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CONCEPTUAL ARTICLE

The Functional Independence of Mands and Tacts: Has It Been Demonstrated Empirically?

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Abstract Recently, there has been a proliferation of research on the functional independence of two of Skinner's (1957) verbal operants, the mand, and the tact. This research has produced highly variable results. In this article, we provide a critical review of the literature on mand–tact independence, a literature that has implications for both theory and practice. Included in the review are 17 studies with a total of 66 participants who were tested for mand emergence following tact training, tact emergence following mand training, or both, and 11 additional studies that systematically manipulated variables expected to affect the outcomes of such tests. A primary finding is that most studies to date suffer from problems with construct validity. However, it may be justifiable to conclude that the literature provides at least weak support for the functional independence of mands and tacts. Future investigators should avoid the major construct validity pitfalls described in this article, describe participant characteristics more thoroughly, and consider alternative approaches to studying mand–tact independence.

Keyword Functional independence · Language · Mand · Tact · Verbal behavior

In *Verbal Behavior*, Skinner (1957) rejected traditional notions of language as a medium for communicating ideas in favor of a "causal analysis of man thinking" (p. 6). His functional account treated verbal behavior as a product of reinforcement contingencies imposed by a verbal community, whose application of said contingencies was in turn shaped by its consequences. Thus, Skinner proposed that language was

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operant behavior, the properties of which differed only superficially from a rat's lever press or a pigeon's key peck in an operant chamber.

In place of analyzing phonemes, words, or sentences as the basic units of speech, Skinner (1957) proposed the *verbal operant* as a unit of analysis. This unit consists of a verbal response and the antecedents and consequences of which it is a function. Skinner described several types of elementary verbal operants that were distinguished by the nature of their controlling variables (e.g., mand, tact, echoic, intraverbal, textual behavior). Importantly, the form of a response does not suffice to classify it as one type of verbal operant or another, as the same response form can appear as part of multiple verbal operants. In order to classify an utterance, such as "water", as a mand, a tact, or some other verbal operant, we must know the circumstances that led to its occurrence on a given occasion.

The appearance of a particular response form as part of multiple verbal operants, according to Skinner (1957), requires a learning history that has promoted control by multiple antecedent stimuli. One does not "learn a word" and then automatically "use the word" in multiple contexts. Rather, social contingencies of reinforcement establish control over particular verbal responses by a variety of stimuli, in accordance with the practices of the verbal community. Because each of these stimuli may participate in a unique reinforcement contingency, it follows from Skinner's analysis that different verbal operants that involve the same response form (e.g., "water" as a mand, "water" as a tact, and "water" as textual behavior) should be functionally independent of one another, in that variables affecting one operant should not necessarily affect the other. The functional independence of verbal operants has been a topic of many empirical investigations; in part because of its implications for the structure of language interventions (cf. Hall and Sundberg 1987), and in part due to efforts to provide empirical support for Skinner's analysis (e.g., Lamarre and Holland 1985). Most of this research has focused on two operants: the mand and the tact.

Skinner (1957) defined the mand as a verbal response under the functional control of deprivation or aversive stimulation. More recently, the class of antecedent events that may evoke a mand has been labeled establishing operations (EOs; Michael 1988, 1993). EOs are a subclass of motivating operations (MOs; Laraway et al. 2003), which are defined as variables that (a) alter the reinforcing value of other stimuli or events, and (b) simultaneously affect the frequency of occurrence of responses that have produced these stimuli or events in the past. Specifically, an EO related to reinforcement serves to increase the reinforcing value of a particular consequence, and increase the frequency of responses that have previously produced that consequence. If those responses are verbal, they qualify as mands. For example, the response "water" is a mand if it is evoked by water deprivation, as a result of a history in which the water-deprived speaker's emission of this response resulted in water being supplied by a listener. In contrast to the mand, the other elementary verbal operants are under discriminative rather than motivational control. In the case of the tact, the discriminative stimulus originates in the nonverbal environment, and may include, for example, the sight of water or the sound of it running. According to Skinner, these stimuli acquire control over a verbal response (e.g., "water") due to a history of generalized reinforcement (e.g., praise or attention) or reinforcement with many different stimuli.

With regard to the proposition that different verbal operants are functionally independent of one another, the mand and the tact may be particularly interesting. As

Skinner (1957) pointed out, some instances of functional independence seem obvious. For example, a non-reading child who has acquired the vocal tact "water" would not be expected to emit "water" as a textual response to the printed stimulus WATER in the absence of any additional instruction. That a person might be able to mand "water" when thirsty, without the tact "water" being in that person's repertoire, by contrast, may seem counterintuitive. Skinner recognized this issue and discussed at length (pp. 187–190) the possible reasons why particular response forms may appear to transfer effortlessly between mand and tact contingencies. For example, the controlling variables for the mand and tact may frequently co-occur in a speaker's natural environment, resulting in simultaneous acquisition of the two operants. In addition, Skinner suggested that mature speakers have been exposed to complex learning histories that eventually result in a repertoire of "suitable behavior of transcription or translation" (p. 188) that enable the emission of a mand when only a tact has been acquired, and vice versa. More recent behavioral accounts of language have also proposed specific higher-order repertoires that may, once acquired, serve to produce this outcome (e.g., Barnes-Holmes et al. 2000; Horne and Lowe 1996). Nevertheless, Skinner's analysis implies that at least for beginning language learners who have not yet acquired such repertoires (e.g., young children or individuals with language impairments due to developmental disabilities), it should be possible to demonstrate independent acquisition of mands and tacts empirically by experimentally isolating the controlling variables for each operant.

The first empirical study on mand–tact independence (Lamarre and Holland 1985) was published almost 30 years ago and soon followed by a handful of applied studies (e.g., Hall and Sundberg 1987; Sigafoos et al. 1989, Sigafoos et al. 1990), but a systematic program of research did not emerge. In recent years, however, a burst of activity has resulted in a rapid expansion of the literature. Some of this burgeoning interest may likely be attributed to growing enthusiasm for language interventions that incorporate Skinner's (1957) analysis, but some of it also appears to be due to researchers questioning data from previous studies (e.g., Egan and Barnes-Holmes 2011; Petursdottir et al. 2005; Wallace et al. 2006). As some authors have noted (e.g., Egan and Barnes-Holmes 2010, 2011; Finn et al. 2012), the literature has become difficult to interpret due to variable results across studies, coupled with methodological variations. As a result, a critical review of this research is timely.

The purpose of this review was to summarize the existing data on mand–tact independence and evaluate it in light of methodological considerations. After describing how we selected articles for review, we will discuss two major categories of studies on mand–tact independence, briefly review other relevant research, and present conclusions and directions for future research.

Selection of Articles for Review

In order to identify articles for inclusion in the review, we conducted a PsycINFO search for the terms "mand" and "tact" in the abstracts of peer-reviewed articles published in English, Spanish, Portuguese, and Italian (i.e., languages that the authors could read). Articles were selected for review if their abstracts indicated that they included data on the effects of tact training on mand emergence or vice versa.

Reference sections of selected articles were examined in order to locate additional literature. In addition, we included a few studies of which we were aware that were not indexed in PsycINFO. Studies that did not employ Skinner's (1957) verbal operant terminology were not included, as we thought conceptual clarity might be best served by including only studies that explicitly set out to study mands and tacts as defined by Skinner.

The initial search yielded 28 studies that we divided into two categories. First, 17 studies on *independent acquisition* examined the effects of tact training on mand emergence (tact-to-mand transfer), the effects of mand training of tact emergence (mand-to-tact transfer), or both. Second, 11 studies examined *variables affecting independent acquisition* of mands and tacts.

Research on Independent Acquisition

Shown in Tables 1, 2, and 3 are 17 studies that produced data on independent acquisition without systematically manipulating any variables hypothesized to affect tact-to-mand or mand-to-tact transfer. The primary stated purpose of these studies was in most cases to evaluate mand–tact independence, or to assess the effects of mand or tact training on the emergence of the other operant under a given set of conditions. In a few studies, however, mand–tact independence data were secondary to another primary purpose (Halvey and Rehfeldt 2005; Normand et al. 2011; Ziomek and Rehfeldt 2008). Nine studies evaluated both tact-to-mand and mand-to-tact transfer, either within or between participants; five studies evaluated mand-to-tact transfer only, and three studies tact-to-mand transfer only. Fourteen studies were published in English-language journals, two were published in Portuguese (Alves and Ribeiro 2007; Córdova et al. 2007) and one in Italian (Pino 1994). We will first summarize methodological characteristics and results of the 17 studies; followed by a discussion of potential sources of variability within and across studies.

