's engaging in subvocal behavior (see Schlinger 2008, for an interpretation of listener behavior and a review of related brain-imaging studies). Because of the state of the accessibility problem, an approach to understanding verbal behavior about private events is based on Skinner's natural science *interpretation* of private events, which accounts for private stimuli and private responses without requiring any new behavioral principles (Skinner 1953). Skinner (1945) described public accompaniments as one way that a verbal community might differentially reinforce verbal behavior regarding private events. Public accompaniments are public events that correspond, to some degree, with

² Skinner (1957) generically described listener behavior as any responses—explicitly conditioned by a verbal community—that are occasioned by verbal stimuli produced by a speaker. For example, when a parent (speaker) says “Go clean your room” and the child (listener) does so, the child's behavior is controlled by the parent's request due to the behavioral history provided by a verbal community. More recently, Schlinger (2008) suggested that an adequate conceptualization of listener behavior includes subvocal verbal behavior. Reconsidering the example above, Schlinger suggests that only when the child engages in echoic (“Go clean your room”) or intraverbal (“I think my bed isn't made”) responses will the parent's request occasions effective listener behavior.

private events and provide an opportunity for members of the verbal community to occasion and reinforce tacts of private events. That is, one might teach a child to report private events by arranging contingencies of reinforcement based on the occurrence of public predictors of private stimulation. For example, the correspondence between painful stimulation in the stomach (non-verbal private stimulus) and a pale face (public event) provides a stimulus that occasions a parent's response, "It looks like your stomach hurts," and the child labeling the painful stimulation, "My stomach hurts" that is reinforced by the parent's attention or approval, "I bet it does. Maybe you should lie down." Skinner's interpretation suggests that public accompaniments are one way the verbal community might generate verbal behavior with respect to private events, an interpretation that appeals for empirical support.

In this study, we developed an experimental analogue to study variables influencing tacting of private events. The participant had exclusive access to one set of stimuli (the private stimuli), and the experimenter attempted to teach tacts for private stimuli based on their correspondence with public stimuli accessible to both the experimenter and participant. In experiment 1, we investigated the influence of varying degrees of public-private correspondence and contingencies of reinforcement. In experiment 2, we evaluated the possible role of audience control over verbal behavior about private events. In experiment 3, we investigated how complex public-private relations might lead to private events exerting control of tacting repertoires. All three studies were aimed at putting some "empirical meat on the interpretive bones" (Palmer 2011, p. 203) of Skinner's account of language regarding private events (Skinner 1945, 1957). That is, we sought to further understand the conditions that might bring tacts under the control of private events and to identify variables that distort reports of such events.

General Method

Participants and Setting

Participants were undergraduate students. Experimenters recruited the participants by visiting university classes and offering the opportunity for voluntary

participation. The participants exchanged the total points received in sessions for gift cards upon the completion of participation. For P-1, the exchange rate was \$5 in gift card value for every 50 points received. The costs of this exchange rate were too high to be maintained for multiple participants, so the exchange rate was changed to \$5 value for every 100 points received for all subsequent participants. All sessions were conducted in a research room equipped with a table, two chairs, and a one-way mirror. A camcorder behind the one-way mirror was positioned to record the private stimuli, which were inaccessible to the experimenter during sessions.

Materials and Stimuli

Materials included a sheet of paper that listed all possible nonsense syllables for a given session and two separate decks of 30 cards that were 2.3 in.×3.4 in. The print on all cards was in grayscale.

Private Events A symbol was printed on one side of each card. Wingdings™ symbols were used to minimize the potential effects of participant history. Three different symbols were included in each deck of cards, and each symbol was printed on ten cards. These symbols were considered analogous to private events because they were observed only by the participants in sessions.

Public Accompaniments An image was printed on the reverse side of the card from the symbol. These images were considered analogous to public accompaniments because they were visible to the participant and experimenter during sessions. We used pictures as public accompaniments, rather than simpler stimuli (e.g., color), to decrease the likelihood that participant behavior would come under control of the public accompaniment. In experiments 1 and 2, images of two different paintings were used for each deck of cards: Monet's Water Lilies for the strong deck and van Gogh's Wheat Field Under Threatening Skies for the weak deck (see below for descriptions of strong and weak) (Monet 1906; van Gogh 1890). The images were cut into three panels (i.e., left, middle, and right panel), creating three separate public accompaniments from each painting. To minimize the potential effects of participant history with public accompaniments in experiment 3, we used

Table 1 Arbitrary symbol-syllable relations and the degree of correspondence between symbols and painting panels used in experiment 1

Private Stimuli	Monet Painting (Strong)			Van Gogh Painting (Weak)		
	Left	Middle	Right	Left	Middle	Right
Stimulus A	80% - CUG	10% - CUG	10% - CUG	40% - BEH	30% - BEH	30% - BEH
Stimulus B	10% - ZID	80% - ZID	10% - ZID	30% - FUA	40% - FUA	30% - FUA
Stimulus C	10% - PAF	10% - PAF	80% - PAF	30% - VEK	30% - VEK	40% - VEK

images of current and former players for a professional baseball team that were not likely to be recognized by participants (i.e., the team was from a different geographic region). Experimenters selected images of players that were as similar as possible (e.g., all players facing the camera and wearing a team hat). Additionally, experimenters cropped all images so all players were shown from the shoulders up. Across all studies, three private symbols and three public stimuli were used to

create nine symbol-image combinations per deck of cards (see Tables 1, 2, and 3).

