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Studying the impact of intensity is important but complicated

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Abstract

This commentary suggests that the most commonly studied aspect intensity (dose frequency) on overall rate of response to treatment may often be weak or conditional. To improve statistical power of tests of weak effects additive statistical models have typically been used. However, multiplicative models may be a more productive route to understanding dose frequency effects on children' s speech and language development. To illustrate, recent findings are presented that dose frequency effects on vocabulary development varied by two child characteristics. Finally, it is suggested that spacing of teaching episodes within an intervention session be included as a variable in the multi-dimensional model of treatment intensity. Spacing teaching episodes may eventually prove to be one of the more powerful aspects of intensity.

Keywords

Intensity; treatment; speech/language pathology

Baker (2012) offers an insightful discussion of treatment intensity issues in speech-language-pathology (SLP). In response, we offer a few observations to illustrate why thinking about and studying the effects of intensity of treatments can be surprisingly complicated. We have recently completed a randomized control trial in which outcomes of an early communication intervention were compared when delivered in one 60-minute session a week vs five 60-minute sessions a week (Fey, Yoder, Warren, & Bredin-Oja, 2012). The results of this study and related experiences contribute to our current thinking about the topic.

As Baker (2012) notes, we shared our initial thoughts about intensity by offering a conceptual model for treatment intensity research and by calling for an expansion of research on treatment intensity (Warren, Fey, & Yoder, 2007). In our model, "dose" is conceptualized as the number of properly administered teaching episodes during a single intervention session and is usually quantified as the number of trials per minute (i.e., rate of correct trials). "Dose form" is the typical task or activity within which the teaching episodes

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are delivered. Highly-structured drill-and-practice approaches can be contrasted with approaches in which trials are embedded within the context of activities that are familiar and enjoyable to the child (i.e., an activity-based approach). Activity-based approaches usually result in a lower dose of the treatment than structured, drill-and-practice approaches, but not always. “Dose frequency” refers to the number of times teaching sessions are implemented per day or per week (Warren et al., 2007). Finally, cumulative intensity is the result of multiplying dose × dose frequency × duration of therapy. Cumulative intensity can be increased by altering any of its component variables while keeping the other component variables constant.

In our RCT, we kept dose, dose form, and duration of therapy constant to study the effect of dose frequency on communication and language generalization and retention (Fey et al., 2012). We used Milieu Communication Teaching (MCT) that first targeted pre-linguistic communication and then focused on spoken words and early word combinations. Our instantiation of MCT embedded about one teaching episode per minute in joint-action routines. We manipulated dose frequency by providing 1-hour MCT sessions either one (low dose frequency, LDF) or five times (high dose frequency, HDF) a week for 9 months to a group of 64 toddlers with intellectual disabilities (ID). Children were randomly assigned to dose frequency levels. Many design elements and preliminary findings make the study unusually informative regarding the possible effects of dose frequency on language development. For example, our study included blind assessors, blind coders, frequent fidelity of treatment coding, and frequent measurement of non-project treatment attendance. Additionally, we were successful in manipulating dose frequency as intended (4.19 times more sessions for the HDF group than in the LDF group). There were non-significant differences between groups prior to treatment onset on a number of important pre-treatment variables. Non-project treatment attendance was unrelated to outcome or group, and there was low attrition that was equally divided between groups.

Perhaps the most important finding of the study was that there was no main effect of dose frequency on communication and language development. Put most simply, more was not generally better. However, that is not the whole or even the most interesting part of the story.

When simple main effects of dose frequency (i.e., those tested with no covariate and no statistical interaction between dose frequency and child variables) are tested, many scientists will seek to increase the statistical power of their test of dose frequency by searching for a covariate that reduces the error variance without reducing the variance due to dose frequency (Howell, 2009). Using a covariate to increase the statistical power of the test of dose frequency effects is an application of an additive model. Additive models are based on the concept that the influence of multiple factors can be summed to understand variability in an outcome (Howell, 2009).

One such powerful correlate in our recent study was pre-linguistic communication frequency. Regardless of what dose frequency group the children were assigned to, children who used more pre-linguistic communication at the pre-treatment period showed faster receptive and expressive vocabulary development than children with relatively less pre-

linguistic communication at the pre-treatment period. Thus, we thought that after statistically controlling for pre-treatment pre-linguistic communication use, we might detect an effect of dose frequency on vocabulary. However, the effect of dose frequency on speed of growth on receptive and expressive vocabulary was non-significant even after controlling for initial levels of pre-linguistic communication. Therefore, use of an additive model did not reveal a significant effect of dose frequency on communication or language outcomes.

Besides our own investigation, at least two other studies examining main effects of dose frequency have found non-significant effects (Denton, Cirino, Barth, Romain, Vaughn, & Wexler, 2011; Ukrainetz, Ross, & Harm, 2009). Additionally, the Denton et al. study examined several covariates (i.e., attempted to use an additive model) and still did not find an effect for dose frequency on the outcome. This is not to say there is no support for the hypothesis that greater dose frequency can be more beneficial than smaller dose frequency. A small number of relevant studies using rigorous experimental designs have found such support (Al Otaiba, Schatschneider, & Silverman, 2005; Barrett, Littlejohns, & Thompson, 1992).