Summary of Methods and Results

Participants The 17 studies included a total of 66 participants (see Table 1). Participants in five studies were typically developing children whose ages ranged from 8 months (Normand et al. 2011) to 5 years (Lamarre and Holland 1985). Children or adolescents with developmental delays or disabilities participated in seven studies, five of which included one or more participants diagnosed with autism spectrum disorder (ASD). Adults with intellectual disability participated in four studies, and adults with acquired brain injury in one study (Sundberg et al. 1990). Few studies included standardized measures of language or intellectual functioning. Narrative descriptions of verbal repertoires indicated that most participants with developmental disabilities had existing, albeit limited, mand, and tact repertoires. However, participants in three studies (Pino 1994; Sigafoos et al. 1990; Ziomek and Rehfeldt 2008) were not reported to have any functional verbal repertoires (e.g., mands, tacts, intraverbals) in the form of intelligible vocal speech (other than echolalia), manual signs, or other recognized mode alternative communication modes. The

Table 1 Participants and direction of transfer evaluated in studies on independent acquisition

Authors	Tact-to-mand transfer	Mand-to-tact transfer	Participants					
			N	Age in years	Diagnosis	Language measures	Intellectual functioning	Description of verbal skills
Albert et al. (2012)		x	3	5–8	ASD	–	–	Existing mand repertoires and limited (2) to well-developed (1) tact repertoires
Alves and Ribeiro (2007)	x	x	6	2–4	None	–	–	
Córdova et al. (2007)	x	x	10	2–4	None	–	–	
Finn et al. (2012)	x	x	4	3–6	ASD	PPVT-3 age equivalent 1–9 to 3–4	–	Frequent mands and tacts for 3 of 4 participants, utterance length 1–3 to 6–8 words
Hall and Sundberg (1987)	x		2	16–17	Severe ID; deaf	–	–	Extensive tacting repertoires; low rates of manding
Halvey and Rehfeldt (2005)		x	3	Adult	Severe ID	ICAP social/communicative age equivalent 1–8 to 3–11	IQ 32–36[b]	Utterance length 1–2 words
Kelley et al. (2007a)	x	x	3	3–10	ASD (1), apraxia (1), language delay (1)	–	–	Utterance length 1–3 words
Lamarre and Holland (1985)	x	x	9	3–5	None	–	–	
Normand et al. (2011)		x	2	0–1	None	–	–	No vocal language
Petursdottir et al. (2005)	x	x	5	2–3	None	–	–	
Pino (1994)		x	1	9	ASD and severe ID	–	–	Echolalia; followed simple instructions
Shillingsburg et al. (2009)	x	x	3	2–7	ASD	–	–	Echoic, tacts, mands, and intraverbals; utterance length 1–4 words
Sigafoos et al. (1989)	x		3	Adult	Severe to profound ID	–	IQ <30–40[b]	Sign only; 3–27 mands; 0–6 tacts

Table 1 (continued)

Authors	Tact-to-mand transfer	Mand-to-tact transfer	Participants					
			N	Age in years	Diagnosis	Language measures	Intellectual functioning	Description of verbal skills
Sigafoos et al. (1990)	x		2	Adult	Severe ID	–	–	No intelligible vocal speech or manual signs
Sundberg et al. (1990)	x	x	2	Adult	TBI	–	–	Strong receptive, echoic, and textual repertoires; weak mand, tact, and intraverbal repertoires
Twyman (1996)	x	x	4	4	Moderate to severe language delays	At least one year below chronological age[a]	–	Strong echoic repertoires; 12–21 vocal mands and tacts
Ziomek and Rehfeldt (2008)		x	3	Adult	Mild to profound ID	ICAP social/communicative age equivalent 1–8 to 1–10	IQ <20–24[b]	No intelligible vocal speech; communicated with gestures

"x" in the Mand-to-Tact Transfer and Tact-to-Mand Transfer columns indicates that this type of transfer was tested. Numbers in parentheses under Diagnosis refer to number of participants

ASD= autism spectrum disorder, *ID* = intellectual disability, *TBI* = traumatic brain injury, *PPVT* = Peabody Picture Vocabulary Test, *ICAP* = Inventory for Client and Agency Planning

[a] Standardized instrument not specified

[b] Available for two of three participants

Table 2 Some procedural variations in studies on independent acquisition

Study	Stimuli[a]	SPA	Target responses			Reinforced probes?	Manded item visible?	Verbal antecedents in tact/mand probes
			Response modality	Response form	Required frames			
Albert et al. (2012)	Neutral[a]	None	Vocal	Conventional	None	No	No	"What's this?"
Alves and Ribeiro (2007)	Relative locations[c]	None	Vocal	Arbitrary	None	No	Yes	"Where is __?"/"Where do you want __ to go?"
Córdova et al. (2007)	Relative locations[c]	None	Vocal	Arbitrary	None	No	Yes	"Where is __?"/"Where do you want __ to go?"
Finn et al. (2012)	Neutral[b]	MSWO[h]	Vocal	Arbitrary	None[j]	No	No	"What is this?"/"What do you need?"
Hall and Sundberg (1987)	Neutral[b]	None	Sign	Conventional	None	FR1	No	None
Halvey and Rehfeldt (2005)	Preferred[d]	MSWO	Vocal	Conventional	None	FR1	Yes	"What is this?"
Kelley et al. (2007a)	Preferred	PS or free-play observation	Vocal	Conventional	None	FR1	Yes	"What is it?"/"What do you want?"
Lamarre and Holland (1985)	Relative locations[c]	None	Vocal	Conventional	"on the _____"	No	Yes	"Where is the __?"/"Where do you want me to place the __?"
Normand et al. (2011)	Preferred	None	Sign	Arbitrary and conventional	None	FR1	No	Not clear
Petursdottir et al. (2005)	Neutral[b]	None	Vocal	Arbitrary	None	No	No	"What is this?"/"What do you need?"
Pino (1994)	Preferred	Free-operant assessment	Vocal	Conventional	None	FR1	Yes	"What is it?"
Shillingsburg et al. (2009)	Preferred and neutral[e]	PS	Vocal	Conventional	None	FR1	Yes	"Is this a __?"/"Do you want __?"
	Neutral	None	SB	Conventional	None	FR1	No	None

Table 2 (continued)

Study	Stimuli[a]	SPA	Target responses			Reinforced probes?	Manded item visible?	Verbal antecedents in tact/mand probes
			Response modality	Response form	Required frames			
Sigafoos et al. (1989)								
Sigafoos et al. (1990)	Neutral	None	SB	Conventional	"want" symbol[k]	FR1	No	None
Sundberg et al. (1990)	Neutral	None	Vocal	Conventional	None	No	No	"What is this?"/none
Twyman (1996)	Neutral[b, f]	None	Vocal	Conventional	"please"[k]	FR1	Yes[l]	"What is this?"/"What do you want?"
Ziomek and Rehfeldt (2008)	Preferred and neutral[b, g]	MSWO	SB[i]	Conventional		No	Yes[l]	"What is this?"

SPA = stimulus preference assessment, *MSWO* = multiple-stimulus without replacement assessment, *PS* = paired stimulus assessment, *SB* = selection based

[a] Correct tacts and mands consisted of emitting conventional or arbitrary names of these stimuli, unless otherwise specified

[b] Blocked-response procedure used to contrive EO in mand condition

[c] Left/right locations of stimuli relative to other stimuli

[d] Correct response consisted of item's category name

[e] Target responses were "yes" and "no"; preferred and non-preferred items used in mand condition; neutral items in tact condition

[f] Correct responses consisted of an adjective describing each items (e.g., "whole")

[g] For only one participant

[h] Used to identify consequence of behavior chain completion (remote mand consequence)

[i] Manual signs were also taught within the study, but probes for untrained tacts occurred only for selection-based responding

[j] Not required, but occurrence was tracked

[k] Mands only

[l] Communication cards with line drawings of stimulus items were visible

Table 3 Number of participants who passed, failed or had mixed outcomes in mand and tact probes

Study	Mand probe outcomes			Tact probe outcomes		
	n passing/*n* probed	*n* failing/*1* probed	*n* mixed/*n* probed	*n* passing/*n* probed	*n* failing/*n* probed	*n* mixed/*n* probed
Albert et al. (2012)				3/3	0/3	0/3
Alves and Ribeiro (2007)	4/6	2/6	0/6	6/6	0/6	0/6
Córdova et al. (2007)	0/6	3/6	3/6	1/4	0/4	3/4
Finn et al. (2012)	3/4	1/4	0/4	3/4	1/4	0/4
Hall and Sundberg (1987)	0/2	2/2	0/2			
Halvey and Rehfeldt (2005)				2/3	1/3	0/3
Kelley et al. (2007a)	2/3	0/3	1/3	1/3	0/3	2/3
Lamarre and Holland (1985)	0/5	5/5	0/5	0/4	4.4	0/4
Normand et al. (2011)				0/3	3/3	0/3
Petursdottir et al. (2005)	1/5	4/5	0/5	4/4	0/4	0/4
Pino (1994)				0/1	1/1	0/1
Shillingsburg et al. (2009)	0/2	2/2	0/2	0/1	1/1	0/1
Sigafoos et al. (1989)	0/3	0/3	3/3			
Sigafoos et al. (1990)	0/2	0/2	2/2			
Sundberg et al. (1990)	2/2	0/2	0/2	0/2	2/2	0/2
Twyman (1996)	0/4	3/4	1/4	0/4	4/4	0/4
Ziomek and Rehfeldt (2008)				0/2	1/2	½
Total	12/44	22/44	10/44	20/44	18/44	6/44

same was true of the young, typically developing children who participated in Normand et al. (2011).