Nonsense Syllables Each symbol was assigned a designated nonsense syllable prior to the start of sessions. The nonsense syllable was the tact of the private event. The experimenters selected syllables used in previous literature with arbitrary syllable-symbol relations (McIlvane et al. 1987). The participants were presented with a sheet

Table 2 Arbitrary symbol-syllable relations and the degree of correspondence between symbols and painting panels used in experiment 2

Private Stimuli	Varied Deck			Constant Deck		
	Left	Middle	Right	Left	Middle	Right
Stimulus A	80% - KEZ	10% - KEZ	10% - KEZ	80% - WEF	10% - WEF	10% - WEF
Experimenter 1	KEZ	KEZ	KEZ			
Experimenter 2	SUY	SUY	SUY			
Stimulus B	10% - SUY	80% - SUY	10% - SUY	10% - GAW	80% - GAW	10% - GAW
Experimenter 1	SUY	SUY	SUY			
Experimenter 2	NEY	NEY	NEY			
Stimulus C	10% - NEY	10% - NEY	80% - NEY	10% - CLO	10% - CLO	80% - CLO
Experimenter 1	NEY	NEY	NEY			
Experimenter 2	KEZ	KEZ	KEZ			

Table 3 Simple and complex arbitrary symbol-syllable relations and degree of correspondence between symbols and pictures of baseball players used in strong deck sessions for experiment 3

Private Stimuli	Simple Set			Complex Set		
	Player A	Player B	Player C	Catchers	First Basemen	Center Fielders
Stimulus A	80% - CUG	10% - CUG	10% - CUG	80% - CUG	10% - CUG	10% - CUG
Stimulus B	10% - ZID	80% - ZID	10% - ZID	10% - ZID	80% - ZID	10% - ZID
Stimulus C	10% - PAF	10% - PAF	80% - PAF	10% - PAF	10% - PAF	80% - PAF

of paper at the start of each session that listed the nonsense syllables used within that session (e.g., a sheet with “CUG,” “ZID,” and “PAF” printed on it). A sample of preassigned syllable-symbol pairings for all three experiments can be seen in Tables 1, 2, and 3 (e.g., = CUG).

Data Collection, Interobserver Agreement, and Procedural Integrity

The experimenter used pen and paper to record the public accompaniment present and nonsense syllable spoken by the participant on each trial during sessions. Experimenters referred to video recordings after each session to record the private symbol present for each trial. Experimenters recorded the number of trials on which each verbal response, public accompaniment, and private event occurred; the percentage of trials with accurate tacting of private symbols was calculated. An independent observer recorded data for a minimum of 20 % of sessions for all participants. An agreement occurred when the same verbal response (e.g., CUG), public accompaniment (e.g., left painting panel), or private event (e.g.,) was scored by both the experimenter and independent observer on a single trial. A disagreement occurred when the verbal response, public accompaniment, or private event scored by the experimenter differed from that of the independent observer on a single trial. For example, if the experimenter scored

the verbal response “CUG on one trial, but the independent observer scored FUA” on the same trial, then that would count as a disagreement. Interobserver agreement was calculated by dividing the number of agreements by the number of trials and converting to a percentage. Mean agreement was 98 % or higher for all participants (range, 96 to 100 %).

We also collected data on procedural integrity for a minimum of 20 % of sessions for all independent variables (e.g., strong and weak correspondence). We scored correct implementation when the experimenter delivered the appropriate consequence on a given trial. Experimenters delivered consequences with at least 99 % accuracy in each session.

Procedures

Before the start of sessions, the experimenter explained to the participants that they would be taught to label symbols printed on cards. The participants were shown the lists of nonsense syllables, and the experimenter explained that each syllable corresponded with a symbol that would be presented (e.g., “In this deck of cards, you will see three symbols. They are “CUG, ZID, and PAF”). It was explained that the experimenter would slide cards symbol side down to the participant, and the symbols were only to be seen by the participants. The participants were instructed to never show the printed

symbol to the experimenter. No participants revealed any printed symbols to the experimenter during sessions. The participants were told that the experimenter would deliver points exchangeable for gift cards at local stores. Experimenters never told the participants how they could earn points across the study.

A session consisted of 30 trials that included ten presentations of each symbol of a given deck. Before presenting the first card, the experimenter shuffled each deck of cards and presented the participant with the list of nonsense syllables that they could say during that session. The experimenter then removed the card at the top of the deck and slid it across the table to the participant. If the participant did not pick up the card within 3–5 s on the first trial, the experimenter told the participant to pick up the card and look at the symbol, without revealing it to the experimenter, and to say one of the syllables listed on the sheet of paper in front of them. After the participant said one of the nonsense syllables, the experimenter either delivered a point or delivered no programmed consequence. The experimenter tallied marks on a sheet of paper in front of the participant when points were delivered and said “Point” when a point was delivered. Point delivery contingencies were manipulated across conditions as described below. For three of five participants (P-2, P-7, and P-8) in experiment 1, we included a point removal contingency because performance was highly variable for the first 11–17 sessions. When a point removal contingency was included, the experimenter also tallied points lost and said “Point lost” when a point was lost. Points gained and points lost were tallied in two separate columns, and total points gained/lost were calculated at the end of the session. Once the experimenter delivered the appropriate consequence, the participants were instructed to put the card down symbol side down and put it off to the side. The experimenter then presented the next card from the deck and repeated this process until all 30 cards were presented.