Rather, it is to say that another type of statistical model, a multiplicative one, may improve our thinking about the conditions under which dose frequency influences speed of treatment response. Multiplicative models test the relation of the statistical interaction between predictors (e.g., group × child characteristic) on the outcome (Howell, 2009). When testing dose frequency level effects, multiplicative models test whether the magnitude of the differences between the dose frequency groups on the outcome vary as a function of another variable, in our case a pre-treatment child characteristic. That is, multiplicative models of dose frequency require testing the statistical interaction between individual differences on a child characteristic × dose frequency group assignment on change in the outcome. This is how conditional dose frequency effects are tested.

Two multiplicative effects were seen in our recent RCT, in which all participants had intellectual disability (ID). Children with initially high object interest (i.e., those who played meaningfully with many objects) (Warren et al., 2007) and children who did not have Down syndrome (DS) (Yoder, Fey, Warren, & Woynaroski, 2012) benefitted more from the 5 hours/week of MCT than the 1 hour/week of MCT. Object interest and aetiology are examples of dose frequency “moderators”. That is, the between-dose-frequency group differences varied as a function of the “type of child” treated.

Interestingly, object interest and aetiology represent two distinct classes of child moderators of treatment effect: malleable and not malleable. Malleable moderators are abilities we can teach or characteristics we can change through treatment (e.g., McDuffie, Lieberman, & Yoder, in press). Therefore, the results highlight the importance of teaching object play when children have initially low object interest prior to our language therapy. On the other hand, presence or absence of DS is not malleable. That is, presence of a third 21st chromosome will not be affected by speech-language therapy. However, taking note that a child’ s ID is caused by DS can be used to organize our thinking about treatments that might be more appropriate for the DS sub-group.

The latter finding suggests that there may be a point of diminishing return to increasing the dose frequency in some children. It has long been noted that children vary in the degree to which therapy will affect them. The term “reaction range” was coined to describe the concept that response to therapy varies because of individual differences in biological factors such as brain functioning (Gottesman, 1963). However, this does not imply that therapy is a waste of time for children with DS. It does imply that, as a general rule, the children with DS probably do not need more MCT targeting non-symbolic gestures, gaze, and spoken words. Rather, they may need interventions that teach the use of aided (e.g., speech generation devices) or unaided (e.g., manual signs) forms of augmented communication as a bridge to spoken language.

One interesting and crucially important element of dosage that our 2007 model did not make explicit is the spacing, or distribution, of teaching episodes within sessions. Whether more concentrated or spaced teaching trials are used is related to our concept of dose form. Let’ s say we have deemed it appropriate to engage the child in play, feeding a doll to teach the word, “feed”. We have further prescribed a dose of 10 uses of the word “feed” (e.g., “I can feed the baby. Now, you feed her”) during a 30 minute play period, or a dose of .33 models per minute. In massed-trial training, we might deliver all 10 models of “feed” in the first 5 minutes of play. In distributed-trial training, we might deliver one or two of those models in the first 5 minutes but reserve other models for later in the session. Thus, we could have the same dose (i.e., averaging .33 models per minute) in a concentrated flurry or more broadly spaced throughout the session.

There are reasons to believe that effects of these different distributions of trials make a difference to learning. In fact, one of the most consistent findings in the study of cognitive learning is that generalization and retention are inferior when trials are massed vs when they are distributed (Fanselow & Tighe, 1988; Yin, Barnet, & Miller, 1994). Riches, Tomasello, and Conti-Ramsden (2005) have demonstrated this effect on verb learning for children with specific language impairment (SLI). Performance on a production task revealed better learning after only 12 presentations of novel verbs in spaced trials (i.e., three in each of four sessions) than after 18 presentations in massed trials in a single session.

At the same time, it is well documented that children with language impairments need more exemplars of words and grammatical forms than do typical children to learn new language targets (Leonard, 1994; Oetting, Rice, & Swank, 1995; Rice, Oetting, Marquis, Bode, & Pae, 1994). Riches et al. (2005) propose that higher densities of teaching episodes may be needed in early intervention sessions to foster basic mental representations of new language forms, whereas lower densities in follow-up sessions may be best to stabilize and shape the quality of those early representations. The potential long-term advantages of less successive (i.e., less blocked and more interrupted) or random teaching episodes also have been recognized in other areas of child communication intervention, such as in treatment of childhood apraxia of speech, but evidence is limited (Edeal & Gildersleeve-Neumann, 2011) and not always supportive (Maas & Farinella, 2011). Discovering how best to deal with the conflict between the need for greater frequency of teaching episodes (Gray, 2003), while also providing sufficient spacing, is one of the most significant challenges related to intensity that clinicians face in early communication and language intervention.

In conclusion, there is much work to do before we have a handle on the treatment effects of different components of treatment intensity. The complexity of the task is probably why we have learned so little about the effect of varying intensity levels of treatment on client' s speed of response to treatment. Yet the development of truly effective treatments demands that we embrace this complexity through appropriate conceptual models, experimental designs, measures, and analytic methods. The intent of Warren et al. (2007) was to advance a conceptual model of treatment intensity as a therapeutic and experimental construct to reduce the complexity of this challenge. That model is not without its shortcomings. On the other hand, it has given us a productive point from which to begin.

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