Procedural Variables Table 2 outlines several variations in methodology across studies. The first column describes the stimuli tacted and manded, and the next column displays the type of preference assessment, if any, that was used to select these stimuli. In four studies, the stimuli were highly preferred toys or edibles. Eight studies employed blocked-response procedures in the mand condition. In these studies, the stimuli to be tacted and manded were non-edible items that were not presumed to be highly preferred most of the time. During mand training and testing, however, the

stimuli were absent (i.e., out of sight or out of reach) and needed in order to access preferred items or complete tasks that ultimately produced preferred outcomes. One study (Ziomek and Rehfeldt 2008) employed both preferred items and blocked-response procedures. Participants in three studies (Alves and Ribeiro 2007; Córdova et al. 2007; Lamarre and Holland 1985) learned to tact or mand for the relative placement (i.e., left and right) of various items. Finally, in Shillingsburg et al. (2009), the target response forms were "yes" and "no"; preferred and nonpreferred items were employed in the mand condition but neutral items in the tact condition.

Table 2 further shows the modality and the form (conventional vs. arbitrary) of responses that were established as tacts or mands, and specifies whether or not responses had to be accompanied by tact or mand frames (e.g., "This is . . ." or "I want . . .") to be scored as correct. Finally, the table shows whether correct responses were reinforced during probes, whether the item to be manded was visible to the participant when a mand trial was initiated during training or testing, and which verbal antecedents were presented by the experimenter during mand and tact probes (e.g., "What is this?" or "What do you want?").

Results Table 3 shows the probe performance of participants in the 17 studies. In order to determine whether or not participants in a particular study showed passing performance, we used the passing criterion specified by the authors if possible, but a criterion of 80 % correct responding if no criterion was specified. Participants who were tested with multiple stimulus sets and passed some probes but failed others are designated as having mixed outcomes in the table.

Results varied within and across studies. Of the 12 studies that evaluated tact-to-mand transfer, four studies produced results that were consistent across all participants, in that all participants either failed (Hall and Sundberg 1987; Lamarre and Holland 1985; Shillingsburg et al. 2009) or passed (Sundberg et al. 1990) mand probes following tact training. In the remaining eight studies, results varied across and in some cases within participants. Of the 14 studies that evaluated mand-to-tact transfer, seven studies produced results that were consistent across participants, with all participants either failing tact probes (Lamarre and Holland 1985; Normand et al. 2011; Sundberg et al. 1990; Twyman 1996) or passing tact probes (Albert et al. 2012; Alves and Ribeiro 2007; Petursdottir et al. 2005). Of the remaining seven studies, the results varied across and sometimes within participants. Two studies included only one participant who was evaluated for mand-to-tact transfer (Pino 1994; Shillingsburg et al. 2009); the participant failed tact probes in both cases.

Overall, in the 12 studies that assessed tact-to-mand transfer, a total of 44 participants underwent testing for mand emergence following tact training. Twelve participants (27.3 %) passed all mand probes, 22 participants (50.0 %) failed all mand probes, and mixed outcomes were obtained for 10 participants (22.7 %). In the 13 studies that assessed mand-to-tact transfer, 44 participants also underwent testing; 20 (45.5 %) passed all tact probes, 18 (40.9 %) failed all tact probes, and mixed outcomes were obtained for 6 participants (13.6 %).

Figure 1 shows the 17 studies divided into two categories based on their results, separately for tact-to-mand and mand-to-tact transfer. In the first category, at least one participant failed all probes for the untrained operant following training of the other. In the second category, no participant consistently failed all probes. The reasoning behind

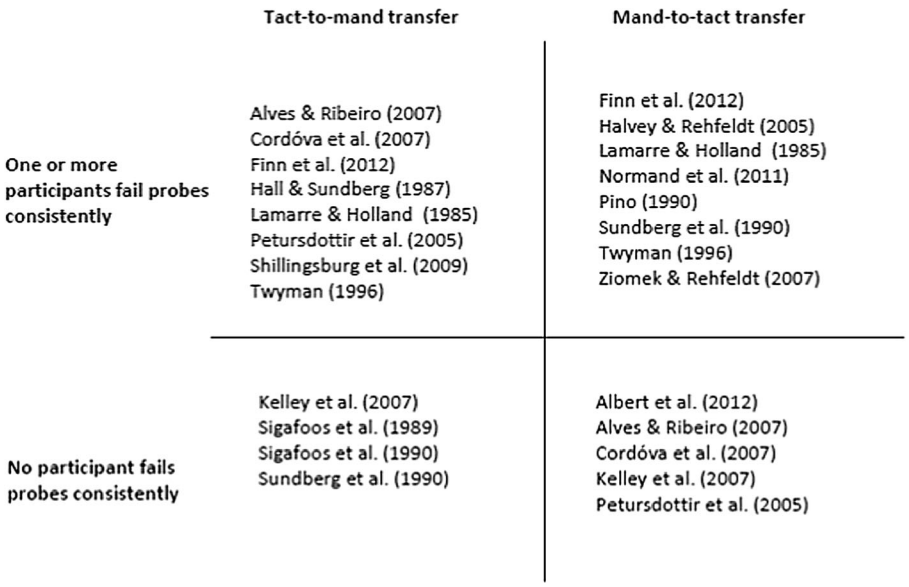

Fig. 1 The figure shows, separately for tact-to-mand and tact-to-mand transfer, studies that produced data consistent with mand–tact independence (one or more participant failed all probes for the untrained operants consistently) and studies that produced data less consistent with mand–tact independence (all participants passed or had mixed outcomes in probes for the untrained operant)

this classification is that (a) the number of participants in each study was small, and (b) assuming a sound methodology and subsequent replication, it should take only one participant in a small-*N* study to provide a tentative demonstration that independent acquisition of mands and tacts occurs in at least some learners. Thus, data from the first category might be described as consistent with mand–tact independence, whereas data from the second failed to demonstrate the phenomenon.[1] Given the number of studies that fall into the first category, the literature may seem largely consistent with Skinner's (1957) analysis. However, the variability observed within and across studies raises questions regarding its sources and the resulting effects on the conclusions that may be drawn from each study.

Potential Sources of Variability

Participant Characteristics Given the assumption of Skinner (1957) and others (Barnes-Holmes et al. 2000; Horne and Lowe 1996) that learning histories influence transfer between tact and mand contingencies, variability across participants and studies should be expected. Each participant presumably brings to the experiment an unknown history that may not be fully captured in either standardized or curriculum-based

[1] A more conservative criterion could have been used; for example, we could have required a majority of participants to fail all probes for the untrained operant in order for results to be considered consistent with functional independence. We did not find that using a more conservative criterion altered any of the conclusions presented in this article. However, Tables 1, 2, and 3 should provide enough data for readers to conduct independent analyses based on other criteria for classifying study outcomes.

language assessments. As a result, researchers cannot easily select participants who are homogeneous in this regard, or deliberately select participants who lack the relevant learning histories. Nevertheless, it may be reasonable to ask if any documented participant characteristics appear correlated with study outcomes.