Experiment 1

Experiment 1 investigated the influence of different contingencies of reinforcement across sessions involving strong and weak public-private correspondence (i.e., decks of cards). Manipulations in experiment 1 were inspired by two sources. First, Skinner (1945) suggested that “In a description of one’s own behavior, the private

component may be much less important. A very strict external contingency may emphasize the public component, especially if the association with private events is faulty” (p. 423). That is, differential reinforcement based on public accompaniments may result in discriminative stimuli occasioning verbal responses that do not correspond with a private event. Skinner suggests that this is especially likely if there is a weak relation between the public accompaniment and private event. In some cases, public accompaniments can be good predictors of sensations or feelings; other times, they can be bad predictors. For example, imagine a boy who experiences headaches and allergies (i.e., private events). A pale face (public accompaniment) is sometimes paired with a headache, but it is not a good predictor of headaches. Allergies, on the other hand, might be reliably predicted by the presence of red eyes (public accompaniment). The degree of public-private correspondence in the weak deck was analogous to the headache example, and the strong deck represents the allergy example. Therefore, we were interested in differences in performance when private events were accompanied by a strongly correlated public accompaniment (i.e., a good predictor of a given private event) or a weakly correlated public accompaniment (i.e., a poor predictor of a given private event). Second, de Freitas Ribeiro (1989) demonstrated the influence of reinforcement on the correspondence between children’s verbal and nonverbal behavior. Correspondence was measured as children’s accurate reports of engagement with toys during a play time. Higher levels of correspondence were observed when reinforcement was provided for correspondence, and increased noncorrespondence was observed when contingencies of reinforcement were placed on the occurrence of a particular verbal report, irrespective of correspondence. Therefore, we compared performance when reinforcement was based on a strongly correlated public accompaniment to that of reinforcement based on the form of the participant’s response. This is analogous to a parent who reinforces reports of private events (a) only when there is a public predictor of the reported private event or (b) simply trusts the child’s word without looking for any public predictors. Using the headache example described above, the boy might approach his mom before school and tell his mom “My head hurts.” In some cases, mom might (a) only allow him to stay home from school if there is a public predictor, like a pale face. At other times, mom might (b) allow the child to stay home from school given a report of a

headache, regardless of the presence of any public predictors.

Method

Participants

Participants were seven undergraduate students (four females and three males) between the ages of 18 and 21. The total number of sessions ranged from 24 to 50 per participant ($M=38.4$). The participants received a mean of \$26 (range, \$10–\$45) for points earned during the study. The participants had no experimental history with our analogue arrangement.

Procedures

We alternated between strong and weak public-private correspondence sessions. A different deck of cards consisting of a distinct painting and trio of symbols were used in strong and weak sessions. The decks of cards also differed in their degree of public-private correspondence (see Table 1).

Public-Private Correspondence In the strong deck, each symbol correlated with a specific painting panel in eight out of the ten cards in which it appeared. The remaining two cards were paired with the other two painting panels once. The weak deck also contained symbols that each corresponded more highly with a particular painting panel; however, the degree of correspondence was weaker. Each symbol was correlated with a specific painting panel in four out of the ten cards in which it appeared. The remaining six cards were divided across the other two painting panels. We chose these degrees of correspondence because (a) it is unlikely that all public-private relations are perfectly correlated, and (b) the strength of those relations is likely to vary. The order of strong and weak sessions was predetermined by coin flip.

Public-Accompaniment-Based Reinforcement The experimenter delivered a point following the verbal report of a private symbol highly correlated (strong deck = 80 %, weak deck = 40 %) with the public image presented on a given trial. For example, a point was awarded if a participant reported CUG in the presence of the left panel of the Monet painting (i.e., the highly correlated public accompaniment for the predetermined

CUG symbol in the strong deck). If the participant reported CUG in the presence of the middle or right panel of the Monet painting, a point was not awarded; if point removal was in place, then a point was removed. Through these arrangements, experimenters taught the participants to report private events (i.e., symbols) based on a highly correlated public event (i.e., image).

Form-Based Reinforcement Points were delivered based on the participants' verbal report regardless of the public image or private symbol present. To ensure the opportunity to demonstrate an effect, experimenters decided the verbal report for which points would be awarded within sessions before the start of this condition by visually analyzing the level, trend, and variability of the data paths. During sessions, points were awarded only for the verbal report selected by experimenters before the start of the condition. For example, experimenters selected ZID (strong deck) and FUA (weak deck) for P-3. If P-3 said ZID during strong deck sessions, or FUA during weak deck sessions, irrespective of the public image, or private symbol present, a point was delivered. If P-3 said any other nonsense syllable during this condition, a point was not awarded; for some participants, a point was removed.

Results and Discussion

Figure 1 shows session-by-session data for a participant whose performance represents our main findings. This graph illustrates verbal reports across sessions. The left panel represents performance during strong correspondence sessions, and the right panel shows weak correspondence sessions. Each bar depicts the number of verbal reports for a given syllable during a particular session. For example, in our first strong correspondence session (left panel) for P-3, there were 9 reports of CUG, 12 ZID, and 9 PAF. The shaded portion of the bar represents incorrect reports; the open portion shows correct reports. As a reminder, correctness was determined by preassigned symbol-syllable pairings. When a larger portion of the bar is shaded, that indicates that the majority of reports were incorrect. By comparing the proportion of correct and incorrect responses depicted in the left (strong correspondence) and right panels (weak correspondence) of this figure, we can evaluate the influence of degree of public-private correspondence. Accurate tacting of private symbols was most likely when reinforcement was based on a more highly

Fig. 1 Frequency of verbal reports per nonsense-syllable across experiment 1 sessions for P-1. The *left panel* shows reports during the strong deck and the *right panel* for the weak deck. Correct

verbal reports (i.e., preassigned nonsense-syllable and private symbol pairs) are depicted in *solid white bars*. Incorrect verbal reports are depicted in *solid black bars*

correlated public accompaniment. The private symbols exerted less control over participant reports in form-based reinforcement sessions. When reinforcers were provided contingent on form alone (e.g., parents trust the child's report of illness without looking for public predictors of illness), we observed increases in P-3's reports of targeted syllables (i.e., ZID and FUA). The increase in targeted verbal reports demonstrated tacting that Skinner described as "distorted" (Skinner 1957, p. 149–150) or tacting that becomes mand-like. For example, a child might inaccurately report feeling ill because it has resulted in staying home from school in the past. The degree of distortion was not influenced by the degree of public-private correspondence. In other

words, if a parent allows the child to stay home from school, without checking for any public indicators of illness (e.g., a temperature), then it is likely that the child's inaccurate reports of illness will increase, regardless of the history of accurate private control.

Data for participants 4 and 5 were excluded from analysis for two reasons. Data for P-4 indicated behavioral insensitivity to our experimental manipulations across 28 sessions. In a postexperimental interview, she said "I named the symbols a particular nonsense syllable by associating which symbol most likely resembled the nonsense syllable," which indicated instructional control that was insensitive to contingencies (Galizio 1979; Hackenberg and Joker 1994). P-5 completed six

Fig. 2 Summary graphs for experiment 1 that show the percentage of correct reports during strong and weak correspondence sessions when reinforcement was based on a highly correlated public accompaniment or the form of the response. Percentage of correct reports was calculated from the final two sessions of each

phase per condition. Performance during strong correspondence sessions are depicted in the *filled bars*, and weak correspondence sessions are in *open bars*. Data for P-7 are not included because reports were controlled by public image

sessions before he was excluded from this study because his hand was blocking the private symbol during those sessions, preventing data analysis. During those sessions, however, it became apparent that his verbal reports were controlled by the public accompaniments (i.e., panels of paintings) and not by the private symbols. On one trial, P-5 provided a verbal report without picking up the card and looking at the private symbol. P-3 also gave similar verbal reports in his final session (i.e., session 24, weak correspondence), and he told the experimenter that he figured out that points were based on painting panels. Because these participants' responses seemed to be controlled by public accompaniments, we investigated some conditions under which public control of reports might be more likely and both P-3 and P-5 participated in that arrangement (see "Experiment 3").

Figure 2 summarizes our main findings from experiment 1. Summary graphs include aggregated data from the final two sessions of each phase per condition. For example, the solid bars depicting P-3's performance from strong correspondence sessions included data from sessions 11, 13, 21, and 23 (PA-based) or sessions 15 and 17 (Form Based). There are more sessions included

in the PA-based sessions because of the reversal design. These results suggest that accurate reports of private events are most likely when reinforcement is based on a highly correlated public accompaniment. Future studies should continue to investigate the conditions under which tacting private events is more or less distorted.

Experiment 2

The results of experiment 1 suggested the possibility of private events acquiring stimulus control of tacting. Across manipulations of contingencies and public-private correspondence, participant verbal reports came under the control of symbols accessible only to the participants. However, it is likely that most verbal behavior is multiply controlled (see Michael et al. 2011, for a recent discussion). Skinner (1957) proposed the likely influence of audience members on verbal behavior. That is, the presence of particular people might modify the control of other variables and alter one's verbal responses. Consider a situation where a child is experiencing a headache. During the morning hours of a school day,

the child might be asked by either parent how he is feeling. Perhaps mom has allowed the child to stay home from school when he reported having a headache in the past. Dad, on the other hand, might not think a headache is a good enough reason to stay home from school, so he has allowed his son to stay home only when he reports feeling queasy. As a result, on days in which the child is experiencing the private stimulation related to a headache, he might report a headache to mom, but report queasiness to dad. Experiment 2 was conducted to investigate potential audience control of tacts of private events.

Method

Participants

Participants were three female undergraduate students between the ages of 18 and 19 years old who had no experimental history with our analogue arrangement. The total number of session blocks ranged from 6 to 9 per participant ($M=8$). The participants received a mean of \$28.33 (range, \$25–\$35) for the points accumulated during the study.

Procedures

Sessions were arranged similarly to those in experiment 1. However, two experimenters presented cards and delivered points in separate, alternating sessions. Two decks of cards were used, and both decks arranged strong private-public correspondence (80 %). One block of sessions consisted of one varied and one constant deck session (see below for descriptions) with each of the two experimenters for a total of four sessions per block. For example, block 1 for P-10 consisted of sessions in the following order: (1) varied reinforcement with experimenter 1, (2) constant reinforcement with experimenter 1, (3) constant reinforcement with experimenter 2, and (4) varied reinforcement with experimenter 2. We compared performances across decks of cards and across experimenters to assess audience control.

Constant Reinforcement Schedule Across Audience Members The preassigned highly correlated public accompaniments for which points were delivered were identical across experimenters for this deck of cards. For example, both experimenters delivered points for the participants reporting “WEF” when the left panel of the Monet painting was present (see Table 2). Therefore, it was expected that participant verbal reports would be

similar for this deck of cards across the two experimenters.

Varied Reinforcement Schedule Across Audience Members The point delivery contingencies based on public accompaniments varied across experimenters. That is, the private-public relations were the same across experimenters, but each public accompaniment signaled different point delivery contingencies for experimenters. For example, one experimenter delivered points for reporting “KEZ” when the left panel of the van Gogh painting was present; the second experimenter delivered points for saying “SUY” when the same panel was present (see Table 2). It was expected that participant verbal reports would conform to the different reinforcement contingencies operating in the presence of each experimenter. That is, the same private symbol would come to control different verbal reports in the presence of each of the two experimenters.