Because few studies reported standardized assessment information, we are limited to assessing the relationship between study outcomes (Fig. 1) and reported diagnoses and other narrative descriptions of participants. If tact-to-mand transfer is considered first, all studies conducted with typically developing children (Alves and Ribeiro 2007; Córdova et al. 2007; Lamarre and Holland 1985; Petursdottir et al. 2005) produced data, whereas studies conducted with children or adults with developmental disabilities fell into both of the categories shown in the Fig. 1. For mand-to-tact transfer, studies conducted with typically developing children fell into both categories, as did studies with individuals with developmental disabilities. Of the four studies in which the participants' verbal repertoires appeared most limited, three produced data consistent with independent acquisition (Normand et al. 2011; Pino 1994; Ziomek and Rehfeldt 2008), whereas in the fourth (Sigafoos et al. 1990), each of the participants passed probes for two of three mands following tact training.

Interestingly, participants whose verbal repertoires may have been relatively advanced (i.e., typically developing children of preschool or kindergarten age) in some cases appeared less likely to show transfer between tact and mand contingencies (e.g., Lamarre and Holland 1985) than children who had language delays due to developmental disabilities (Finn et al. 2012; Kelley et al. 2007a) or adults who were more or less nonverbal (Sigafoos et al. 1990). This aspect of the results may raise questions about procedural differences that may have contributed to variability across studies.

Construct Validity When an untrained tact fails to appear in probes following mand training, or an untrained mand fails to appear in probes following tact training, functional independence of mands and tacts provides one possible explanation. Other possible explanations that must be ruled out include that (a) mand or tact testing conditions did not capture relevant controlling variables for the target mands and tacts, and (b) the responses trained as mands or tacts did not function as such, but instead, were controlled by other variables present in the training situation. These issues may be summarized as problems with construct validity (Shadish et al. 2002). Construct validity issues may also affect results in the opposite direction. Specifically, apparent mand-to-tact transfer or tact-to-mand transfer may be observed because (a) mand testing conditions included the controlling variable for the trained tact, or vice versa, or (b) responses trained as mands were under the control of tact variables present during mand training, or vice versa. Under those conditions, participants who might not otherwise mand following tact training or vice versa may appear to do so.

During tact training and testing, it is relatively simple to control and verify the presence of the proposed relevant controlling variable (a visual stimulus in all of the studies listed in Table 1[2]), although it may be slightly more cumbersome to rule out that a potential controlling variable for a mand is not also present. In mand training and

[2] For this reason, we will sometimes refer to the controlling variables of tacts as visual stimuli and speak of them being visible, in the context of discussing these studies. However, it is important to acknowledge that the non-verbal discriminative stimulus that controls a tact may be presented in any sense modality (Skinner 1957).

testing, by contrast, it may be more complicated to arrange and verify the presence of an appropriate EO, as well as to design a mand condition that is free from the presence of the potential controlling variable for the tact (e.g., sight of the manded item or another stimulus that is correlated with it). In our discussion of how this issue may have affected the results of studies of independent acquisition of mands and tacts, we will make the following assumptions:

1. *When data do not show tact-to-mand transfer:* Testing a mand requires the presence of a relevant EO. Various procedures may be employed to promote its presence in a probe trial, but its actual presence should be supported with additional information. This information might include (a) a formal preference assessment suggesting that the manded stimulus is highly preferred at the time of testing, (b) other data showing that the antecedent variables present in a mand probe evoke approach or nonverbal attempts to obtain the stimulus, and (c) data showing a reinforcement effect when the mand consequence is delivered contingent on a response under the same antecedent conditions that are present in probe trials. This last category of supporting information may include data showing successful mand acquisition during direct training, after failure to emerge following tact training. However, because mand training may include additional variables that are not presented in probes (e.g., prompting and prompt fading), a highly convincing demonstration would also include evidence that the trained response was under EO control (see point #2 below).
2. *When data do not show mand-to-tact transfer:* Training a mand requires not only the presence of an EO in training trials but also it must be shown that the trained response is under the functional control of the EO. If the trained response is not under EO control, failures of tacts to emerge in subsequent probes cannot speak to the issue of mand–tact independence. The most direct way to demonstrate EO control is to show empirically that the response is more likely to occur in the presence than in the absence of the EO. However, we assume that EO control can also be inferred by exclusion under some circumstances. Specifically, when multiple mands for different items are trained simultaneously, and those mands are acquired successfully, we assume that control by *nonspecific* aspects of the training situation is ruled out. To clarify, if the mand "X" appears mostly in trials for stimulus X, mand "Y" in trials for stimulus Y, and mand "Z" in trials for stimulus Z, then it seems implausible that the primary source of control over these responses lies in antecedent variables that are common to X, Y, and Z trials, such as intraverbal control by an instruction (e.g., "What do you want?") or EO control by aversive properties of the training situation that might evoke trial-termination responses. If it is also possible to rule out trial-specific sources of control (e.g., tact control by visual stimuli X, Y, and Z or other trial-specific discriminative stimuli; see point #4 below), it can likely be inferred that the trained responses are mands controlled by an EO specific to each trial type.
3. *When data show tact-to-mand transfer*: If the manded stimulus is present at the beginning of mand probe trials following tact training, correct responses in these trials may represent occurrences of the directly trained tact, rather than an emergent mand. This possibility might be ruled out by conducting mand probe trials both in the presence and in the absence of a presumed EO, and showing that correct responses appear only in its presence. In addition, of course, it is ruled out if the

manded stimulus is not visible prior to the participant's response, and the response still occurs in its absence.

4. *When data show mand-to-tact transfer:* If the manded stimulus (or another potential discriminative stimulus uniquely correlated with a specific trial type) is present during mand training, the reinforcement contingency could establish tact control by that stimulus in addition to or instead of control by the EO In this case, tacts that appear following mand training would in fact be a result of direct training.[3]
5. *When data show mand-to-tact transfer:* If an EO of relevance to the tact discriminative stimulus is present in tact probe trials following mand training, correct responses may represent occurrences of the directly trained mand, rather than an emergent tact. This possibility is best ruled out by trying to remove the presumed EO (e.g., via satiation) during tact probes.

In this section, we will first discuss controlling variables for the mand and the tact in three categories of studies that represent three different approaches to arranging EO presence in mand trials, and correspond to the three major categories of stimuli manded or tacted that are shown in Table 2 (i.e., preferred items, neutral stimuli along with blocked-response manipulations, and relative locations of items). Our primary interest is in the construct validity of studies that produced data consistent with mand–tact independence, but we will also briefly consider how construct validity issues might have affected results in the opposite direction in the remaining studies. Finally, we will discuss two other issues related to construct validity: instructions presented in probe trials and the definition of a correct response.

Stimuli Manded and Tacted Studies in which the stimuli manded and tacted were highly preferred items (Halvey and Rehfeldt 2005; Kelley et al. 2007a; Normand et al. 2011; Pino 1994; Ziomek and Rehfeldt 2008) represent the approach of *capturing an EO* (Sundberg 1993) by identifying a stimulus that is currently high in reinforcing value (e.g., as determined by approach) and temporarily blocking access to that stimulus in order to evoke a mand. In most of the studies, a mand training or mand probe trial began with the visual presentation of a preferred item to which the participant's access was blocked. Visual presentation presumably served the purpose of evoking a particular mand in each trial (e.g., "cookie"), as opposed to other mands trained or tested within the study (e.g., "chips") or mands related to uncontrolled EOs (e.g., "water"). In the study by Normand et al. (2011), however, only one mand was trained for each participant, and the item was not visible during mand trials, except during prompting and periods of consumption.