Data Analysis (Difference in Reports)

To assess audience control, we calculated the difference in reports by taking the absolute value of the difference between the dominant report for each symbol in sessions with experimenter 1 and the number of those same reports given the same symbol in sessions with experimenter 2. For example, if a participant reported “KEZ” eight times in the presence of the)(symbol with experimenter 1, but only twice with experimenter 2, then we would get a difference score of 6. After we completed this calculation for all symbols in a given deck, we summed the difference scores. A score of 30 represents performance that is completely different across experimenters; a score of 0 represents performance that is the same.

Results and Discussion

Figure 3 illustrates the main findings from experiment 2; these graphs illustrate the difference in reports of private events across blocks of sessions. By comparing the difference in reports across data paths, we can see that all participant reports came under audience control in the varied deck, and reports in the constant deck remained more similar across experimenters. That is, separation between data paths suggests differences in performance when reinforcement varied or was constant across audience members. Data points closer to 30 in the

Fig. 3 Differences in participant reports when reinforcement practices were constant or varied across experimenters. A score of 30 represents performance that is completely different across experimenters; a score of 0 represents performance that is the same. One block of sessions consisted of one varied and one constant deck session (see below for descriptions) with each of the two experimenters for a total of four sessions per block

varied deck session suggest that participant performance fluctuated due to the presence of a given audience member, and those closer to 0 in the constant deck session suggest that performance was similar across experimenters. Data analysis revealed that reports for P-6 and P-10 were controlled by public images whereas

P-9's results demonstrate audience control of reports controlled by private events.

Given that participant reports differed across experimenters, we might extrapolate that consistent reports are less likely when reinforcement practices vary across members of the verbal community. If parents teach completely different verbal reports in the presence of the same public accompaniment, then children might report different sensations or feelings across parents. For example, consider a child who experiences allergies (private), which is reliably accompanied by redness in the eyes (public). If mom reinforces "I have allergies" when the child's eyes are red, but dad reinforces "I feel sleepy," then the presence of an itchy sensation in his eyes might come to control different reports across parents. The child's report to mom would be accurate, but it would be inaccurate to dad. In this case, accuracy is important because inaccurate reports inhibit effective action on the part of the parent. Because mom and dad do not have direct access to the child's sensations and feelings, it is also possible that reports are inaccurate across both parents. Furthermore, audience control might simply contribute to subtle differences in the form of the response. For example, because of differences in reinforcement practices, the child might say "I have allergies" to mom, but say "I have itchy eyes" to dad. These data lend empirical support to Skinner's (1957) interpretation of verbal behavior controlled by audience, but more research is needed to better understand the nuances of audience control. Skinner suggested that "Multiple audiences which control different responses or the same response in different ways produce more interesting effects" (Skinner 1957, p. 230). Though the participants experienced different histories with experimenters during varied deck sessions, we never tested participant performance in the presence of both experimenters at the same time. Future studies might evaluate the effect of multiple audiences by giving the participants different experimental histories with two separate audience members and then measuring performance in the presence of both audience members. That is, the presence of two or more audience members that simultaneously strengthen and weaken different reports of private events might produce interesting results, like increases in latency to responding or novel combinations of responses (e.g., "I have sleepy, itchy eyes"). We encourage

researchers to investigate this and other nuances of audience control in future studies.

Experiment 3

Because some participants' reports (experiments 1 and 2) were controlled exclusively by public accompaniments, we investigated the conditions that produce control by private versus public stimuli. Public events may control tacting more readily when the public-private arrangement is fairly simple. For example, in experiments 1 and 2, each private event was highly correlated with only one public accompaniment. In experiment 3, we manipulated the complexity of the public-private arrangement to explore some conditions under which tacting might be controlled by public versus private stimuli.

Let us consider the analogous situation of a man experiencing high blood pressure.³ If his family members teach him that he has high blood pressure only in the presence of a highly correlated public accompaniment—driving in heavy traffic—then it is likely that a report of “My blood pressure is through the roof!” would be exclusively controlled by the public accompaniments of bad traffic. This might be described as a *simple* public accompaniment. In another scenario, his parents might be doctors who have a unique history of identifying signs of high blood pressure. Due to their unique history, his parents might teach him to report high blood pressure in the presence of a variety of public accompaniments that are established as a stimulus class for their behavior, but not for their son's behavior. Under these conditions, the man's reports of high blood pressure might be more likely to be under private control. A third scenario might occur in a doctor's office. The man might experience high blood pressure in the absence of any discernible public accompaniments. Nurses and doctors, however, use instruments, like a sphygmomanometer, that produce public predictors of the man's private sensations related to high blood pressure (i.e., the digital blood pressure reading displayed on an electronic sphygmomanometer). The man might learn to tact high blood pressure because corresponding reports are reinforced by nurses and doctors who have access to public predictors not seen by the patient. We were interested in the conditions that produced public versus private control of reports of private events.

Method

Participants

Participants were three undergraduate students (one female and two males) between the ages of 17 and 20 years old. The total number of session blocks ranged from 34 to 38 per participant ($M=36.3$). The participants received a mean of \$33.33 (range, \$30–\$40) for their participation in this experiment. Two participants had experience with the analogue arrangement from experiment 1. P-3 experienced all experiment 1 manipulations and completed 38 sessions. P-5 experienced public-accompaniment-based reinforcement and completed six sessions. As a reminder, these two participants were included in experiment 3 because of performance during experiment 1 sessions. P-3's performance during his final session of experiment 1 suggested that verbal responses were under public control for that session, and he told an experimenter that he knew that points were based on public images. P-5's responses also appeared to be controlled by public images. On one trial, P-5 gave a report without picking up the card and looking at the private symbol. Because performance suggested public control, we thought that these two participants were appropriate candidates to investigate variables that might shift control from public to private stimuli.

Procedures

Sessions were arranged similarly to experiment 1. Reinforcement across all conditions was based on highly correlated public accompaniments, which were changed from paintings to images of baseball players. For example, when the image of player A was present during a strong deck session, a point was delivered if the participant reported CUG. We used images of baseball players as public accompaniments to facilitate the stimulus complexity manipulation. That is, we chose public accompaniments that were already established as a stimulus class for the experimenter but that were not for the participant.

Symbols (private stimuli) and syllables were the same as those in experiment 1 with the exception of those used for one participant. P-3 had a history with the syllables and symbols used in experiment 1, so we created a new set of materials for P-3's sessions to minimize history effects.

³ We thank David Palmer for suggesting this example.

Simple Public Accompaniment Each symbol was highly correlated with one image of a particular baseball player. In the strong deck, eight out of the ten cards with stimulus “ŷ” printed on the symbol side of the card had player A printed on the image side of the card. The other two stimulus A cards consisted of one card with player B and one with player C on the image side of the card. In the weak deck, four out of the ten cards with stimulus “ŷ” printed on the symbol side of the card had player D on the image side of the card. The other six cards were split across players E and F. Therefore, arranged reinforcement varied from trial to trial based on which image of a baseball player was present. We considered this a simple arrangement of public-private correspondence because each private symbol had only one highly correlated public accompaniment (see Table 3). This was the same arrangement we used in experiment 1. We anticipated that verbal reports would likely come to be controlled by public accompaniments (i.e., images of baseball players).

Complex Public Accompaniment Experimenters identified images of ten baseball players for each of six different fielding positions for a total of 60 images of baseball players. All images were of current or former members of the same baseball team. Three baseball positions were preassigned to the strong (catchers, first basemen, and center fielders) and weak (pitchers, second basemen, and right fielders) decks of cards. Each symbol was highly correlated with images of players who played a particular fielding position. For example, in the strong deck, eight out of ten cards with stimulus “ŷ” printed on the symbol side of the card had images of eight different catchers printed on the image side of the card. Arranged reinforcement varied from trial to trial based on which fielding position was played by the depicted player present on the card. This condition was considered complex because a private symbol was not presented with the same public accompaniment more than once within a session (see Table 3). Additionally, the stimulus class (baseball position) that controlled the experimenter’s point delivery was unlikely to control participant behavior because of a lack of relevant history. Experimenters expected that stimulus control of participant verbal reports might shift from public control (i.e., images of players) to private control (i.e., symbols).

Hidden Public Accompaniment This condition was included when data suggested that a participant’s verbal

reports were partly still under the control of public accompaniments during complex public accompaniment sessions. After each deck was shuffled, the experimenter placed each deck of cards on the floor, out of the participant’s sight. At the start of each trial, the experimenter looked at the image of a player and then covered it using a piece of cardboard that was slightly larger than the cards so that the previously public stimulus was inaccessible to the participant. The experimenter held up the card so the private symbol was viewable by the participant, but not by the experimenter. This condition was included only for P-5.

Data analysis

Data collection methods were the same as experiment 1. We calculated one additional dependent measure in experiment 3. To determine the control by public accompaniment, we calculated the percentage of verbal reports that occurred in the presence of the preassigned public accompaniment for which reinforcement was arranged. For example, there were ten trials when player B was presented and reinforcement was arranged for a participant reporting ZID. If a participant reported ZID on eight of those trials, then that performance would be reported as 80 %.

Results and Discussion

Figure 4 shows session-by-session data that represent our main findings from experiment 3. Lines plotted on the secondary y-axis illustrate control by public accompaniment during sessions. As a reminder, if reports were reliably controlled by private symbols, we would not expect data points exceeding 80 % in strong correspondence sessions and 40 % in weak correspondence sessions. Data points at 100 % illustrate that all reports of a given syllable occurred in the presence of the correlated public accompaniment for which reinforcement was arranged for that syllable. For example, the final three data points of the first simple phase indicate that all reports of CUG occurred in the presence of the picture of player A (i.e., the CUG accompaniment), irrespective of the symbol present. Percentages of verbal reports in the presence of highly correlated public accompaniments were at, or near, 100 % for at least two sessions of the simple condition before switching to the complex condition. An immediate drop in percentage of verbal reports was captured when the public stimuli changed

Fig. 4 Frequency of verbal reports per nonsense-syllable across experiment 3 sessions for P-11 is plotted on the primary axis. The *left panel* shows reports during the strong deck and the *right panel* for the weak deck. Correct verbal reports (i.e., preassigned nonsense-syllable and private symbol pairs) are depicted in *solid white*

bars. Incorrect verbal reports are depicted in *solid black bars*. Lines are plotted on the secondary axis. *Lines* depict the percentage of verbal reports for each nonsense syllable in the presence of the preassigned highly correlated public accompaniment (i.e., saying CUG in the presence of the CUG accompaniment)

from simple to complex. Control shifted from public to private for two participants when private events were paired with complex public accompaniments. When reports were under private control, we observed that accurate reports were more likely when reinforcement was based on a highly correlated public accompaniment (i.e., strong public-private correspondence), which replicates our findings from experiment 1. These data indicate that public control is less likely when public-private relations are complex. These findings were replicated with P-3.