Of the five studies that used this approach, only one (Kelley et al. 2007a) assessed tact-to-mand transfer. Two of three participants passed all mand probes following tact training, and mixed results were obtained for the third. By contrast, all five studies assessed mand-to-tact transfer, and the results varied across studies. Data of Kelley et al. (2007) again showed

[3] Mand training procedures typically involve specific reinforcement via the delivery of the stimulus manded in each trial, which is the defining consequence of the mand (Skinner 1957). However, specific reinforcement is not sufficient to establish a mand; the reinforcement must also result in control by a relevant EO. Similarly, although tacts are generally not established via specific reinforcement, we cannot rule out the possibility that a mand training procedure involving specific reinforcement may establish tact control in addition or instead of control by an EO. For example, a consequence that appears specific from the experimenter's point of view (e.g., cookies) might actually function as a nonspecific reinforcer ("someone gave me something") unrelated to a particular EO.

substantial transfer; specifically, one participant passed all tact probes following mand training and the other two participants had mixed results. In this study, the manded stimulus was visible during mand probe and mand training trials, which may have facilitated transfer (points 3 and 4 above). The remaining four studies produced data consistent with mand–tact independence for one or more participants. One study (Normand et al. 2011) included a functional analysis to confirm the mand function of the trained responses. However, in the other three studies (Halvey and Rehfeldt 2005; Pino 1994; Ziomek and Rehfeldt 2008), multiple mands were trained and acquired simultaneously, ruling out control by nonspecific aspects of the training situation. Although the manded stimulus was visible during mand training in all three studies, it seems implausible that the trained responses were under the control of that stimulus, given that accurate tacts did not occur during tact probes for most participants. In addition, we could not identify any other trial-specific variables that could plausibly have acquired control over these responses. As a result, we conclude that data from all four studies remain consistent with the notion that the trained responses functioned as mands. Thus, this set of studies provides some evidence that mands can be acquired without the collateral acquisition of corresponding tacts

Studies that used blocked-response procedures in mand training or probes (Albert et al. 2012; Finn et al. 2012; Hall and Sundberg 1987; Petursdottir et al. 2005; Sigafoos et al. 1989, 1990; Sundberg et al. 1990; Twyman 1996; Ziomek and Rehfeldt 2008) represent the approach of contriving an EO (Sundberg 1993) by introducing conditions presumed to increase the reinforcing value of an ordinarily neutral item. In some studies, the participant was presented with a preferred stimulus (e.g., a bottle of soda; Sigafoos et al. 1989, 1990), but an item that was necessary to consume it (e.g., a bottle opener) was missing. Other studies used interrupted-chain procedures in which a participant was presented with a set of materials relevant to a particular behavior chain, the completion of which had a history of producing a preferred item, automatically (e.g., Albert et al. 2012; Hall and Sundberg 1987) or via social mediation (e.g., Finn et al. 2012; Petursdottir et al. 2005). However, one of the items necessary to complete the chain was missing. For example, in Hall and Sundberg (1987), a participant was told to make soup (a preferred edible) and presented with a pack of instant soup, a bowl, and a spoon, but no hot water. Regardless of the specific procedure, a correct response during mand training resulted in the delivery of the missing item (hereafter referred to as the immediate mand consequence), which ultimately led to access to the preferred item (the remote mand consequence). A possible advantage of blocked-response procedures is that they enable separating potential tact-controlling variables from potential mand-controlling variables. The manded item needs not be visible at the beginning of mand trials, and an EO of relevance to the item is presumably not present in tact trials, when the item is presented in the absence of the blocked-response manipulation. As in other studies, however, EO presence in the mand condition cannot be taken for granted without additional supporting evidence.

Of the nine studies that used blocked-response procedures, seven assessed tact-to-mand transfer. In three of these studies (Sigafoos et al. 1989, 1990; Sundberg et al. 1990), no participant failed mand probes consistently. Participants in Sundberg et al. (1990) passed consistently, whereas participants in Sigafoos et al. (1989, 1990) tended to fail mand probes for the first items for which tacts were trained.[4] The remaining four

[4] In the Sigafoos et al. (1989, 1990) studies, tact-to-mand transfer may have been facilitated by the use of iconic communication cards. Specifically, although the manded item itself was not visible at the beginning of each mand trial, a pictorial representation of the item was visible on the participants' communication cards.

studies produced data consistent with mand–tact independence, in that some (Finn et al. 2012; Petursdottir et al. 2005; Twyman 1996) or all (Hall and Sundberg 1987) participants consistently failed to mand following tact training. Were relevant EOs present during mand probes in these studies? Finn et al. (2012) selected the remote mand consequence (backup reinforcers for tokens delivered following task completion) based on a paired-stimulus preference assessment, which provides tentative support for the presence of an EO related to the remote mand consequence. However, the assessment was conducted only at the beginning of the study, leaving open the possibility of shifting EOs. In the remaining studies, no preference assessment was employed to select the remote mand consequence, although anecdotal reports often indicated that it functioned as a reinforcer. In addition, none of the four studies assessed the occurrence of other approach responses under mand probe conditions. However, other types of possible evidence for EO presence in mand probes were reported. First, three studies (Finn et al. 2012; Hall and Sundberg 1987; Petursdottir et al. 2005) required the participants to learn novel behavior chains at the outset of the study. In all cases, the remote mand consequence apparently sufficed to produce acquisition. Additionally, two studies (Finn et al. 2012; Petursdottir et al. 2005) interspersed probe trials with opportunities for successful chain completion, which permitted observing the participants' performance of this behavior during probe sessions (successful chain completion would seem to indicate the presence of an EO for the consequence of completion). However, this methodological feature would have been stronger if data from these trials had been included. Second, all four studies provided evidence, for at least some participants, that when the immediate mand consequence was delivered contingent on correct responses during mand training, multiple response forms that had failed to occur in mand probes following tact training were acquired successfully. Although none of the studies included a functional analysis of EO control over the trained mand responses, it appears possible to rule out alternative sources of control in at least some cases. Given that multiple response forms were acquired, control by nonspecific aspects of the mand training situation appears to be ruled out. Tact control over the trained mands is also ruled out in three studies (Finn et al. 2012; Hall and Sundberg 1987; Petursdottir et al. 2005), as the item targeted in each trial was not visible at the beginning of the trial, but cannot be ruled out in the fourth (Twyman 1996). Control by other trial-specific stimuli may also be difficult to rule out in some cases (e.g., one of two tasks in Petursdottir et al. 2005, in which the shape of the missing item was apparent in each mand trial, or Hall and Sundberg 1987, in which each trained mand was correlated with a specific behavior chain that required a unique set of items), but is less plausible in others (e.g., Finn et al. 2012). Overall, we find it possible that at least some of these studies had appropriate EOs in place during mand probes following tact training. Thus, this set of studies appears to provide limited evidence that tacts can be acquired without the collateral acquisition of mands.

Six of the nine blocked-response studies assessed mand-to-tact transfer. In two studies (Albert et al. 2012; Petursdottir et al. 2005), no participant failed tact probes consistently following mand training. In the remaining four studies (Finn et al. 2012; Sundberg et al. 1990; Twyman 1996; Ziomek and Rehfeldt 2008), one or more participants failed tact probes consistently. None of the studies included a functional analysis of the trained mands, but at least some alternative sources of control can be ruled out, as multiple response forms were targeted in mand training in all four studies.

However, control by trial-specific stimuli appears highly difficult to rule out except in the study by Finn et al. (2012), as each mand was typically taught in the presence of a set of items related to a unique behavior chain. As a result, this set of studies may not serve to provide a demonstration of functional independence.

The third category of studies consists of three studies (Alves and Ribeiro 2007; Córdova et al. 2007; Lamarre and Holland 1985) in which the target mands and tacts concerned relative placement of stimuli on the left or on the right of other stimuli. In the tact condition, participants were presented with two stimuli and asked about the location of one stimulus. In the mand condition, participants were asked to indicate where they wanted a particular stimulus placed relative to another stimulus. All three studies examined both tact-to-mand and mand-to-tact transfer. In all cases, some (Alves and Ribeiro 2007; Córdova et al. 2007) or all (Lamarre and Holland 1985) participants failed mand probes consistently following tact training. In Lamarre and Holland's study, all participants also failed tact probes following mand training, but no participants in the other two studies did so consistently. In none of the three studies was it clear that any particular steps were taken to promote EO presence in the mand condition. In other words, it was not clear why the participants should "want" stimuli placed on one side or the other in mand trials. As a result, the data from these studies are somewhat difficult to interpret. In two studies (Alves and Ribeiro 2007; Lamarre and Holland 1985), participants who had previously failed mand probes following tact training were shown to successfully acquire mands during mand training. However, in each mand trial, both "left" and "right" responses were considered correct and followed by placement of the item as specified. Thus, it seems difficult to rule out that the participants unsystematically responded with either "left" or "right" in each mand trial (e.g., under intraverbal control of the verbal instruction), instead of emitting responses controlled by an EO.

Finally, in the study by Shillingsburg et al. (2009), the target responses were "yes" and "no." In the mand condition, participants were presented with either a preferred or a nonpreferred edible and asked if they wanted it, whereas in the tact condition, participants were presented with a non-edible item along with a question such as "Is this a cup?". From an applied perspective, this study underscores the need to include in training all variables intended to control "yes" and "no" responses, as no transfer occurred from one condition to another. However, "yes" and "no" in the tact condition might be better described as qualifying autoclitics (Skinner 1957) than as regular tacts, so this study's contributions to the mand–tact literature are hard to evaluate.