Data for P-5 (see Fig. 5) indicated that verbal reports came under the control of private symbols

only when the public accompaniments were hidden from the participant. When we switched from simple to complex public accompaniments, it appeared that the participant continued to search for patterns or common characteristics present in the images of baseball players used in the complex public accompaniment sessions. After the experimenter slid each card to P-5, he would look at each player's image for an extended time. Increasing trends in line plots during complex public accompaniment sessions support the interpretation that behavior was still partly under the control of the public accompaniment. Additionally, the inconsistency in correct/incorrect reports depicted

Fig. 5 Frequency of verbal reports per nonsense-syllable across experiment 3 sessions for P-5 is plotted on the primary axis. The *left panel* shows reports during the strong deck and the *right panel* for the weak deck. Correct verbal reports (i.e., preassigned nonsense-syllable and private symbol pairs) are depicted in *solid white*

bars. Incorrect verbal reports are depicted in *solid black bars*. Lines are plotted on the secondary axis. *Lines* depict the percentage of verbal reports for each nonsense syllable in the presence of the preassigned highly correlated public accompaniment (i.e., saying CUG in the presence of the CUG accompaniment)

in stacked bars suggests that the symbols (private stimuli) were not reliably controlling reports. Taken together, these patterns suggest the participant was still attending to the public accompaniment. A drop in percentage of verbal reports was captured when the public stimuli changed from simple to hidden. High levels of reports controlled by public accompaniments were recovered upon returning to the simple condition. No reliable differences in correct reports were observed between simple and complex public accompaniment arrangements. However, reports became more variable during the complex public accompaniment arrangement. The participant's recent

history of reinforcement for responding with respect to public accompaniments (i.e., participation in experiment 1) might have contributed to the failure to transfer control from the public to private stimulus in the complex public accompaniment sessions. That is, given a recent history of reinforcement for attending to the public accompaniments, one is likely to continue to attend to the stimulus features with a more recent history of reinforcement (see Catania 2007, for a discussion of attending as an operant). P-5's data indicate that attempts to bring tacting under the control of private stimuli might result in control by the public accompaniment.

Fig. 6 Summary graphs for experiment 3 that show the percentage of reports that occurred in the presence of preassigned public images or private symbols (e.g., CUG reports that corresponded with presentation of player A or γ_D on a trial). Percentage of correct reports was calculated from the final two sessions of each

phase per condition. The *left panel* represents performance during strong public-private correspondence sessions; weak correspondence sessions are on the *right panel*. P-5 is the only participant who experienced the hidden public accompaniment phase

Figure 6 summarizes our findings from experiment 3. For all participants, public control was most likely when stimuli included simple public accompaniments. Like summary graphs from experiment 1, data are aggregated from the final two sessions of each phase per condition. Shaded bars represent the percentage of reports that occurred in the presence of the preassigned public image (e.g., CUG in the presence of the CUG accompaniment); open bars depict reports that occurred in the presence of the preassigned private symbol (e.g., CUG in the presence of γ_D). Because the shaded bars are consistently the highest during simple public accompaniment sessions, these data suggest that public control is most likely when reinforcement is based on a highly correlated, simple

public accompaniment. The open bars in Fig. 6 illustrate that consistent and accurate private control is most likely to develop when reinforcement is based on a highly correlated, complex public accompaniment. Future studies should continue to investigate the conditions under which reports of private events are controlled by public accompaniments.

General Discussion

We used an analogue arrangement to investigate the conditions under which reports of private events are more or less accurate. In this set of experiments, accuracy was defined as a preassigned syllable-symbol

relation. Accurate reports of private stimuli were most likely when (a) consequence delivery was based on public accompaniments that were (b) highly correlated with a given private event and when consequence delivery was (c) consistently controlled by the same highly correlated public accompaniment across members of the verbal community (e.g., two parents). When reports came under control of public stimuli, control was shifted to private stimuli by increasing the complexity of the public-private arrangement. These data provide empirical support for Skinner's (1945, 1957) interpretation of how the public accompaniments of private events play a role in the development of language about those private events.

In some cases, participants' reports were controlled by public accompaniments. The cards in our experiments were compound stimuli, each composed of several properties (e.g., symbols and images). Reynolds (1961) demonstrated that when pigeons were presented with a compound stimulus, the property of the stimulus that acquired discriminative control varied across organisms. Two pigeons were taught to peck in the presence of a red triangle. When stimulus properties were presented separately, Reynolds observed that the color acquired discriminative control for one pigeon's responding and the shape-controlled pecking for the other pigeon. Like Reynolds, we observed individual differences in the stimulus properties (i.e., public images or private symbols) that controlled participant responding. Public control, however, was less likely when public stimuli were more complex and the experimenter had a unique behavioral history with respect to those stimuli that the learner did not (experiment 3).

Under some conditions, control by public accompaniments might be desirable. For example, the private sensations related to allergies might be very similar to those of a cold. Searching for public accompaniments that typically correspond with a given private sensation (e.g., red puffy eyes might typically correspond with allergies) might increase the likelihood of effective action. It is equally likely that, like most verbal behavior, many reports of private events are multiply controlled by several variables that are both private and public (see Michael et al. 2011, for a discussion on the role of multiple control in verbal behavior). Future research should investigate variables that contribute to shifts in attention and explore the conditions under which control by public accompaniment is desirable. Additionally, because attending to the public images resulted in a

higher rate of reinforcement, public images might become a more salient property of the cards. Dinsmoor et al. (1972) demonstrated that observing responses will be maintained only when they produce discriminative stimuli. That is, observing responses will not be maintained when they produce stimuli that signal the absence of reinforcement (i.e., S^{Δ} s). When two stimuli are correlated with different schedules of reinforcement, it makes sense that the stimulus correlated with a richer rate of reinforcement might control observational responses. Future research on shifts in stimulus control might compare rates of observational responses across stimuli correlated with different schedules of reinforcement.