Instructions During Probes One reason why a mand or a tact may fail to occur in a probe trial is the omission of the antecedents that exert instructional control over manding and tacting. For example, a participant may not engage in tacts without a specific request to emit it (e.g., "What is this?"). Although mands may generally be more likely than tacts to occur without antecedent instructions, it is also conceivable that some participants' learning histories support a higher probability of manding in the presence of an invitation to mand (e.g., "What do you want?"). Thus, a tact or a mand that is in a participant's repertoire may fail to occur during a probe if an appropriate request or invitation is not presented (see Finn et al. 2012). This issue may also be classified as a construct validity issue, in that the probes may not actually measure the emergence of untrained operants that they are intended to measure.

Table 2 shows the verbal antecedents presented during mand and tact probes in each study. Most studies that produced data consistent with mand–tact independence

included supplemental verbal stimuli during probes, such as "What do you want?" and, "What is this?" These stimuli might reasonably be expected to increase the probability of emitting mands and tacts for many individuals with prior histories of manding and tacting. The results would be strengthened, however, by showing empirically that the participants would emit known tacts and mands in the presence of these antecedents. Such assessments were included in only two studies (Finn et al. 2012; Petursdottir et al. 2005). In addition, results from studies in which participants had minimal or no prior mand and tact repertoires may be difficult to interpret. When untrained operants fail to emerge, is it because they are not in the participants' repertoires, or are tacting and manding not under instructional control? If the latter is true, untrained operants may fail to occur within the specific time window of a probe trial, even if they readily occur at other times (e.g., outside of the experiment).

In studies in which the stimuli manded and tacted were relative locations of items (Alves and Ribeiro 2007; Córdova et al. 2007; Lamarre and Holland 1985), the verbal antecedents differed from those used in most other studies (see Table 2). A few studies (Egan and Barnes-Holmes 2009, 2010, 2011) have examined the effects of modifying the type of instruction used under these circumstances, and their findings will be discussed in a later section.

Definition of Correct Response Overly restrictive response definitions are another construct validity issue that might result in data falsely suggesting mand–tact independence. For example, scoring mands as correct only if accompanied by a mand frame, such as "I want . . ." could mask tact-to-mand transfer. Two studies that have produced data consistent with mand–tact independence have employed response definitions that required mand or tact frames. Participants in Lamarre and Holland (1985) were required to say "on the left" and "on the right" rather than just "left" and "right", and in Twyman (1996), mands were scored as correct only if accompanied by "please."

Summary and Conclusions

In summary, 17 studies have investigated mand–tact independence by training tacts and probing untrained mands, training mands and probing untrained tacts, or both. Data from 13 studies were consistent with mand–tact independence in that at least one participant failed all probes for either tact-to-mand or mand-to-tact transfer. After considering the construct validity of these studies, we find that data from at least four studies may be difficult to interpret due to major uncertainty regarding the mand or tact functions of some of the trained or tested responses (Alves and Ribeiro 2007; Córdova et al. 2007; Lamarre and Holland 1985; Shillingsburg et al. 2009). Absence of mand-to-tact transfer has been demonstrated fairly convincingly in a set of studies in which the stimuli tacted and manded were preferred items (Halvey and Rehfeldt 2005; Normand et al. 2011; Pino 1994; Ziomek and Rehfeldt 2008) and absence of tact-to-mand transfer appears to have been demonstrated in a set of studies that used blocked-response procedures (Finn et al. 2012; Hall and Sundberg 1987; Petursdottir et al. 2005; Twyman 1996), although minor uncertainty regarding EO presence in the mand condition may be present in some of them. Although these results may be at least promising, only two of the above-mentioned studies (Finn et al. 2012; Petursdottir et al.

2005) demonstrated instructional control over tacting and manding during probes, which may be particularly problematic in studies with minimally verbal participants (Normand et al. 2011; Pino 1994; Ziomek and Rehfeldt 2008). Finally, overly restrictive correct-response definitions may have been employed in some studies (Lamarre and Holland 1985; Twyman 1996). Thus, most of the literature suffers to some extent from one or more construct validity issues. The study by Finn et al. (2012) is perhaps the strongest in terms of construct validity; however, this study produced data consistent with mand–tact independence for only one out of four participants.

Given that such limitations are present in virtually every study that has produced data consistent with mand–tact independence, is it reasonable to suggest that mand–tact independence has not yet been demonstrated? Such a conclusion may be overly conservative. In many of the studies we have reviewed, the limitations seem too minor or their consequences too improbable to invalidate the results. A more reasonable conclusion may be that at least some portion of this literature provides at least *weak* empirical support for mand–tact independence. We will return to this issue in a later section.

Variables Affecting Independent Acquisition

Table 4 shows 11 studies that manipulated potential influences on tact-to-mand or mand-to-tact transfer. Six studies manipulated either the preference rank of mand consequences or the presence of EOs for mand consequences; three studies manipulated instructions presented in probe trials, and two studies manipulated instructional histories. It is notable that a primary goal of the first two categories of studies was to address some of the possible construct validity issues discussed in the previous section.

Stimulus Preference and EO Presence in Mand Probes

In the original study in this category (Wallace et al. 2006), adults with developmental disabilities were taught to tact high-preference (HP) and low-preference (LP) stimuli using manual signs. In subsequent probes, mands occurred for HP items but not for LP items. Several studies have since sought to replicate and extend these findings. Gilliam et al. (2013) used procedures similar to those of Wallace et al. with children diagnosed with ASD, and obtained similar results, as did three other studies in which the participants were also children with ASD. Power and Hughes (2011) found that following training to tact HP and LP stimulus properties (e.g., "brown chocolate" vs. "white chocolate"), mands occurred for the HP but not for the LP properties. Kooistra et al. (2012) taught tacts only for HP stimuli, but manipulated satiation and deprivation levels for the stimuli during mand probes. Mands occurred primarily in the deprivation condition. Finally, Davis et al. (2012) manipulated both preference rank (HP vs. LP) and EOs (satiation vs. deprivation). No mands were observed in initial probes. When a series of tact trials were introduced prior to mand probes, mands began to occur in the deprivation condition for both the LP and the HP stimuli. However, rates of manding for the LP stimuli subsequently decreased to zero. All of these results are highly consistent with Skinner's (1957) analysis of the mand. Even if an individual's learning history permits transfer between mand and tact contingencies, emergent mands should occur only when motivation to mand for an item is high. That is, mands should not occur under satiation or when the mand consequence is an LP item.

Table 4 Studies on variables affecting independent acquisition

Authors	Tact-to-mand transfer	Mand-to-tact transfer	Independent variable	Participants				
				N	Age in years	Diagnosis	Assessment information	Description of verbal skills
Davis et al. (2012)	x		Preference rank and EO presence	1	4	ASD		5–10 vocal tacts; no mands
Egan and Barnes-Holmes (2009)		x	Antecedent instructions	4	5–7	ASD		Existing tact and mand repertoires
Egan and Barnes-Holmes (2010)	x		Antecedent instructions	8	7–11	ASD		Existing tact and mand repertoires
Egan and Barnes-Holmes (2011)	x	x	Antecedent instructions	8	4–5	None		
Gilliam et al. (2013)	x		Preference rank	3	3–5	ASD		Vocal mands and 60 to >100 vocal tacts (2); a few mands and tacts (1)
Hernandez et al. (2007)	x		Mand frames	3	1–4	None (1); nonspecific developmental delays (2)		
Kooistra et al. (2012)	x		EO presence	2	4–5	ASD	PLS-4 receptive 67 (2), 56 (1)	Existing tact and mand repertoires
Nuzzolo-Gomez and Greer (2004)	x	x	Multiple-exemplar training	4	6–9	ASD (2); ID (2)	IQ 64–68[a]	Existing tact and mand repertoires
Pino et al. (2010)	x	x	Preference ranking	6	1	None		Did not tact and mand consistently
Power and Hughes (2011)	x		Preference ranking	3	5–6	ASD		Vocal mands and >100 vocal tacts (1); limited vocal behavior and 22–26 signed mands (2)
Wallace et al. (2006)	x		Preference ranking	3	Adult	Moderate to severe ID		Limited vocal behavior, no vocal or signed mands, communicated with gestures

Numbers in parentheses refer to number of participants

ASD = autism spectrum disorder, *ID* = intellectual disability, *PLS* = preschool language scale

[a] Available for two of four participants

On the basis of these data, some authors (e.g., Wallace et al. 2006) have questioned the results of previous studies in which tact-to-mand transfer has not occurred. However, it does not necessarily follow that participants in other studies would have manded following tact training given a stronger EO. Although participants' verbal repertoires do not seem to differ substantially from those in studies that have failed to find tact-to-mand transfer, some procedural details may explain why mand emergence was observed in the HP or deprivation condition for all participants in the five aforementioned studies. Specifically, the five studies described above may have suffered from one of the construct validity problems introduced previously. In all five studies, the manded items were visible during mand probes, and could have served to evoke the previously trained tact. By itself, this procedural detail would not explain why correct responses in mand probes occurred primarily for HP items or in the deprivation condition, as pure tacts should not be influenced by these variables. However, in all five studies, correct responses during mand probes also resulted in the delivery of the mand consequence. Thus, during repeated mand probes, it seems possible that responses that initially occurred as tacts were directly reinforced as mands in the HP or deprivation conditions (but not in the LP or satiation conditions, in which the mand consequence was presumably not an effective reinforcer), which might explain why mands occurred at higher rates in those conditions. In support of this interpretation, there appeared to be a tendency in at least some of the studies (e.g., Davis et al. 2012; Gilliam et al. 2013; Wallace et al. 2006) for correct mands for LP items to occur in the initial mand probe session(s). In other words, mand emergence in HP and deprivation conditions may have been overestimated in those studies. Thus, although the results have been quite consistent across participants and studies, they may not necessarily suggest that the presence of an EO or the use of an HP mand consequence is sufficient for mand emergence following tact training.

The final study in this category (Pino et al. 2010) was conducted with typically developing toddlers (16 to 21 months) and addressed both tact-to-mand and mand-to-tact transfer. Participants learned to either tact or mand for HP stimuli (which were unavailable to the participants outside of sessions) and neutral (not-HP) stimuli. The results differed from the other five studies in that tact training yielded minimal manding for either HP or neutral stimuli, with no difference between HP and neutral. In addition, tacts following mand training did not reach criterion levels. These results may support the suggestion that the presence of an EO, or the use of an HP item in the mand condition, is not sufficient for mand emergence following tact training (nor for tact emergence following mand training). A possible weakness, however, is that the HP items used in this study were selected on the basis of an informant assessment instead of an objective, approach- or engagement-based preference assessment.

Given the possibility that mand emergence was inflated in this set of studies, we do not think they can serve to call into question the results of other studies in which mands failed to emerge following tact training. Nevertheless, they serve as an important reminder of the previously discussed importance of attending to EO presence in the mand condition.

Antecedent Instructions in Probe Trials

A series of three studies (Egan and Barnes-Holmes 2009, 2010, 2011) have investigated the effects of modified verbal antecedents on mand-to-tact and tact-to-mand transfer. In the first study (Egan and Barnes-Holmes 2009), children with ASD were

taught to mand for preferred items using adjectives that described different bowls in which the items could be placed (e.g., "small" vs. "medium" vs. "large"). Tacts emerged only in the presence of a verbal instruction to tact ("What is it?") and not when the experimenter simply pointed to a bowl. The second and third studies (Egan and Barnes-Holmes 2010, 2011) investigated the effects of modified antecedents when participants were taught to tact or mand for the relative location of objects. Participants were children with ASD in the 2010 study and typically developing children in the 2011 study. In both studies, participants who had previously failed to mand following tact training or tact following mand training performed to criterion with modified antecedent instructions. Specifically, the antecedents used by Lamarre and Holland (1985), "Where do you want me to put the ___?" (mand probes) and "Where is the ___?" (tact probes) were modified by adding the question "Which side?", accompanied by the experimenter pointing to the two locations.

The results of Egan and Barnes-Holmes (2009) underscore that tacts of visual stimuli may fail to occur without a verbal instruction to tact. This finding may not have any particular implications for other studies, as all studies in which mand-to-tact transfer did not occur included an instruction to tact (see Table 2). However, as we noted previously, any particular instruction used in probe trials should ideally be tested to ensure that it evokes tacting or manding for familiar items, and researchers might consider testing modified instructions if tacts and mands do not appear in probes initially.[5] The two subsequent studies (Egan and Barnes-Holmes 2010, 2011) suggest the possibility that the results of other studies on mands and tacts for relative locations (Alves and Ribeiro 2007; Córdova et al. 2007; Lamarre and Holland 1985) may in part be attributed to ineffective control by the verbal stimuli used during probes. In this regard, it is interesting to note that Alves and Ribeiro (2007) found a substantially greater degree of transfer than the other two studies. Alves and Ribeiro's study differed from the other two in that stimuli were presented to participants on a computer screen. Computerized presentation may have had similar effects as the modified verbal stimuli in Egan and Barnes-Holmes (2010, 2011), in that the well-defined locations on the computer screen may have restricted the range of possible responses. Therefore, they may have eliminated responses such as "on your head" and "over here" that Egan and Barnes-Holmes (2011) reported to occur in the absence of modified verbal stimuli. In any case, this series of studies supports the point made earlier, that absence of correct responses in probe trials may occur due to lack of appropriate instructional control over tacting and manding.

Instructional Histories

Two studies examined the effects of instructional histories on mand–tact independence. Nuzzolo-Gomez and Greer (2004) investigated the effects of multiple-exemplar

[5] In Petursdottir et al. (2005), one participant was given modified instructions in mand probes after repeatedly responding "I need another piece" in the presence of the verbal stimulus "What do you need?" The instruction was modified by adding "Which one?" following occurrences of this response. However, no mands were observed in spite of the modified instruction.

training on mand-to-tact and tact-to-mand transfer with children who had developmental disabilities. In mand training, participants were taught to mand for containers that held preferred edibles, using adjective–noun combinations (e.g., "small cup"; "middle bowl"). In tact training, participants were taught to tact the same containers. Following tact or mand training with an initial stimulus set, no transfer to the other operant was observed. In multiple-exemplar training, participants received both mand and tact training, alternated on a trial-by-trial basis, with a new stimulus set. Finally, each participant received tact or mand training with a third stimulus set, and this time, transfer was observed for all participants. These results are consistent with an observation made in some studies that untrained operants began to emerge following training and testing with multiple stimulus sets (Hall and Sundberg 1987; Sigafoos et al. 1989, 1990).

Second, Hernandez et al. (2007) examined the effects of differentially reinforcing only framed mands following tact training (e.g., "I want the truck, please", as opposed to single-word mands, such as "truck") on the emergence of additional framed mands that had not been directly trained. The participants were two children who had developmental delays and one young, typically developing child. The results varied across participants. For one participant, however, it was clear that few or no untrained mands occurred when mand training contingencies did not differentiate between single-word and framed mands, but once framed mands had been differentially reinforced with a few stimulus sets, additional framed mands emerged for untrained stimulus sets. These results are consistent with Sigafoos et al.'s (1990) suggestion that participants' learning to use a "want" symbol prior to selection-based mand probes contributed to greater tact-to-mand transfer in that study than in Sigafoos et al. (1989).

Each of these studies has some limitations. In Nuzzolo-Gomez and Greer (2004), the experimental design did not permit separating the effects of multiple-exemplar training from the effects of continued instruction of mands only or tacts only, and in Hernandez et al. (2007), the relevant results were limited to one participant. Nevertheless, both studies suggest that learning histories influence the extent to which mand-to-tact or tact-to-mand transfer occurs.

Other Relevant Research

This review has focused on investigations of the effects of tact training on mand emergence and vice versa. However, we are aware of additional studies that may be of relevance to mand–tact independence.

First, two studies (Sundberg et al. 1990; Ribeiro et al. 2010) have produced data on the emergence of both tacts and mands following training of a third relation. If tacts and mands are functionally independent, we might expect to sometimes see one operant emerge in the absence of other from the training of a third relation. Sundberg et al. (1990) found that intraverbal training, in which participants were taught to respond to questions such as "What do you need to use to plug a three pronged plug into a two pronged socket?", resulted in the emergence of both tacts and mands (e.g., manding "adapter" when presented with a three-pronged plug and a two-pronged socket) for one participant but neither tacts nor mands for the other. Ribeiro et al. (2010) found that listener training yielded both mands and tacts for

one of two participants (the other did not pass tact probes initially, and mands were not probed until he had received direct tact training). Thus, neither study yielded evidence that tacts might emerge in the absence of emergent mands or vice versa, but so far, the database is limited.