These results might also inform practical advice for parents teaching their children to talk about private sensations or feelings. For example, when a child reports feeling queasy, parents should consider identifying a highly correlated public accompaniment, or several, to inform their consequence delivery. If there are other signs or symptoms of illness, such as high body temperature, then a parent might respond by allowing the child to stay home from school and by giving the child the proper medication and food. This example demonstrates the practical implications of these findings for arranging conditions that foster honest reports of sensations and feelings. From a behavior analytic perspective, honesty is the correspondence between doing and saying (see Lloyd 2002, for a review of the correspondence literature). Because observing or attending is operant behavior (e.g., Dinsmoor et al. 1972), we are indeed *doing* something when we experience private sensations or feelings, which might correspond with what we say about those private events. For example, it is considered "honest" when a child is experiencing a stomachache and reports "My stomach hurts" (i.e., correspondence). In contrast, if the same child *is not* experiencing a stomachache, but still reports "My stomach hurts," then it is considered dishonest (i.e., noncorrespondence). Our results might provide direction for researchers evaluating interventions to promote honesty. For example, a preschool curriculum focused on promoting honesty might incorporate the arrangement of consequences based on highly correlated public events. To promote honesty, researchers might arrange evocative situations, similar to Hanley et al. (2007), like requiring children to brush their teeth before reading a book. Consequence delivery for reports of tooth brushing could be based on highly correlated public events (e.g., wet bristles and sink); perhaps the child is allowed to choose the book if

his/her report corresponds with the public events or a low preference book is chosen for them if there is a discrepancy in their report and the public events. For data collection purposes, a camera could be placed near the sink to record if a boy brushed his teeth. The practical applications of these data are likely but are yet to be studied.

It should be noted that statements regarding these data should be limited to verbal behavior regarding private events that are not verified by members of the verbal community. That is, the experimenter did not have access to the private stimulus at the time of teaching. Reporting stimulation referred to as “feeling queasy” might never be verified by a public event (e.g., vomiting). A report of a fever, on the other hand, is readily verifiable with the use of a thermometer. The verifiability of a private event might affect the accuracy of verbal reports of private stimulation. It is plausible that verifiable private events might lead to more accurate reports of private stimulation, as in the case of the fever. When reporting unverifiable private events, one might engage in behavior that typically corresponds with a given private event, such as coughing when reporting feeling sick (i.e., collateral responses, Skinner 1945). Future research should investigate the influence of verifiability on reports of private events.

We must acknowledge that public accompaniments are but one part of Skinner’s interpretation of how we acquire language regarding private events. Skinner also identified collateral responses, stimulus generalization, and response reduction as important components in his complete interpretation of how we come to talk about private events. Each of these components likely relates to the occurrence and accuracy of reports of private events under certain conditions. For example, the degree of public-private correspondence might become more complex when we consider the variables controlling collateral responses (i.e., public responses that tend to accompany private events), such as coughing when feeling sick. Because collateral responses *are* responses (cf., public accompaniments), they might come under the control of contingencies in the absence of a correlated private event, resulting in a degradation of public-private correspondence. For example, a man might cough when saying “I can’t come into work today because I’m sick,” even when he is not sick. Perhaps reports of feeling sick were punished in the past when they have not occurred in conjunction with a collateral response. In other words, undesirable collateral

responses might be a byproduct of punishing reports that occur in the absence of a highly correlated collateral response or public accompaniment. Given the difficulty of manipulating private events, experimentation proves challenging. We encourage researchers to consider analogue arrangements, such as ours, to investigate variables related to these important aspects (e.g., collateral responses) of Skinner’s interpretation.

Although this study provides some empirical support for Skinner’s (1945, 1957) interpretation, it only alludes to how individuals *might* come to talk about private events. Our experimental arrangement might not be a perfect analogue to Skinner’s interpretation of private events. For example, we told the participants that they would be taught to label the symbols on the printed cards and gave them a list of possible responses. It is unlikely that a parent would do either of these things when teaching children to talk about sensations or feelings. However, we must ask ourselves, “How do we know what parents do in these situations?” To address the potential imperfections in our analogue arrangement, we encourage researchers to further investigate two avenues of research. First, researchers might investigate the influence of potential imperfections, like instructions and list of syllables, on participant performance in a similar analogue arrangement. Second, descriptive studies would provide useful data on the naturally occurring parent-child interactions involving verbal behavior regarding private events. Baer (1973) discussed how tightly controlled experimental studies, such as this one, provide only a possible explanation of what could be occurring in nature. That is, if this preparation is not a good analogue of what occurs in nature, then it does not add to our understanding of verbal behavior related to private events. Descriptive studies might provide supporting evidence of the relations uncovered during these experiments, or they could uncover other variables not included in this study that warrant further investigation. In any case, descriptive studies are a necessary component to a complete understanding of naturally occurring interactions that lead to verbal behavior regarding private events.

The role of private events in the science of behavior is still a debated topic (see Baum 2011 and corresponding commentaries). However, these data provide empirical support for Skinner’s interpretation and suggest that the science of private events might be possible. The orderly patterns of data obtained suggest that analogue arrangements are likely a useful, and even

necessary, starting point for experimental investigations of how private events may enter into the analysis of behavior. Future studies should investigate more variables related to tacting private events. For example, how are teaching practices of the verbal community established and transmitted across its members? What is the influence of verifiability of private events? How are reports affected by form-based punishment? These and other questions could be investigated with an analogue arrangement to advance our understanding of relations between private events and behavior.

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