Second, several studies (Kelley et al. 2007b; LaFrance et al. 2009; Lerman et al. 2005; Normand et al. 2008) have reported functional analyses of the existing verbal repertoires of participants with ASD or other developmental disabilities. The purpose of these studies has not been to investigate mand–tact independence, but rather, to demonstrate how verbal operants may be isolated in a person's repertoire for the purposes of behavioral language assessment. The general approach has been to alternate test and control conditions for each of several verbal operants, including mands and tacts, across brief sessions. The same vocal or signed response form is targeted in all conditions. Each test condition involves the presentation of relevant antecedent stimuli for the response to occur as part of a particular verbal operant, and if it does, consequences appropriate to that operant are provided. In the control condition for that verbal operant, these antecedents and consequences are absent. For example, in the mand test condition of the original study by Lerman et al. (2005), a preferred item for which the participant had experienced pre-session deprivation (e.g., cake) was presented and then removed from sight, and a listener was present. In addition, a verbal prompt ("What do you want?") was presented every 20 s if the target response failed to occur. If the target response (e.g., "cake") occurred, the participant was presented with a small piece of cake. In the mand control condition, by contrast, the participant had pre-session access to the item, as well as continuous access to it during the session, and the target response did not produce consequences. Consistently higher levels of responding in the test than in the control condition suggested that the response functioned as a mand. Of relevance to mand–tact independence, the results of the individual assessments indicated that specific response forms could exist in the participants' repertoires as mands but not as tacts, and as tacts but not as mands. Subsequent studies also found tacts in the absence of mands (Kelley et al. 2007b) and mands in the absence of tacts (LaFrance et al. 2009; Normand et al. 2008). These results may provide additional evidence for mand–tact independence. It may be noted, however, that the data on tacts in the absence of mands may be difficult to interpret, because mand consequences were not selected on the basis of a reinforcer assessment, but rather, on the basis of response forms that the participants had been observed to emit under naturalistic conditions. As a result, these stimuli may or may not have functioned as reinforcers.

Third, two studies have compared outcomes of tact-like reinforcement contingencies with the outcomes of mand-like reinforcement contingencies. Mand-like contingencies produced faster responding than tact-like contingencies (Stafford et al. 1988) and more emergent listener behavior (Braam and Sundberg 1991). Participants also preferred the mand-like to the tact-like contingencies. These data provide additional support for the mand and the tact as separate operants, although they do not directly speak to the issue of independent acquisition.

Conclusions and Future Directions

Skinner's (1957) distinction between motivational and discriminative control over verbal behavior played an important role in his analysis of various linguistic phenomena. Empirical demonstrations of mand–tact independence would strongly support this distinction, and therefore, provide important empirical support for Skinner's account. The relevant literature has grown substantially in recent years, with numerous studies by multiple research groups devoted to examining transfer (or lack thereof) of new response forms between mand and tact contingencies. As the present review makes clear, this collection of studies is heterogeneous and contains some major weaknesses. One weakness is the absence of standardized information on participants' verbal and cognitive functioning, which makes it difficult to interpret variability in outcomes. This is a problem that has previously been noted in other reviews of behavior-analytic literature (O'Donnell and Saunders 2003). A second large weakness is that when training and testing procedures are analyzed conceptually, problems with construct validity appear to be present in most studies to varying degrees. The potential implications of two such problems (motivation to obtain mand consequence, and instructional control over manding and tacting) have been highlighted in two series of empirical studies, suggesting the need for careful scrutiny of data that appear consistent with mand–tact independence. For example, the original study by Lamarre and Holland (1985) was a highly innovative study with a high degree of experimental control over trained responses that is commonly cited in support of mand–tact independence. However, upon closer examination, and in the light of more recent work (e.g., Egan and Barnes-Holmes 2011), it appears that this study's actual support for mand–tact independence may be questionable. Other studies suffer from relatively more minor limitations, but overall, no single study has produced exceptionally strong evidence for mand–tact independence.

In spite of these issues, we have concluded that collectively, the literature contains at least weak support for the functional independence of the mand and the tact. It is important to know, however, that this conclusion relies on at least two assumptions. The first assumption is that in place of demonstrating that responses trained as mands are under the functional control of an EO, it may be sufficient to rule out other plausible sources of control. The second assumption is that for participants with existing tact and mand repertoires, commonly used verbal antecedents such as "What is this?" for tacts and "What do you want?" for mands may typically be sufficient to evoke tacting and manding. If these assumptions are not agreed upon, the only available conclusion to draw from the literature may be that mand–tact independence still remains to be demonstrated empirically.

Should researchers, then, continue to investigate mand–tact independence? Given the large number of existing studies that have evaluated the effects of tact training on mand acquisition and vice versa, and the limitations present in those studies, the production of additional studies employing this strategy may be of questionable value. In particular, the literature will not benefit from additional studies that suffer from the same limitations that are present in existing studies. However, there may be room for a small number of exceptionally well-designed studies that address the major limitations of the existing literature. A few recommendations can be made in this regard. First, care must be taken to select appropriate participants. Some of the stronger evidence for

mand–tact independence has come from studies conducted with very young typically developing children or individuals with severe language impairments due to developmental disabilities. At the same time, the participants ideally need to have a few existing tacts and mands under the demonstrated control of the antecedent stimuli that are present in mand and tact probes. Participants who fulfill both criteria may be difficult to locate. Second, we recommend reporting standardized language assessment information for each participant. Third, to permit separation of the controlling variables for the mand and the tact, we recommend using blocked-response procedures (e.g., interrupted chains) to contrive potential EOs during mand training and testing, in which (a) each set of stimuli is correlated with more than one mand form (i.e., multiple mands are targeted within the same behavioral chain), (b) the immediate mand consequence is not visible at the beginning of mand trials, and (c) independent evidence (e.g., preference assessment results or data on chain completion) supports the reinforcing value of the remote mand consequence. Fourth, we recommend providing data on approach or search behavior evoked by mand probe conditions. Fifth, we recommend subjecting responses trained as mands to a functional analysis to verify EO control. Table 5 shows the extent to which the last four of these recommendations have been followed in previous studies on independent acquisition, making clear what future research can contribute to the literature. If mand–tact independence is demonstrated, the researchers might consider following up on this finding either with longitudinal data collection (i.e., re-testing participants at regular interval to document at which point in their development mand–tact independence is no longer observed) or by manipulating specific learning histories that might permit an individual to emit a mand when only a tact has been reinforced, and vice versa. Only two studies (Hernandez et al. 2007; Nuzzolo-Gomez and Greer 2004) to date have attempted to investigate such learning histories, and further research is warranted, given the theoretical and applied importance of this issue.

Finally, researchers might keep in mind that training tacts and testing mands, or vice versa, is not the only possible way to investigate mand–tact independence. As the present review implies, it may be exceedingly difficult to design a study using this strategy without leaving the data open for numerous alternative interpretations. We have already provided examples of other types of data that may be relevant to mand–tact independence, such as functional analyses of existing verbal repertoires (e.g., Lerman et al. 2005) or examining the emergence of both mands and tacts following the training of a third relation (e.g., Ribeiro et al. 2010). However, Skinner's (1957) analysis also has other testable implications. For example, if a mand and a tact that share the same response form are products of different reinforcement contingencies, then the manipulation of one contingency (e.g., changing the schedule of reinforcement for the mand "water" or placing it on extinction) should not affect the frequency of occurrence of the same response form as a part of the other contingency (e.g., the tact "water"). This implication suggests an additional approach to studying mand–tact independence. The data might have less applied relevance than data generated by the train-test approach that has predominated in the literature to date, but they could certainly provide support for Skinner's approach to language.

Table 5 Recommended methodological features present in studies on independent acquisition

Authors	Standardized language assessment	Blocked-response procedures that meet all three criteria[a]	Data on Approach or search behavior in mand condition	Functional analysis of trained mands
Albert et al. (2012)				
Alves and Ribeiro (2007)				
Córdova et al. (2007)				
Finn et al. (2012)	x	x		
Hall and Sundberg (1987)				
Halvey and Rehfeldt (2005)	x			
Kelley et al. (2007a)				
Lamarre and Holland (1985)				
Normand et al. (2011)				x
Petursdottir et al. (2005)				
Pino (1994)				
Shillingsburg et al. (2009)				
Sigafoos et al. (1989)				
Sigafoos et al. (1990)				
Sundberg et al. (1990)				
Twyman (1996)				
Ziomek and Rehfeldt (2008)	x			

"x" indicates that a particular feature is present in a study

[a] The three criteria are (a) each set of stimuli is correlated with more than one mand form (i.e., multiple mands are targeted within the same behavioral chain), (b) the immediate mand consequence is not visible at the beginning of mand trials, and (c) independent evidence (e.g., preference assessment results or data on chain completion) supports the reinforcing value of the remote mand consequence

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